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PART I

Lower Cenomanian Foraminifera from Peace River Area, Western Canada

BY

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PART II

Lower Cenomanian Ammonoidea and Pelecypoda from Peace River Area, Western Canada

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FOREWORD

The Research Council of Alberta publishes the following report as the fifth in a series describing the Foraminifera from the Cretaceous sequence of the Peace River area of Western Canada. (Previous reports in this series are numbered 68, 70, 72 part I, and 75, Research Council of Alberta.) The five reports provide a succession of microfaunal identifications to assist in the dating of petroliferous Cretaceous sand tongues in northwestern Alberta.

Various agencies have separately made this report possible. In 1947, the senior writers made field collections while under assignment from Imperial Oil Limited. Additional field collections and financial support were received through cooperation with Pacific Petroleums, Stanford University, University of Alberta, and the Research Council of Alberta.

C. R. Stelck incorporated part of the study in a doctoral dissertation at Stanford University. R. E. Wetter developed a master of science thesis at the University of Alberta from additional field collections. J. H. Wall re-examined the theses material and pertinent microfaunal suites for this report.

Technical assistance has been received from the staff of the Research Council of Alberta. S. Antoniuk, while a graduate student at the University of Alberta, prepared upper Shaftesbury formation core-samples provided by Pacific Petroleums. Former University of Alberta students, R. Sutherland and J. Ontko, assisted in the collection of shale sequences used in this study.

A University of Alberta Research Fund grant has assisted in the collection of diagnostic megafossil suites pertinent to the dating of the microfauna. Other megafaunal collections studied include those made by the writers, by W. G. Bahan (formerly of Pacific Petroleums), by Hudson Bay-Marland Oil, and by the late Dr. R. L. Rutherford for the Research Council of Alberta.

PART I

Lower Cenomanian Foraminifera from Peace River Area, Western Canada

ABSTRACT

Sixteen species and subspecies of Foraminifera—one of which is named—from the Lower Cenomanian portion of the St. John and Dunvegan formations of the Peace River area, Western Canada, are figured and described. Microfaunal assemblages are integrated with local megafaunal sequences of the Lower Cenomanian substage of the Upper Cretaceous. Lithologic sections are given for the Lower Cenomanian strata in the Fort St. John area. The Lower Cretaceous-Upper Cretaceous boundary occurs at a fish-scale sand marker-bed in the Shaftesbury formation in outcrop. Correlative fish-scale beds are found in the lower part of the Colorado shale of Alberta and Saskatchewan, and in the Mowry shale of the Black Hills area of the United States.

The foraminiferal assemblages are dominantly arenaceous. Micro- and macrofauna indicate a progressive change from a relatively deep, cool, euxinic, normally saline environment to shallow, brackish and fresh, deltaic conditions.

INTRODUCTION

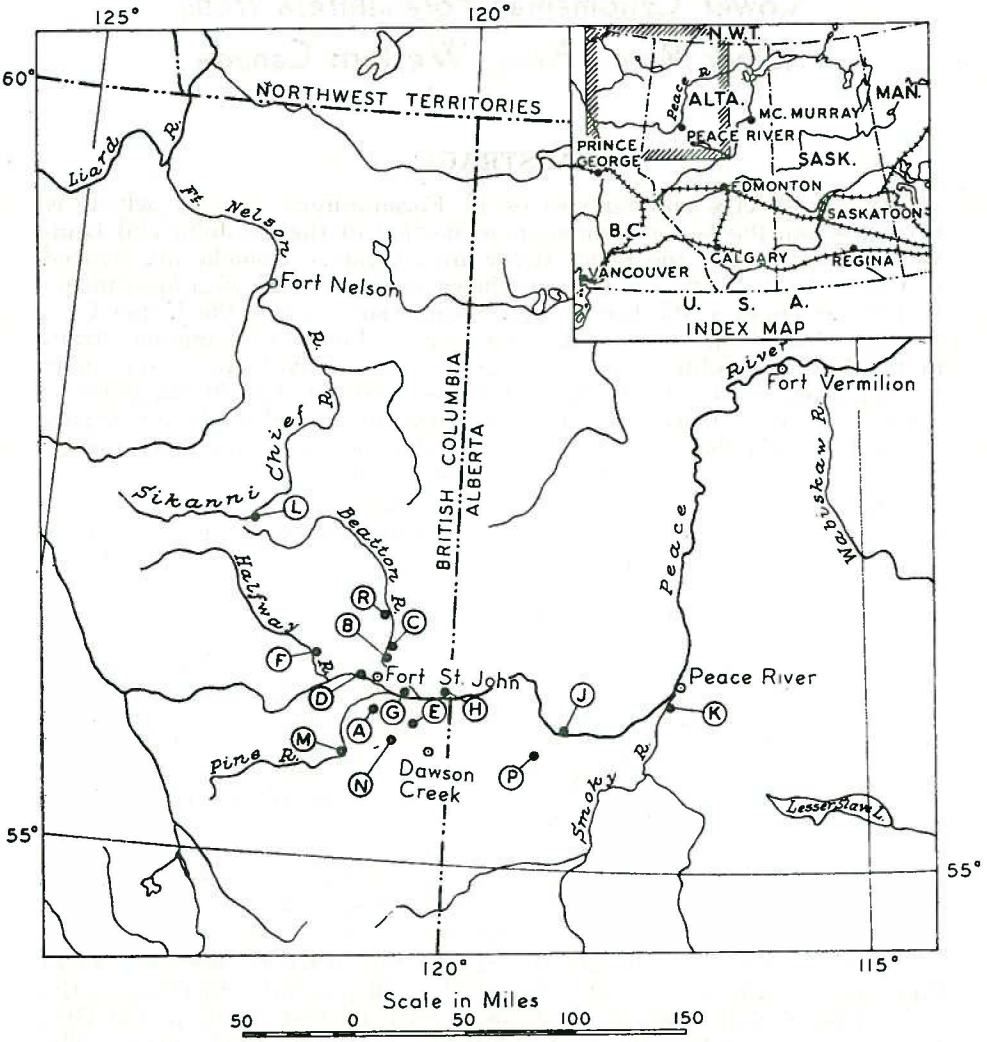
The Lower Cretaceous- Upper Cretaceous boundary in Western Canada is involved in disconformable relations between the Blairmore formation and the overlying strata of the Colorado group. Paleontologic definition to this boundary is found in thick deposits of the Peace River area of Western Canada. Here the beds carry not only certain diagnostic microfaunas, but also a megafauna that may be correlated in part with the ammonite faunas found in European type sections of the late Lower and early Upper Cretaceous strata. The megafauna is known only from the Peace River area outcrop-sections, therefore the microfauna is herein illustrated for the Lower Cenomanian substage in the hope that these strata may be recognized also in subsurface section.

Lower Cenomanian fossils are rare in the northern parts of North America suggesting a scarcity of deposits, and possibly reflecting, in the central parts of the continent, a hiatus such as that found in the Gulf Coast region between the Comanche and overlying Gulf series. The faunas of the Lower Cenomanian beds of the Peace River area indicate shallowing waters. The scarcity of benthonic megafauna and the presence of dwarf Foraminifera suggest that the Peace River basin represented a euxinic environment of limited connection with other seaways at the beginning of the stage. The faunas tend to be local. They are pelagic at the base of the Lower Cenomanian and brackish at the top of the Lower Cenomanian substage.

The Lower Cenomanian microfaunas in the Peace River area of Western Canada are found within the upper part of the Fort St. John group above a lithologic marker known as the "fish-scale sand". The identification of the Lower Cenomanian strata may be made through the presence

Fig. 1

LOWER CENOMANIAN LOCALITIES IN DRAINAGE AREA OF PEACE RIVER, WESTERN CANADA



KEY TO MAP

A—Septimus Creek, Sec. 20, Tp. 82, R. 18, W. 6th Mer., suites 4900 - 44.
B—Beatton River, mouth of St. John Creek, Sec. 14, Tp. 84, R. 18, W. 6th Mer., suites 4600 - 20.
C—Beatton River, Sec. 1, Tp. 85, R. 18, W. 6th Mer., suites 4500 - 10.
D—Wilder Creek, Sec.3, Tp. 84, R. 20, W. 6th Mer.
E—Kiskatinaw River test holes in SE.¼, Sec. 27, and NW.¼, Sec. 26, Tp. 80, R. 17, W. 6th Mer.
F—Halfway River, a half-mile below mouth of Cameron River, **Irenicoceras** locality.
G—**Irenicoceras** locality, six miles below Peace River bridge, north bank.
H—Mouth of Alces River, British Columbia.
J—Dunvegan locality S47 - 28, about one mile above the mouth of Hines River.
K—Shaftesbury locality S47 - 29, a half mile below Judah, Alberta.
L—Sikanni Chief River locality S47 - 12, 2¼ miles below Alaska Highway bridge.
M—East Pine, British Columbia.
N—Pacific Sunrise No. 1 Well, Sec. 29, Tp. 79, R. 17, W. 6th Mer.
P—Imperial Spirit River No. 1 Well, Lsd. 12, Sec. 20, Tp. 78, R. 6, W. 6th Mer.
R—Beatton River localities, one mile above the mouth of the Doig River, Sec. 6, Tp. 86, R. 17, W. 6th Mer.; localities S47 - 18, S47 - 19.

of the ammonite genus *Irenicoceras*, n.gen. This ammonite is found about 250 feet above the base of the fish-scale sand in the Fort St. John area of British Columbia. The beds immediately below the fish-scale sand carry a species of the ammonite *Neogastroplites* which is indicative of the top of the Lower Cretaceous series.

The beds a short distance above the Dunvegan formation carry the ammonite *Dunveganoceras* indicative of the Upper Cenomanian substage. The Dunvegan formation itself is a brackish to fresh-water sandstone and the upper part is correlative in part with the beds carrying *Acanthoceras athabascense* Warren and Stelck found on the Athabasca River. This indicates that part of the Dunvegan formation itself also belongs to the Upper Cenomanian substage. How much then of the Dunvegan formation belongs to the lower part of the Cenomanian stage is difficult to ascertain. However, the local lithological succession is well known and may suffice to establish correlative horizons independent of Europe.

STRATIGRAPHY

A composite sequence of Cretaceous strata in the Peace River area of Alberta and British Columbia includes the following formations:

Wapiti sandstone
Smoky shale group
Dunvegan formation
Shaftesbury formation or "Upper" St. John shale
Commotion or Peace River sandstones
Moosebar or Loon River shale
Bullhead group

The Shaftesbury shale equivalents in the Foothills consist of the Cruiser shale, Goodrich sandstone and Hasler shale, in descending order.

The boundary between the Upper and Lower Cretaceous series, i.e. the Albian-Cenomanian stage boundary, comes within the Cruiser shale, and the boundary between the upper and lower portions of the Cenomanian stage appears to fall within the Dunvegan formation. The stratigraphy of both the upper St. John formation and the Dunvegan formation are pertinent to the proper assignment of microfaunas to zonal position.

Fort St. John Group (Shaftebury formation)

In dealing with the St. John formation a considerable history of terminology is found requiring explanation.

The type section of the St. John shale is on the Peace River near old Fort St. John, British Columbia (on the river about three miles above the present Alaska Highway bridge crossing, near the Pacific Great Eastern railway bridge) where in 1879, G. M. Dawson (1881) named the "lower dark shales" the Fort St. John shale. F. H. McLearn in 1918 shortened the appellation to St. John shale. In 1943, Wickenden and Shaw, working in the upper Pine River area of British Columbia, raised the term "Fort St. John" to group status and included within it the following formations in descending order: Cruiser shale, Goodrich sandstone, Hasler shale, Commotion formation and Moosebar shale.

In 1944, McLearn and Henderson (p. 3), mapping the Lone Mountain area of northeastern British Columbia, introduced the term Shaftesbury shale for the "formation lying between the Peace River and Dunvegan formations in the eastern part of the Peace River valley between Dunvegan and the town of Peace River". C. O. Hage (1944) working north

Table I. Terminology of Fort St. John group.

STAGE			PEACE RIVER ALBERTA	FORT ST. JOHN B. C.	HUDSON HOPE B. C.	UPPER PINE RIVER B. C.	SIKANNI CHIEF RIVER B. C.	LIARD RIVER AREA B. C.	
UPPER CRETACEOUS	CENOMANIAN	FORT ST. JOHN GROUP	DUNVEGAN	DUNVEGAN	DUNVEGAN	DUNVEGAN	DUNVEGAN	DUNVEGAN	COLORADOAN
			SHAFTESBURY UPPER MEMBER	type section ST. JOHN formation	"UPPER" ST. JOHN shale	CRUISER	SIKANNI shale	SIKANNI shale	
			fish-scales	fish-scales			fish-scales		
LOWER CRETACEOUS	ALBIAN		LOWER MEMBER			GOODRICH	SIKANNI ss.	SIKANNI sandstone	
						HASLER	BUCKINGHORSE	LEPINE	
			PEACE RIVER	PEACE RIVER	"CADOTTE" shale mem.	COMMOTION		SCATTER	
			LOON RIVER	LOON RIVER	GATES MOOSEBAR	MOOSEBAR		GARBUTT	
				BLUESKY					
			"BULLHEAD"	GETHING	GETHING	GETHING	BULLHEAD		

along the Alaska Highway from Fort St. John (town) introduced the terms Sikanni and Buckinghorse formations for the upper and lower divisions of the Fort St. John group, and E. D. Kindle (1944) on the Liard River introduced the terms Garbutt, Scatter and Lepine.

A convenient table of reference shows a relationship summary of terms introduced (Table 1).

The Cenomanian portion of the Fort St. John group includes:

1. The upper part of the Shaftesbury formation of type section, in Alberta;
2. All but the base of the actual exposures at the type section of the St. John shale at Fort St. John, in British Columbia;
3. The upper part of the Cruiser shale in type section in the Pine Pass, British Columbia;
4. The upper part of the Sikanni shale in type section on the Sikanni Chief River, British Columbia.

A composite picture of the lithology of the upper portion of the St. John shale in the type area near Fort St. John is outlined by the following three outcrop sequences taken from Wilder Creek, and from Septimus Creek.

WILDER CREEK SECTION

St. John formation on Wilder Creek, Sec. 3, Tp. 84, R. 20, W. 6th Mer., British Columbia, from the base of the Dunvegan formation to the First Tuff marker-bed.

Feet	
.....	Base of Dunvegan formation.
.....	Top of St. John formation.
2.0	Sandstone, bedded, bluish-grey, very fine-grained, weathers light-grey to light-buff; upper part jointed.
2.5	Shale, silty, brownish-black; the upper part has a brown rusty coating and is cliff-forming like the overlying sandstone; the bottom part weathers grey-black and forms a small bench.
1.5	Sandstone, very fine-grained; interbedded with grey and grey-black sandstone; the laminae are very thin, giving a freshly broken surface a varved appearance.
2.9	Siltstone, bedded, greyish-black, with minor thin lenses of brownish silty shale between the beds; the siltstone weathers light-grey and forms a small bench to the underlying sandstone.
7.0	Sandstone, massive, light-brownish-grey, weathering light-buff, fine-grained, the uppermost 2 feet appear bedded; jointing throughout.
1.3	Siltstone, the uppermost 0.3 feet is shaly, somewhat fissile, greyish-black, the remainder is somewhat sandy, brownish-black to grey-black, weathering to a whitish-grey; siltstone lenses present.
2.0	Sandstone, finely interbedded, cross-bedded, whitish-grey and buff, very fine-grained; weathers buff-grey; occasional lenses of greyish-black siltstone appear at irregular intervals throughout.
4.0	Shale, silty, brownish-grey, with purple staining; this shale fractures in blocky irregular pieces; weathers a light-brownish-grey.

Feet	
1.0	Sandstone, irregular shaped concretion composed of greyish-black fine-grained sandstone; contains fragments of black carbonaceous material.
21.0	Shale, silty, with some siltstones.
1.5	Ironstone, concretionary band.
2.5	Shale, silty.
11.0	Shale, very silty, with silty ironstone bands and occasional siltstone or micaceous sandstone lenses.
0.5	Cone-in-cone bed. This is the cone-in-cone marker horizon used in this report.
3.0	Shale, as above the cone-in-cone bed.
47.0	Shale, silty, with occasional nodules up to 10 by 5 inches.
18.0	Shale, no nodules.
0.2	Ironstone, almost continuous band.
30.5	Shale, heavy-looking, sub-scarp-forming, with bands of ironstone.
0.3	Ironstone, silty to sandy.
7.5	Shale, silty.
0.2	Ironstone, silty
1.5	Shale, very silty.
0.1	Ironstone, silty.
1.5	Shale, very silty, fissile.
9.5	Shale, with semi-continuous one-inch ironstone bands.
3.0	Shale, silty.
0.1	Bentonite, white.
11.0	Shale, silty, fissile.
0.1	Bentonite, white.
7.0	Shale, silty, with sporadic 18 by 4 inch nodules.
0.1	Bentonite.
32.0	Shale, with ironstone.
18.0	Shale, silty, with ferruginous silt bands.
48.5	Shale.
0.5	Tuff, First Tuff marker-bed, pink coloration. This is the same tuff marker-bed as found at the top of the section immediately following.

SEPTIMUS CREEK SECTION (Upper Portion)

St. John formation from the First Tuff marker-bed to the Second Tuff marker-bed on Septimus Creek. (Faunal collections from this interval were collected at the mouth of St. John Creek on Beatton River, British Columbia, in Sec. 14, Tp. 84, R. 18, W. 6th Mer.).

Feet	
0.1	Bentonite, cream-colored band.
0.5	Shale, highly fissile, tending to become flaky, black with brownish rust-staining on exterior surface.
0.5	Tuff, pink (characteristic color of First Tuff), highly consolidated;

Feet

lowermost 2 inches carry abundant biotite flakes. This is known as the First Tuff in this report.

1.5 Shale, highly fissile, almost flaky.

0.1 Bentonite, somewhat tuffaceous, buff.

1.0 Shale, fissile, almost flaky.

0.5 Shale, very platy, flexible; containing small indentations resembling buckshot holes. The individual lamellae are present in large pieces and have a tendency to overhang.

4.0 Shale, fissile, black.

0.8 Shale, flexible, overhanging.

1.0 Shale, silty, flaky, rusty with abundant gypsum crystals between the bedding planes.

2.0 Shale, greyish-black, crumbly, with sporadic fish-scales and abundant gypsum crystals between bedding planes; faint greenish tinge on exterior surface from pickeringite staining.

0.1 Bentonite, yellow.

31.0 Shale, somewhat flaky, brownish-black; fragments do not break regularly along bedding planes; contains minute gypsum crystals along bedding planes and abundant fish-scales; slight green tint from pickeringite staining.

0.2 Ironstone, silty, stained with pickeringite on the exterior surface; slightly fractured, with abundant gypsum crystals and iron staining in the fractures.

1.0 Shale, flaky, greyish-black, with abundant gypsum crystals between bedding planes; fish-scales present; pickeringite staining.

0.3 Shale, tuffaceous; badly weathered, highly rusted between bedding planes with abundant gypsum crystals.

17.0 Shale, somewhat fissile, brownish-black; parting not conformable with bedding planes; fracture somewhat conchoidal; sporadic fish-scales.

1.5 Shale, pyritiferous?, weathering yellow.

18.0 Shale, as above the yellow band.

0.5 Tuff bed, Second Tuff marker-bed. This is the same tuff marker-bed as found at the top of the section immediately following.

SEPTIMUS CREEK SECTION (Lower Part)

St. John formation from the Second Tuff marker-bed to the base of the fish-scale beds, on Septimus Creek, British Columbia, in Sec. 20, Tp. 82, R. 18, W. 6th Mer.

Feet

0.7 Tuff, irregularly-bedded, rusty colored; lowermost 2 inches contain spotty, poorly-consolidated, greyish-white tuff intermixed with yellowish tuff (Second Tuff marker-bed).

1.5 Shale, crumbly, greyish-black, with some pickeringite staining mostly in the bottom portion.

39.9 Shale, flaky to fissile, grey, with minor amounts of pickeringite staining, giving greenish tinge; weathers silvery-grey; contains oblate ironstone modules which sometimes contain ammonites.

0.3 Ironstone, grey, rusty weathering.

Feet	
14.5	Shale, brownish-black; breaks off in irregular fragments not conforming with the bedding plane; minor pickeringite staining; weathers brownish-grey.
25.5	Shale, brownish-grey, as above, lowermost 2 feet tending to be somewhat flaky; sporadic fish-scales; oblate ironstone nodules are found but not abundant and irregularly dispersed.
0.4	Ironstone, greyish-black, weathering rusty.
28.0	Shale, greyish-brown, fracture does not conform with bedding planes; abundant fish-scales and thin lenses of siltstone up to 1/8 inch thick, irregularly dispersed throughout; occasional oblate nodules.
11.0	Shale, flaky, greyish-black, somewhat fissile in irregular pattern and with faint pickeringite staining.
0.2	Ironstone, grey, weathering rusty.
14.0	Shale, flaky, greyish-black, as above.
0.3	Ironstone, grey, weathering rusty.
1.5	Tuff?, partially consolidated, whitish-grey, intermixed with yellowish bentonite.
35.0	Shale, somewhat fissile, brownish-black, with abundant fish-scales and some ¼-inch bands of yellow bentonite; very fine needle-like crystals of gypsum abundant between bedding planes; sporadic ironstone concretions up to one foot in diameter.
10.5	Shale, greyish-black, as above, with faint pickeringite staining.
16.3	Shale, flaky, somewhat fissile, brownish-black, with thin minute needle-like gypsum crystals between bedding planes; abundant fish-scales in uppermost 5 feet; faint tinge of pickeringite.
0.2	Ironstone, greyish-black, weathering rusty.
15.0	Shale, flaky, greyish-black, with abundant fish-scales; thin ¼-inch band of yellowish-grey bentonite 10 feet from top.
13.0	Shale, fissile, brownish-black, containing abundant fish-scales.
33.0	Shale, platy, brownish-grey, heavily coated with pickeringite and containing abundant fish-scales; weathering silvery-grey (typical fish-scale shales); lowermost 3 feet tend to become very fissile.
0.3	Shale, tuffaceous, brownish-grey, contains numerous fish-scales and gypsum crystals.
20.0	Shale, brownish-black, contains fish-scales but not as numerous as in the overlying 33 feet of beds.
14.3	Shale, flaky, brownish-black, containing fish-scales and minute needle-like gypsum crystals between bedding planes; thin lenses of silt, rare.
0.8	Siltstone, interbedded greyish-black and brownish-black, with rusty streaks and abundant gypsum between bedding planes; weathers rusty.
2.0	Shale and sandstone, greyish-black; silty shale and fine-grained, grey sandstone. (Fish-scale sand marker-bed).
0.5	Siltstone, interbedded, greyish-black and brownish-black, with abundant gypsum between bedding planes; rusty weathering.
.....	Base of fish-scale beds.
.....	Top of *Neogastroplites* zone.

Feet

4.0 Shale, flaky, greyish-black with pickeringite staining between bedding planes; occasional lenses of siltstone.

2.0 Shale and sandstone, interbedded; greyish-black silty shale, and greyish-black siltstone.

..... Water level.

The above sections reveal a certain number of marker-beds that may be used as datums of correlative reference. The cone-in-cone bed, 61 feet below the base of the Dunvegan formation (at the Wilder Creek locality), marks the first sharp reduction in salinity of the St. John sea. Brackish conditions persist up into the Dunvegan formation itself, and marine faunas may be obtained from the basal portion of the Dunvegan formation.

The First and the Second Tuff marker-beds, 300 feet and 380 feet respectively below the base of the Dunvegan formation, may be used as time-stratigraphic markers as they represent horizons of widespread volcanic ash-fall.

The fish-scale sand marker-bed is a concentration of silts, sands, fish-scales and fish-bones that occurs 680 feet below the Dunvegan sandstone in the Fort St. John area. The shale below the fish-scale sand marker-bed carries ammonites of Lower Cretaceous affinities. The ammonites occurring above the fish-scale beds have Upper Cretaceous aspects. The top of the fish-scale sand marker-bed is used in this report as marking the boundary of the Upper and Lower Cretaceous series.

Fish-Scale Interval

Fish-scales are a dominant, though sporadic, fossil element in shale sequences spanning the Lower-Upper Cretaceous boundary in the western interior of North America. Locally the argillaceous content may be reduced, and the concentration of fossil material results in "bone-beds" or "fish-scale beds". Such lithofacies need not be synchronous.

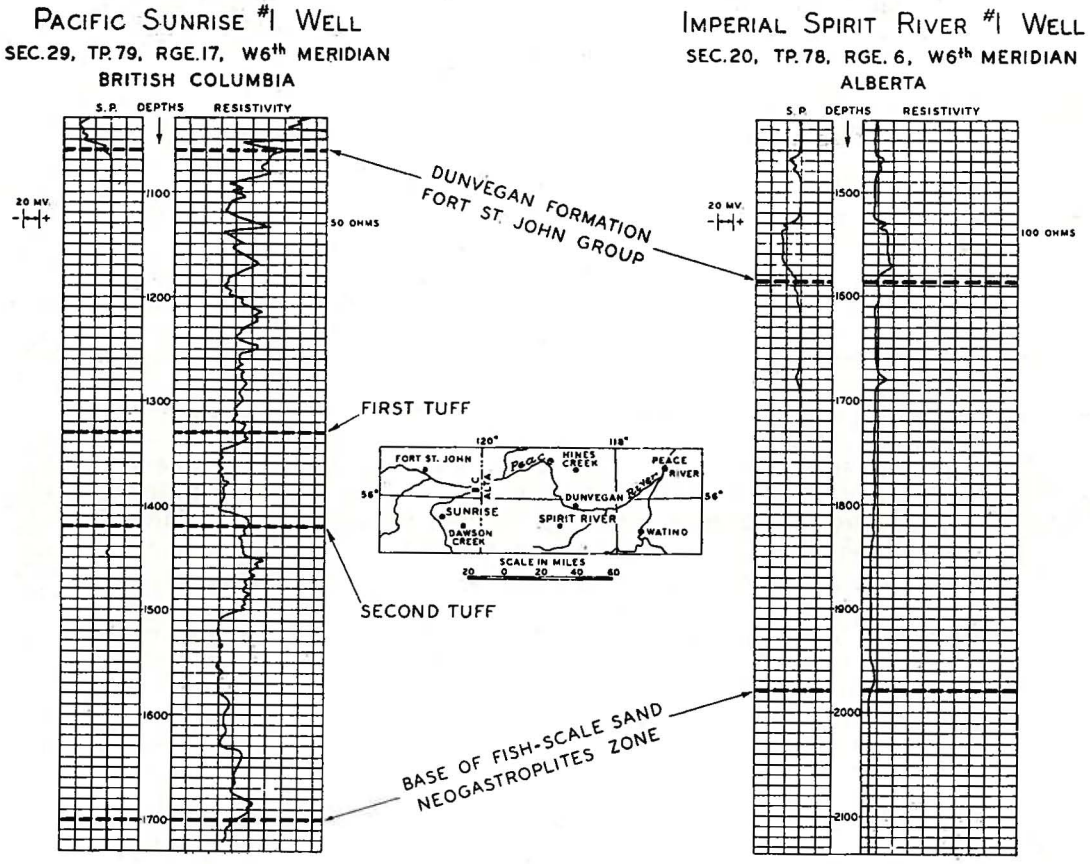
In the Peace River area the shale sequence most closely associated with the fish-scale concentrations is the Shaftesbury formation. In the type area of the Fort St. John group the fish-scale bearing shales extend from 100 feet below, to around 250 feet above the Lower Cretaceous-Upper Cretaceous series boundary (i.e. the fish-scale sand marker-bed). Within these 350 feet of beds, several stratigraphic levels of additional concentrations of fish-scales occur, usually accompanied by the development of siltstones and more rarely, sandstones. The nature of the concentrations suggests a period of retarded shale deposition accompanied by a moderate amount of winnowing. Such bone-beds may be the equivalent of a considerable hiatus elsewhere.

Three of these fish-scale concentrations seem to have added significance. The abundant fish-scales occurring at a distance of 80 feet below the Second Tuff of the St. John shale marked the influx of deeper water, permitting development of a new ammonite assemblage. The presence of stray clean sandstones in the fish-scale beds around 138 feet below the Second Tuff implies the existence of an actual diastem. Below this indicated diastem, the abundance of fish-scales gives a laminated habit to the outcrops for the subjacent 200 feet. Three hundred feet below the Second Tuff is the marker-bed designated the "fish-scale sand" in most reports on the area. The fish-scale sand is thought to represent the inception of euxinic basinal conditions just prior to the spreading of Upper Cretaceous seaways.

Near Judah station, Alberta, the fish-scale sand is only four feet in thickness but is expressed as a distinct ledge (Plate I b) in contrast to the underlying and overlying shale. This development of the fish-scale sand in the Shaftesbury formation of type area is similar to that as expressed in the electric logs taken throughout the Plains of Alberta. The section of fish-scale sands at Judah may be the equivalent of a much greater thickness of the fish-scale interval in the upper Peace River valley.

The Shaftesbury fish-scale sands are known along the Foothills in outcrop, south as far as the Nordegg area in Alberta but are absent in the Foothills still farther south. Under the Plains the fish-scale concentrations are well known down through southern Alberta and Saskatchewan and into the western United States where they give the Mowry formation a characteristic habit.

UPPER SHAFTESBURY FORMATION Fig. 2
SHOWING
CORRELATION AND POSITION OF MARKERS



St. John-Dunvegan Formation Contact

The transitional nature of the boundary between the St. John shale and the overlying Dunvegan sandy beds has already been noted for the Fort St. John area. It is not only transitional but also laterally diachronic. The top of the shaly St. John beds on Favels Creek (below East Pine, British Columbia), although still transitional, is as low as the cone-in-cone marker-bed (i.e. 61 feet stratigraphically below the base of the Dunvegan at Wilder Creek, or around 100 feet below the base at Beatton River). The transition zone in the Imperial Spirit River No. 1 well has caused considerable difficulty in well-log determination of the base In this well, Gleddie (1954, p. 493), including only the arkosic portions, recorded the base of the Dunvegan at 1580 feet and the present writers follow this practice (Figure 2.) An electrolog marker at 1674 feet in the same well indicates the stratigraphic position of the base of the Dunvegan formation as defined for the Beatton River section. The total outcrop exposed at Dunvegan ferry-crossing includes only the arkosic portion of the Dunvegan. The lower brackish member is assumed to be below water level at this point.

At Racing Creek, below Watino, Alberta, the basal sandstone of the Dunvegan formation appears to be approximately equivalent to the sand occurring 130 feet above the base of the Dunvegan in the Beatton River area.

On the upper Pine River the transition zone extends below the cone-in-cone marker-bed. Here, the brackish member at the base of the Dunvegan formation is sanded up and the arkosic member lies disconformably on the basal portion. This disconformable condition is accentuated to the southeast along the Foothills until in the region of the upper Kakwa River the arkosic member sits with erosional relief down on the St. John shale proper.

Out under the Plains of central Alberta the Dunvegan sandstone thins and fades and the Shaftesbury shale becomes a lithologic continuity with the overlying Smoky (Alberta) shales. The term lower Colorado shale is used throughout the southern Plains of Canada to cover the lower Smoky, Dunvegan and Shaftesbury equivalents.

The shallowing represented by the St. John-Dunvegan passage beds may well provide a diastem in other marginal areas of the Colorado sea, and explain why Lower Cenomanian beds have not been recognized in surface outcrops elsewhere in the western interior of North America.

In general the Dunvegan formation may be considered a deltaic tongue projecting into the northwest margin of the Colorado sea and a closer examination of the Dunvegan is warranted.

Dunvegan Formation

Two type sections of the Dunvegan formation were designated by Dawson in 1881—one on the Peace River (at Dunvegan, Alberta) and another on the Pine River (at East Pine, British Columbia). The Pine River section includes in the sandy lithofacies additional stratigraphic interval to the Dunvegan section on the Peace River. To resolve the discrepancy, an outcrop of Lower Dunvegan beds about midway between the two type sections has been selected for description in the Fort St. John area of British Columbia, overlying type St. John shale. This permits elaboration of units of continuous sedimentary sequence for the Lower Cenomanian stage.

A section taken on the Beatton River, just northeast of Fort St. John, British Columbia, one mile above the mouth of the Doig River, shows the following lithology within the Dunvegan formation:

LOCALITY S47-19 BEATTON RIVER

Dunvegan formation: Section from near top of continental member down to the base of the beds transitional with the underlying St. John shales.

Feet	
.....	Boulder clay.
15.0	Shale, silty, black with some ironstone.
1.0	Shale, sandy.
0.5	Sandstone, lensing.
1.0	Shale, sandy.
0.5	Sandstone.
13.0	Shale, silty, carbonaceous with sandy zones.
14.0	Shale, silty, carbonaceous with streaks of fire-clay.
2.5	Sandstone, argillaceous, fine with ironstone.
5.5	Shale, silty to sandy, carbonaceous.
130.0	Sandstone, arkosic, massive, fine- to coarse-grained. This section is replaced by interbedded sand and shale to the west. (This is the arkosic sand-member of this report).
3.0	Sandstone, evenly bedded, fine.
2.0	Sandstone, medium-fine with interbeds of siltstone.
12.0	Siltstone, sandy, carbonaceous.
1.0	Shale, coaly.
0.5	Sandstone, argillaceous with rootlets.
3.0	Sandstone, platy, reddish, medium-fine.
5.0	Siltstone, carbonaceous, argillaceous with coaly streaks and thin fine sandstone.
20.7	Sandstone, medium-fine to medium. This sandstone is very constant in thickness over wide areas and may be mapped.
21.3	Sandstone, argillaceous, shaly, interbedded with lenses of sandstone.
1.3	Sandstone, lenticular, thin-bedded, fine.
3.2	Siltstone, sandy.
2.5	Sandstone, thinly bedded, platy.
23.5	Shale, sandy, interbedded with argillaceous sandstone at top.
0.8	Sandstone, interbedded with siltstone.
7.0	Siltstone, shaly.
2.8	Sandstone, calcareous, grey, carrying *Unio*.
7.0	Sandstone, greenish-grey, fine with siltstones carrying marcasite nodules.
5.8	Sandstone, argillaceous, shaly and siltstones.
6.7	Sandstone, grey-green, fine with shaly sandstone.
9.0	Sandstone, argillaceous, shaly with streaks of ironstone.
2.0	Sandstone, carbonaceous, micaceous, thinly cross-bedded, fine.
7.5	Siltstone, shaly.

Feet	
5.0	Shale, very silty, brown with thin sandstone.
10.0	Shale, very silty, dark-brown in lower portion.
2.0	Sandstone, argillaceous, shaly.
.....	Top of the Basal sand of the Dunvegan formation.
2.5	Sandstone, thin-bedded, laminated.
9.3	Sandstone, evenly bedded, medium-fine.
15.5	Sandstone, cross-bedded, salt and pepper, medium-grained.
4.0	Sandstone, cross-bedded, white, medium-coarse.
7.0	Sandstone, laminated, carbonaceous, micaceous, fine-grained.
.....	Dunvegan—St. John formation contact.
5.0	Sandstone, shaly, soft, argillaceous.
18.5	Sandstone, thinly bedded, silty, micaceous, very fine with thin silty shale interbeds.
26.8	Siltstone, slightly sandy, carbonaceous, micaceous, shaly.
2.0	Sandstone, argillaceous.
6.0	Shale, very silty to sandy at top.
9.0	Siltstone, argillaceous, shaly.
0.1.	Sand, biotitic, bentonitic, soft.
7.5	Shale, silty.
9.8	Shale, sandy with argillaceous sandstone and argillaceous siltstone interbedded.
9.0	Shale, silty to slightly sandy.
.....	Water level.

The above section does not embrace all of the Dunvegan strata. The plant-bearing beds of the Dunvegan formation, indicated only as a remnant below the glacial drift at the top of the above section, extend stratigraphically upward for several hundred feet more before the brackish beds of the succeeding Kaskapau shale appear. The Beatton River section of the Dunvegan formation reveals these main divisions:—

(a) An upper plant-bearing deltaic sequence, 400+ feet thick.

(b) A middle conglomeratic arkosic member to 300 feet thick.

(c) A brackish lower member, 200 feet thick.

(d) A basal sand member, 100 feet thick.

The arkosic member is known to rest at places with an erosional unconformity upon the brackish member, although there is little indication of this on the Beatton River itself. The basal sand is concordant and transitional with the underlying St. John formation at the Beatton River locality and, indeed, the lower Dunvegan facies seems to be no more than the sanding-up of the St. John sea.

The arkosic sand member introduces the fluvial phase of the Dunvegan formation and marks the expulsion of the sea from the Fort St. John area attendant upon the uplift centring around the Cassiar-Omineca batholith area. Beveridge and Folinsbee (1956) have shown that this arkosic member actually represents the unroofing of the batholiths in northern British Columbia. Earlier sands within the Fort St. John area seem to lack the felspathic content. Conglomerates are common in the arkosic member north and west of Fort St. John. The plant-bearing deltaic sequence is known to be transitional and interfingering with the overlying

Kaskapau shales. Arkosic sands very similar to those associated with the conglomeratic member may be found filling fluvial channels in the upper part of the Dunvegan. The intimate relationship of the arkosic sands with both the plant-bearing sequence and the overlying Kaskapau formation is disrupted in the Watino area of Alberta where the white specks zone of the Kaskapau formation lies unconformably upon the heavy sands of the Dunvegan formation with no intervening transition zone. In similar fashion the transitional and interfingering relationship of the brackish zone of the Dunvegan formation with the underlying St. John shale is disrupted in the Commotion Creek (upper Pine River) area. Here the conglomerates of the arkosic horizon sit unconformably low into the transition beds at the top of the St. John (Cruiser) beds. Actual channelled relief is found at the St. John-Dunvegan contact in the upper Kakwa River area in Alberta.

The base of the arkosic member may be used to mark a natural division within the Dunvegan formation with respect to provenance, depositional environment and paleontological content. Sandstone dykes and unconsolidated flow patterns in the top of the transition beds at the top of the St. John formation on the lower Beatton River suggest that actual tectonic movements were involved.

Thus the base of the arkosic member of the Dunvegan formation is chosen in this paper to mark the upper boundary of the Lower Cenomanian substage in this area. The lower boundary of the Lower Cenomanian substage is chosen within the underlying St. John shale section at the top of the fish-scale sand marker-bed.

The faunal succession of these beds assigned to the lower Cenomanian substage is indigenous to the Western Canadian interior. Index fossils of this substage, diagnostic in Texas or in Europe, are not found in the Peace River area.

Local Faunal Succession

Partial faunal successions for the Cretaceous strata of the Peace River area have been given by the writers previously (Stelck and Wall, 1955; Stelck *et al.*, 1956). A continuous sequence of the local faunas for Upper Albian and Cenomanian strata from the Howard Creek sand member of the Kaskapau formation to the base of the Shaftesbury (upper St. John shale) formation is as follows:

Upper Cenomanian:
- *Inoceramus* aff. *I. fragilis* Hall and Meek
- *Dunveganoceras hagei* Warren and Stelck
- *Dunveganoceras* cf. *parvum* Cobban
- *Dunveganoceras albertense* (Warren)
- *Dunveganoceras* cf. *conditum* Haas
- *Ostrea aurea* (Warren and Stelck)
- *Hillites* cf. *septarianus* (Cragin)
- *Inoceramus dunveganensis* McLearn
- *Inoceramus rutherfordi* Warren

Lower Cenomanian:
- *Brachidontes* cf. *fulpensis* Stephenson
- *Pleurobema dowlingi* (McLearn)
- *P. cruiserensis* n.sp; *Brachidontes* cf. *tenuisculpta* (Whiteaves)
- *Beattonoceras beattonense* n.sp.
- *Irenicoceras bahani* n.sp.
- "Fish-scale sands"

Upper Albian:
Neogastroplites wyomingensis (Reeside and Weymouth)
Neogastroplites cornutus (Whiteaves)
Neogastroplites selwyni McLearn
Posidonia goodrichensis (McLearn)
Posidonia moberliensis (McLearn)
Ophiura sp.
Gastroplites cf. *liardense* (Whiteaves)

The top of the Dunvegan formation as defined by Crickmay (1944) comes at about the stratigraphic position of *Inoceramus dunveganensis*. The base of the Dunvegan formation on the Smoky River near the mouth of Racing Creek carries *Pleurobema dowlingi*. The base of the Dunvegan formation near Fort St. John is stratigraphically lower and carries *Pleurobema cruiserensis* Warren and Stelck, n. sp.

The tops of the Sikanni and Goodrich sands in their type areas fall within the zone of *Neogastroplites selwyni*. *Ophiura* sp. marks the transition beds between the Sikanni sandstones and the underlying Buckinghorse shale, and the transition beds between the Goodrich sandstone and the underlying Hasler shale. *Gastroplites* cf. *liardense* is found in the basal beds of the Lepine formation and in the base of the "upper" St. John beds of the Hudson Hope area.

Because of the sparse microfaunal assemblages collected from the Lower Cenomanian beds in the Fort St. John area, microfaunal biozones have not been integrated into the megafaunal succession.

The fossil assemblages within the Lower Cenomanian strata of the Peace River country are marine at the base and brackish toward the top.

The assemblages with *Brachidontes* cf. *fulpensis* Stephenson occurs in the Leith River area either in beds equivalent to the arkosic member of the Dunvegan, or in beds representing the diastem at the base of the arkosic beds in the Fort St. John area. The suite contains the following megafossils:

Psammosolen dunveganensis Warren
Brachidontes cf. *fulpensis* Stephenson
Ostrea dunveganensis Warren
Inoceramus leithensis Warren and Stelck, n.sp.
Tellina sp.
Tellina aff. *T. whitei* Stanton
Callista cf. *tenuis* Meek and Hayden
Cyrena cf. *securis* Meek

The microfaunal elements are restricted but include:
Saccammina sp. (probably of this report)
Tritaxia sp. (this report)
Trochammina rutherfordi variety 2 Stelck and Wall

The assemblage with *Pleurobema dowlingi* McLearn has been collected from the lower Dunvegan formation over most of the northern Foothills and the Peace River plains area. This fauna is known from the base of the Dunvegan in the Smoky River area but occurs about 200 feet above the base in the Fort St. John area. No microfauna is known.

The fresh-water megafauna is well known and includes:
Pleurobema dowlingi (McLearn)
Elliptio sp.
Gastropods

The basal sand of the Dunvegan formation in the Fort St. John area and the transition zone with the underlying Cruiser shale in the upper Pine River area carry the *Pleurobema cruiserensis* fauna with the following known species present:

Pleurobema cruiserensis Warren and Stelck, n. sp.
Pleurobema cf. *dowlingi* McLearn
Brachidontes cf. tenuisculpta (Whiteaves)
Brachidontes sp.
Panope sp.

From the uppermost 200 feet of beds at the top of the St. John shale on the Alces River, British Columbia, there is a microfauna that seems to grade without break up into the *P. cruiserensis* assemblages. This microfauna carries the following:

Ammomarginulina sp.
Hippocrepina sp. cf. *H.* sp. A. (this report)
Saccammina sp. (this report)
Textularia alcesensis Stelck and Wall, n. sp.
Tritaxia sp. (this report)
Trochammina cf. *T. rutherfordi* Stelck and Wall
T. rutherfordi variety 2 Stelck and Wall

Fossils from between the cone-in-cone marker-bed and the First Tuff marker-bed in the "Upper" St. John shales are rare, variable and of primitive design, including:

Hippocrepina sp.
Hyperamminoides sp. (this report)
Lituotuba ?

Beattonoceras beattonense Warren and Stelck, n.sp, is found between the First and Second Tuff marker-beds in the St. John shale in type area. In addition to this large ammonite, the following Foraminifera are represented:

Haplophragmoides sp.
Miliammina sp. A (this report)
Miliammina sp. B? (this report)

The *Irenicoceras bahani* zone extends from the Second Tuff marker-bed to the top of the fish-scale beds of the St. John formation. An extensive fauna has been collected in this interval in the Fort St. John area, consisting of the following species:

Irenicoceras bahani Warren and Stelck, n. sp.
Beattonoceras ontkoi Warren and Stelck, n. sp.
Neogastroplites septimus Warren and Stelck, n. sp.
Metasigaloceras ?
Forbesiceras sp. A
Inoceramus irenensis Warren and Stelck, n. sp.

The microfauna of the *Irenicoceras* zone includes:

Gaudryina cf. G. *hectori* Nauss
Hippocrepina sp. A (this report)
Trochammina sp. (this report)

The fish-scale bearing beds 160 feet in thickness, which include at the base the fish-scale sand marker-bed, carry:

Neogastroplites sp.
Acompsoceras ? sp.

Plesiosaur remains
Fish-scales and bones including *Holcolepis transversa* Cockerall
Spindle-shaped "egg-cases"

The foraminiferal content of the fish-scale beds includes:

Ammobaculites sp. (this report)
Haplophragmoides sp. A (this report)
Haplophragmoides sp. B (this report)
Miliammina sp. A (this report)
Miliammina sp. B (this report)
Reophax sp. (this report)
Microforaminifer *"Gumbelina"*
Microforaminifer *"Globigerina"*

CORRELATIONS

The endemic nature of the Lower Cenomanian faunas in the Peace River area of Western Canada makes inter-regional correlation difficult. Inasmuch as the base of the Cenomanian stage in Europe is the base of the Chalk beds, the non-limy biofacies for this stage is almost unknown in type section. Indirect correlation is required to define the Albian-Cenomanian (Lower Cretaceous-Upper Cretaceous) boundary in Western Canada.

Upper Cretaceous-Lower Cretaceous Boundary

The Cretaceous was divided originally by d'Orbigny into the following stages in ascending order: Neocomian, Aptian, Albian, Cenomanian, Turonian, Senonian and Danian (*fide* Muller and Schenck, 1943).

In Europe the Cretaceous is divided into two series, the Upper Cretaceous and the Lower Cretaceous. In general practice the division is made above the Albian and below the Cenomanian stage. In Europe a natural lithologic division of the Cretaceous is found at about this horizon where a clastic lower sequence of formations (Greensand and Gault) gives way to a chalky upper division (the Chalk). As is the case with most divisions based on lithology, there is a variation in time-boundary dating from place to place, accompanying either facies change or more natural vertical lithological groupings.

Spath (1941) deals fully with the problem of the Lower Cretaceous-Upper Cretaceous boundary and on an historical basis shows that the Albian stage belongs in the Lower Cretaceous because, in 1822 (the same year in which the Cretaceous was named by d'Halloy), Conybeare included his "Chalk-marl" (i.e. The Gault of Folkestone, England) in the lower division. The International Geological Congress in 1885 (ref. 1888, p.cix) made a further ruling on the position of the Gault: "Le Gault sera reuni au cretace inferieur". The Gault of Folkestone is Albian in age, and therefore the Albian stage should likewise be included in the Lower Cretaceous. The Chalk is Upper Cretaceous, and therefore the Cenomanian stage marks the base of the Upper Cretaceous.

The subzones of the European Cenomanian stage and the upper part of the Gault are given here for reference:

Substage	*Zone*	*Subzone*
Upper Cenomanian	Acanthoceratan	*vincinale* *subflexuosum* *rhotomagense* *diadema* *rectense*
Lower Cenomanian	Mantelliceratan	*costatum* *cantianum* *martimpreyi* *pre-martimpreyi*
Upper Albian	Pleurohoplitan	*dispar-inflatum* *substudieri*
	Hysteroceratan	*aequitorialis* *auritus* *varicosum* *orbignyi*
Middle Albian	Euhoplitan	*cristatum* *daviesi* *lautus-nitidus* *subdelaruei*

The ammonites used above for mid-Cretaceous zonation are not readily found in Western Canada and the determination of equivalent zones is dependent on correlative analysis. *Gastroplites cantianum* Spath, a form described from the *cristatum* subzone in England, is found in Canada in the Hudson Hope area of northeastern British Columbia at the top of the "Cadotte" formation. Species equivalent to those found in the Woodbine formation of the Gulf of Mexico (in beds approximately middle Cenomanian in position) are found also in the upper part of the Dunvegan formation in the Peace River area of northwestern Alberta.

The Lower Cretaceous-Upper Cretaceous boundary position in Western Canada is somewhat below the Upper Dunvegan and above the Cadotte formation. However, a species referable to the Upper Cretaceous genus *Forbesiceras* occurs in the *Irenicoceras* zone in Western Canada and an unnamed species of *Utaturiceras* ? (= *Irenicoceras*) has been found in the Cenomanian of Texas. This would imply that the Upper Cretaceous-Lower Cretaceous boundary is below the *Irenicoceras* zone. Just below the base of the fish-scales occurs a *Neogastroplites* n. sp. that Thorsteinson (1952) recovered with *Metengonoceras* which is an Albian form. *Acompsoceras* is an Upper Cretaceous genus and a form tentatively referred to it (this paper) is found low in the fish-scale bearing beds. For practical purposes the fish-scale sand marker-bed may be used as the Lower Cretaceous-Upper Cretaceous series boundary.

Regional Correlation

The restriction of the bulk of the faunas of the Shaftesbury formation to the interior of North America suggests that this sea was almost completely landlocked and may have been intermittently isolated from the major oceans of the world. Reeside (1957) has shown the approximate edge of such a sea with a land barrier between the Gulf of Mexico and the upper Missouri River valley, and the Pacific waters restricted beyond a Cordilleran barrier. No boreal influence has been noted and it is assumed

that restricted Atlantic connections may have been developed across the Hudson Bay region.

Individual members of the Shaftesbury may be traced into the subsurface through electrical and lithologic methods. The fish-scale sand marker-bed has been recognized: in outcrop on the Sikanni Chief River about 200 feet above the top of the Fourth Sikanni sand member; on the Peace River in the Fort St. John area, British Columbia; in the Peace-Smoky River area of Alberta; on the Athabasca River near Pelican Portage; in the Foothills, on the Wapiti, Torrens and Kakwa Rivers, Solomon Creek, and in the Cadomin and Nordegg areas. In subsurface the fish-scale marker-bed is characterized by a typical electrolog "kick" that has been traced from northeastern British Columbia through central and southern Alberta, southern Saskatchewan and into the Williston Basin area of the United States. The character of the containing shales changes in the region surrounding the Black Hills, becoming siliceous and volcanic, and the Shaftesbury equivalents are known as the Mowry shale. These siliceous, fish-scale bearing beds seem to be thicker and slightly earlier in age, and the exact position of the fish-scale sand marker-bed can no longer be discriminated. In the subsurface in Canada, correlation is confirmed by the presence of spindle-shaped "egg-cases" that occur at the top of the fish-scale sand marker-bed. In the Black Hills area the ammonite content of the Mowry shale has so far revealed only Albian forms of *Neogastroplites* that occur below the the marker-bed in Canada.

The fish-scale bearing beds have yielded microforaminifera"*Globigerina*" and "*Gumbelina*" which are ordinarily considered pelagic. This would imply oceanic connections (Atlantic?) at this time, corresponding to the introduction of Chalk deposits on the European side of the North Atlantic Ocean.

The fauna of the "*Irenicoceras* zone" has been recognized in the Fort St. John area, British Columbia, in the Kantah River area and in the area northeast of Fort Nelson, British Columbia. The only other American occurrence reported is in Trans Pecos, Texas. Young (1958) reports *Utaturiceras*? (= *Irenicoceras*) associated with Lower Cenomanian ammonites from the base of the Boquillas flags below *Metoicoceras* cf. *M. bosei* Jones. He remarks on the state of preservation, "It would appear that the silicified Lower Cenomanian faunule had been derived and redeposited into the Upper Cenomanian base of the Boquillas formation".

The genus *Metasigaloceras* found in the *Irenicoceras* zone was originally described from the Lower Chalk (Cenomanian) near Lyme Regis, England.

Pleurobema cruiserensis Warren and Stelck, n.sp. is found in the base of the Dunvegan formation in the Peace and Pine River areas of northeastern British Columbia. This species is found in the Upper Blairmore formation in the Crowsnest Pass area of Alberta.

Pleurobema dowlingi is found in the lower Dunvegan sandstone throughout the Peace River-Smoky River drainage of northeastern British Columbia and Alberta. Elements of the fossil flora found in beds carrying *Pleurobema dowlingi* are identical to the flora described from the top of the Aspen shale in Wyoming.

Brachidontes cf. *fulpensis* is described from the lower Dunvegan in the Peace River area of Alberta where the brackish margin of the

Dunvegan delta replaces the fresh-water facies. *Brachidontes fulpensis* was originally described from the Cenomanian Woodbine formation of Texas. The suite carrying *Inoceramus leithensis* may well be Upper Cenomanian in age as the Woodbine is usually assigned an Upper Cenomanian age.

ECOLOGY

The above discussion on regional correlation shows fresh-water, brackish, and marine faunas present in the Lower Cenomanian strata of the Peace River area of Western Canada.

At the end of the Upper Albian substage in the Fort St. John area of British Columbia, species of the ammonite *Neogastroplites* occur with large smooth ammonites and with normal marine pelecypods. The assumption may be made that although paleogeographic studies indicate a large landlocked sea, the waters of that sea were of normal salinity in a cool temperate latitude.

The accumulation of fish-scales that marks the top of the Albian stage and the base of the Cenomanian stage in this area implies the development of a euxinic condition within the inland sea. At the same time there was retardation of clastic accumulation as the seaways spread over the Sikanni delta to the northwest. The cessation of the expansion of the sea was marked by the condensed bioclastic accumulation known as the fish-scale sand marker-bed. This expansion of the Shaftesbury sea seems to be coincident with the rise of ocean level that brought about the cessation of clastic deposition in Europe and brought the introduction of the chalk facies there. The pelagic connections made possible by the higher ocean level is indicated within the Peace River area by the planktonic forms *"Globigerina"* and *"Gumbelina"*. Except for the appearance in the fish-scale sand of these calcareous microforaminifera, the Lower Cenomanian foraminiferal assemblages are exclusively arenaceous.

If the absence of calcareous benthonic Foraminifera is not from subsequent destruction, then it is necessary to postulate deep-water conditions of the upper St. John shale from the base of the fish-scale sand marker-bed to the First Tuff marker-bed. Normal marine salinity in the upper water is assumed to have prevailed until the deposition of the First (upper) Tuff marker-bed, as ammonites appear continuously throughout the upper St. John shale to that horizon.

The retarded deposition of fish-scale bearing beds gave way to an accelerated rate of accumulation of clastic material within the basin and a diminution of bioclastic content. Conditions of salinity, depth and temperature apparently remained stable. The ammonite population remained endemic and the only apparently exotic element is the pelecypod *Inoceramus irenensis* Warren and Stelck, n.sp. from the *Irenicoceras* zone.

Uplift of the area to the west and northwest of Fort St. John apparently supplied additional detritus, and accompanying volcanism provided tuffaceous beds.

The absence of Mollusca in the St. John formation above the First Tuff and below the cone-in-cone marker-bed implies a change from normal marine conditions. Continuing uplift to the northwest may have produced freshening of the upper waters of the euxinic basin as the rivers emptied closer to Fort St. John.

The *Pleurobema cruiserensis* fauna does indicate freshening and the cone-in-cone bed itself marks the initial stages of marked reduction

in salinity. The appearance at the top of the St. John shale of *Brachidontes* and rather coarse-grained species of *Trochammina* and *Textularia* indicates a shallowing of the water and restoration of benthonic life.

The river that created the Dunvegan delta delivered its arenaceous fraction, fanning out over the Fort St. John area as a submarine delta. By *Pleurobema dowlingi* time the Fort St. John area became fresh-water deltaic with dicotyledonous swamps and the marine portions of the delta reached out to the Smoky River area. It is doubtful if fresh-water conditions were maintained for any great length of time in the Dunvegan area of Alberta, as *Inoceramus, Ostrea, Brachidontes* are found throughout the Dunvegan formation. The presence of *Trochammina, Tritaxia,* and *Saccammina* implies shallow marine conditions in the middle portion of the Dunvegan formation at its Alberta type locality. The Dunvegan delta wedges into the Colorado sea deposits, and the delta itself (and the formation) is not recognized beyond the Athabasca River. In the Fort St. John area emergent conditions were reached in Dunvegan time as dinosaur tracks are known from that formation.

FORMAL DESCRIPTIONS

Order *Foraminifera*

Genus AMMOBACULITES Cushman, 1910

AMMOBACULITES sp.

Plate III, figures 1, 2, 3

Test medium size, strongly compressed; early portion close-coiled comprising one-quarter length with five indistinct chambers exposed; later portion straight, sides tapering slightly, of three to four chambers increasing slightly in size except for much larger subpyriform final chamber; sutures indistinct, slightly depressed, nearly straight in coil, transverse in uncoiled portion; wall arenaceous, of variously sized grains to about 0.04 mm. but averaging much less, considerable cement imparting resinous luster, surface somewhat rough; aperture terminal, elliptical.

Length of specimen (fig. 1): 0.57 mm.; diameter of coiled portion 0.22 mm.; length of final chamber 0.22 mm.; width of final chamber 0.26 mm.

Length of specimen (fig. 2, 3): 0.56 mm.; diameter of coiled portion 0.21 mm.; length of final chamber 0.20 mm.; width of final chamber 0.24 mm.

Locality of figured specimens: Sec. 20, Tp. 82, R. 18, W. 6th Mer., on Septimus Creek, British Columbia, Canada, from the upper St. John shale, one foot above the base of the fish-scale sand (Map locality A).

Figured specimens: Univ. of Alberta Paleont. Type Coll.

Occurrence: This species has been observed through a 17-foot interval of the upper St. John shale directly overlying the fish-scale sand at Septimus Creek. At least 15 complete or nearly complete specimens, and additional fragmentary material were recorded.

Remarks: This rather featureless form does not appear closely related to any previously published species. It is left unnamed pending further investigation of the upper Albian-Cenomanian microfaunal sequence in the area.

Genus GAUDRYINA d'Orbigny, 1839

GAUDRYINA sp. cf. G. HECTORI Nauss

Plate III, figures 23, 24

Gaudryina hectori Nauss, 1947, Jour. Paleont., vol. 21, p. 335-336, pl. 48, fig. 6 a - b.

Test elongate, first two to three whorls obscure, of three (?) tiny chambers per whorl, later portion biserial of about six whorls, twisting at mid-length, the later half of test appearing buliminellid; chambers rather rapidly enlarging, becoming progressively more inflated as added; sutures distinct except in earliest portion, depressed; wall finely arenaceous, much cement, smooth; aperture a notch at the inner margin of the final chamber extending part way up the terminal face.

Length of figured specimen: 0.46 mm.; maximum width 0.18 mm.

Locality of figured specimen: Test hole in NW. 1/4, Sec. 26. Tp. 80, R. 17, W. 6th Mer., on the Kiskatinaw River, British Columbia, Canada,

from core at depth 530 feet, in the upper St. John shale, about 450 feet below the base of the Dunvegan formation (Map locality E).

Figured specimens: Univ. of Alberta Paleont. Type Coll.

Occurrence: Abundant at the level and locality of the figured specimen with about 60 individuals recorded.

Comparison: This form is closely related to *G. hectori* Nauss from the basal Lloydminster shale of east-central Alberta but, for the present, it is not considered unquestionably identical because of the obscure nature of the chamber arrangement in its earliest whorls. The early (triserial?) portions of the St. John specimens seem shorter and less robust than the corresponding parts of Lloydminster shale topotypes. The walls of the St. John individuals appear finer-grained than those of type area specimens.

Remarks: The exact characteristics of this form can be determined in only the pyritized specimens which comprise about one-third of the total number of individuals obtained. The non-pyritized specimens are collapsed and reveal little character. The earliest portions of the tests are unfortunately not pyritized in any of the available material and, as previously indicated, it is not possible to determine the chamber arrangement with any degree of certainty.

Genus HAPLOPHRAGMOIDES Cushman, 1910

HAPLOPHRAGMOIDES sp. A

Plate III, figures 15, 16

Test medium size, strongly compressed, planispiral, partly evolute with portion of inner whorl typically exposed, small umbilicus developed, periphery subangular, peripheral margin slightly lobulate; about nine nearly equi-sized chambers in outer whorl; sutures indistinct, slightly depressed, nearly straight, their positions in part indicated by ridges as a result of crushing; spiral suture depressed, surrounded by ring-like ridges resulting from compression of chambers; wall thin, finely arenaceous, with much translucent cement imparting a resinous luster, surface, smooth; aperture obscure, a low arch at the base of the terminal face.

Maximum diameter of figured specimen: 0.39 mm.; minimum diameter 0.29 mm.; greatest thickness 0.08 mm.

Locality of figured specimen: Sec. 20, Tp. 82, R. 18, W. 6th Mer., on Septimus Creek, British Columbia, Canada, from the upper St. John shale, 17 feet above the base of the fish-scale sand (Map locality A).

Figured specimens: Univ. of Alberta Paleont. Type Coll.

Occurrence: This species is common to abundant through a 23-foot interval of the upper St. John shale directly overlying the fish-scale sand at Septimus Creek. About 12 specimens were found in a sample taken from the Sikanni shale, 202 feet above the top of the Fourth Sikanni sandstone at Locality S47-12 on the Sikanni River (Map locality L).

Comparison: The evolute nature of this form together with its finely arenaceous wall suggests a general relationship to *H. fraseri* Wickenden from the Upper Cretaceous Bearpaw shale of southern Alberta. The St. John specimens all are strongly compressed with subangular peripheries and, as no rounded individuals were observed, it is difficult to make detailed comparison.

HAPLOPHRAGMOIDES sp. B

Plate III, figures 13, 14

Test small, strongly compressed, planispiral, evolute with portions of inner whorls visible, periphery subangular; six nearly equi-sized chambers in outer whorl; sutures fairly distinct, somewhat thickened, slightly depressed, nearly straight; wall thin, arenaceous, grains about 0.01 mm. in diameter, for the most part neatly arranged in a mosaic pattern, thin outer coating of cement, smooth finish; aperture obscure, a small low arched slit at the base of the terminal face; color yellow.

Maximum diameter of figured specimen: 0.18 mm.; minimum diameter 0.15 mm.; maximum thickness (approximate) 0.04 mm.

Locality of figured specimen: Sec. 20, Tp. 82, R. 18, W. 6th Mer., on Septimus Creek, British Columbia, Canada, from the upper St. John shale 17 feet above the base of the fish-scale sand (Map locality A).

Figured specimen: Univ. of Alberta Paleont. Type Coll.

Occurrence: This form occurs in association with *Haplophragmoides* sp. A over the same interval at Septimus Creek and is rather common.

Remarks: *Haplophragmoides* sp. B may represent a juvenile of *Haplophragmoides* sp. A but is treated as a separate unit because of its more distinctive features, particularly the mosaic pattern of the wall structure and its clearer sutures.

Genus HIPPOCREPINA Parker, 1870

HIPPOCREPINA sp. A

Plate III, figures 21, 22

Test small, a single chamber, somewhat compressed, vase- to barrel-shaped, base broadly rounded, maximum width at about mid-length; test constricted on the exterior at five to eight points and in some specimens rather sharply narrowing distal to the final constriction, the apertural region appearing contracted as a collar; wall finely arenaceous with much cement, somewhat resinous, smooth; aperture terminal, a round to elliptical opening.

Length of figured specimen: 0.28 mm.; maximum width 0.18 mm.

Locality of figured specimen: Test hole in NW. 1/4, Sec. 26, Tp. 80, R. 17, W. 6th Mer., on the Kiskatinaw River, British Columbia, Canada, from core at depth of 530 feet, in the upper St. John shale, about 450 feet below the base of the Dunvegan formation (Map locality E).

Figured specimen: Univ. of Alberta Paleont. Type Coll.

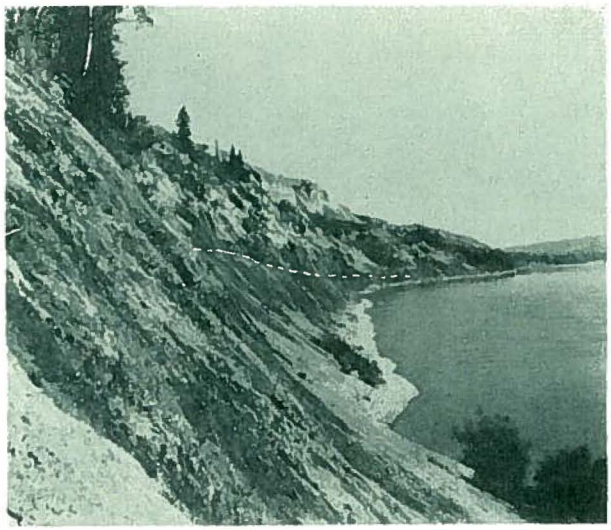
Occurrence: About 25 representatives of this species were recorded at the level and locality of the figured specimen. Three or four specimens of a closely related and perhaps identical form were found in the upper St. John shale at Locality S47-5, the mouth of the Alces River (Map locality H).

HIPPOCREPINA sp. B

Plate IV, figure 18

Test rather large, a single chamber, flattened, attenuated barrel-shaped with maximum width at mid-length; chamber rather indistinctly constricted on the exterior at about six places; wall arenaceous, consisting

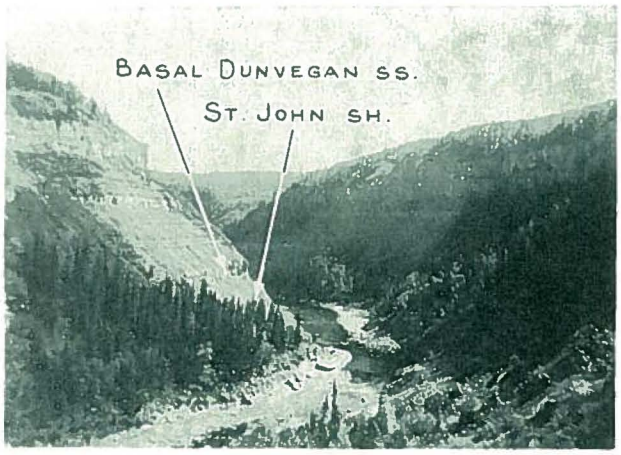
PLATE I



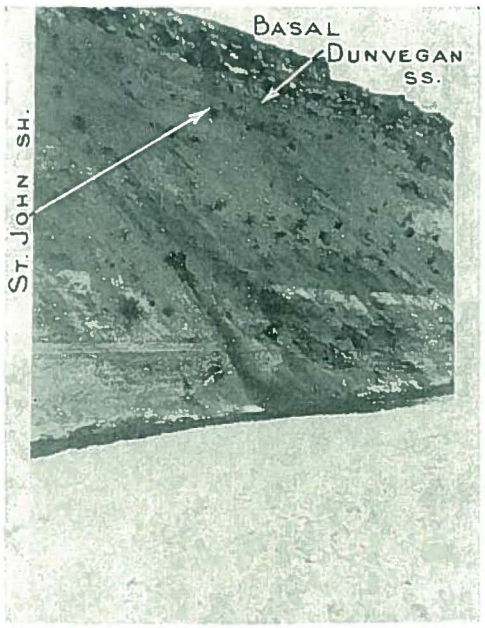
(a) Outcrop of upper St. John shale with *Irenicoceras,* showing position of Second Tuff marker-bed (white line). Map locality G, six miles below Alaska Highway bridge, Peace River, British Columbia.

(b) Outcrop of Shaftesbury formation on Smoky River, near Judah station, Alberta, showing position of fish-scale siltstone member. Map locality K.

PLATE II



(a) Outcrop of Dunvegan and St. John formations, Beatton River, British Columbia. View downstream from map locality R.



(b) Outcrop of Dunvegan and St. John formations, mouth of Alces River, British Columbia. Map locality H.

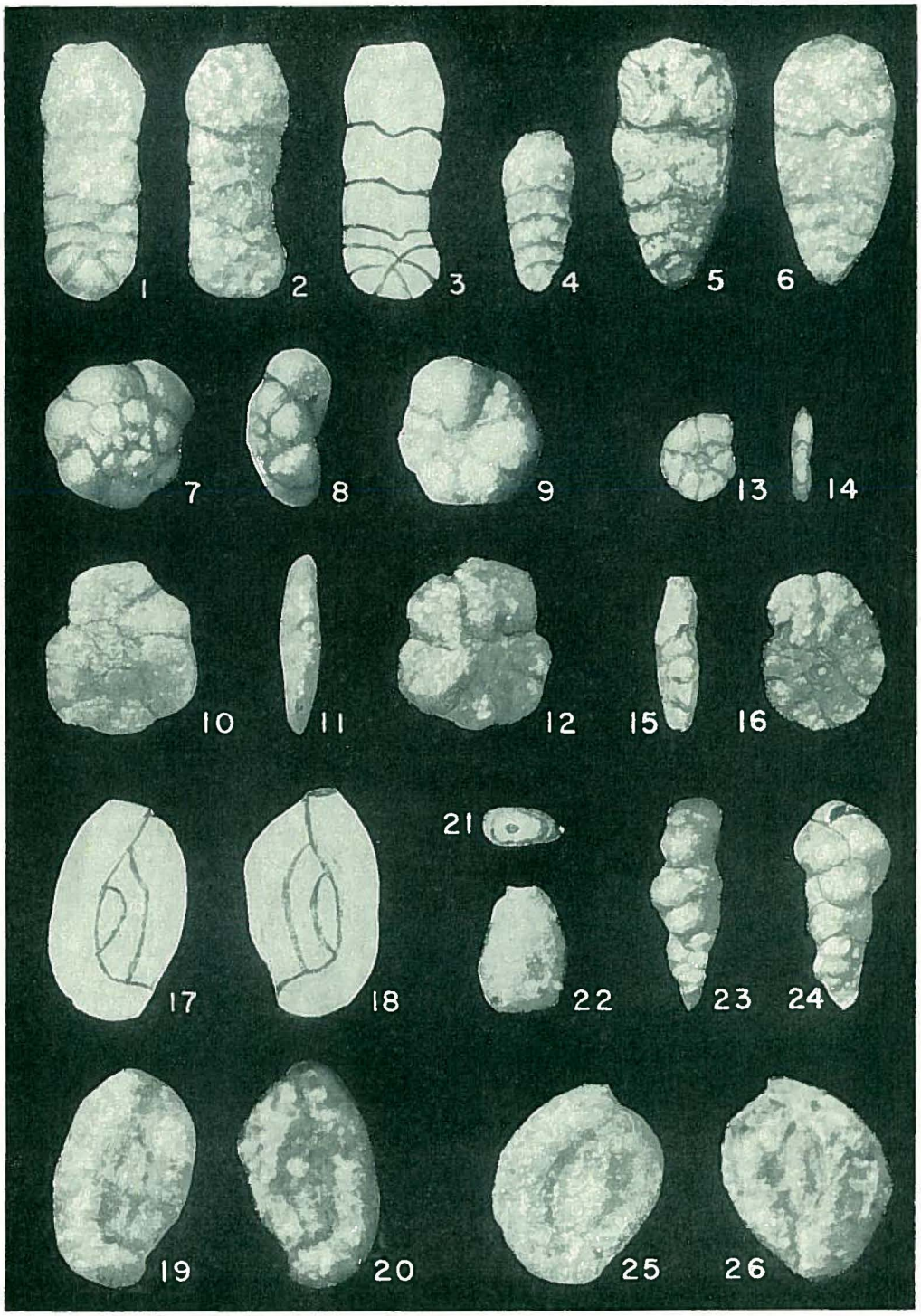


Plate III—Foraminifera from upper St. John shale.

EXPLANATION OF PLATE III

Upper St. John Shale

Northeastern British Columbia

Magnification about x65

Figures 1-3: *Ammobaculites* sp. from Septimus Creek; 1—photograph of a specimen; 2, 3—photograph and sketch of another specimen (p. 26)

Figures 4-6: *Reophax* sp.; 4—photograph of specimen from Septimus Creek; 5, 6—sketch and photograph of specimen from Sikanni Chief River (p. 30)

Figures 7-12: *Trochammina* sp. from test hole, Kiskatinaw River; 7, 8, 9—dorsal, peripheral and ventral views of pyritized undeformed, dextral specimen; 10, 11, 12—dorsal, peripheral and ventral views of non-pyritized, crushed, sinistral specimen (p. 34)

Figures 13, 14: *Haplophragmoides* sp. B from Septimus Creek; 13—side view, 14—peripheral view (p. 28)

Figures 15, 16: *Haplophragmoides* sp. A from Septimus Creek; 15—peripheral view, 16—side view (p. 27)

Figures 17-20: *Miliammina* sp. B from Sikanni Chief River; 17, 18—sketches of opposite sides; 19, 20—photographs of same (p. 30)

Figures 21, 22: *Hippocrepina* sp. A from test hole, Kiskatinaw River; 21—apertural view; 22—side view (p. 28)

Figures 23, 24: *Gaudryina* cf. *G. hectori* Nauss from test hole, Kiskatinaw River; side views of specimen (p. 26)

Figures 25, 26: *Miliammina* sp. A from Sikanni Chief River; views of opposite sides (p. 29)

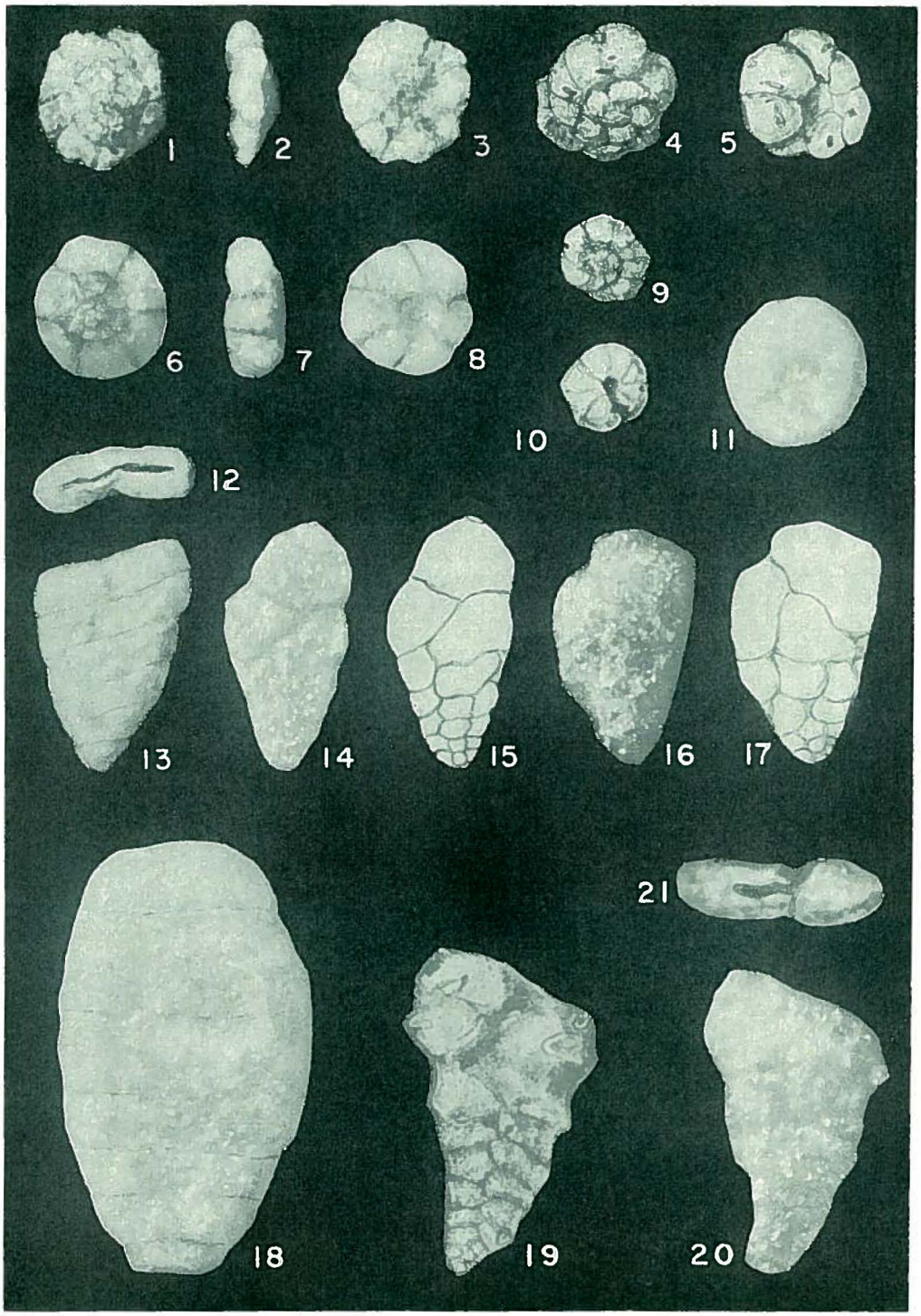


Plate IV—Foraminifera from upper St. John and Dunvegan formations.

EXPLANATION OF PLATE IV

Upper St. John and Dunvegan Formations

Peace River Area, Alberta and British Columbia

Magnification about x65

Figures 1-5: *Trochammina rutherfordi* variety 2 Stelck and Wall from Dunvegan formation on Peace River, Alberta; 1, 2, 3—photographs of dorsal, peripheral and ventral views of a normal specimen; 4, 5—drawings of dorsal and ventral views of a deformed specimen ..... (p. 34)

Figures 6-10: *Trochammina* cf. *T. rutherfordi* Stelck and Wall from the upper St. John shale, mouth of Alces River, British Columbia; 6, 7, 8—photographs of dorsal, peripheral and ventral views of a normal specimen; 9, 10—drawings of dorsal and ventral views of immature specimen ..... (p. 33)

Figure 11: *Saccammina* sp. from the upper St. John shale, mouth of Alces River, British Columbia ..... (p. 31)

Figures 12, 13: *Hyperamminoides* sp. from the upper St. John shale, Beatton River, British Columbia; 12—apertural view; 13—side view ..... (p. 29)

Figures 14-17: *Tritaxia* sp. from the upper St. John shale, mouth of Alces River, British Columbia; 14, 15—photograph and sketch of a specimen; 16, 17—photograph and sketch of another specimen ..... (p. 32)

Figure 18: *Hippocrepina* sp. B from the upper St. John shale, Beatton River, British Columbia ..... (p. 28)

Figures 19-21: *Textularia alcesensis* Stelck and Wall, n.sp., holotype, from upper St. John shale, mouth of Alces River, British Columbia; 19—drawing of side view; 20, 21—photographs of side and apertural views ..... (p. 32)

Plate V—*Irenicoceras bahani* Warren and Stelck.

EXPLANATION OF PLATE V

Figures 1, 2, 3: *Irenicoceras bahani* Warren and Stelck, n.sp., upper St. John shale, northeastern British Columbia; 1—paratype, Ct. 1118, side view (x½); 2—partial suture of Ct. 1119, at whorl height of 6 cm. (x1); 3—holotype, Ct. 1117, ultimate suture at whorl height 8 cm. (x1) (p. 38)

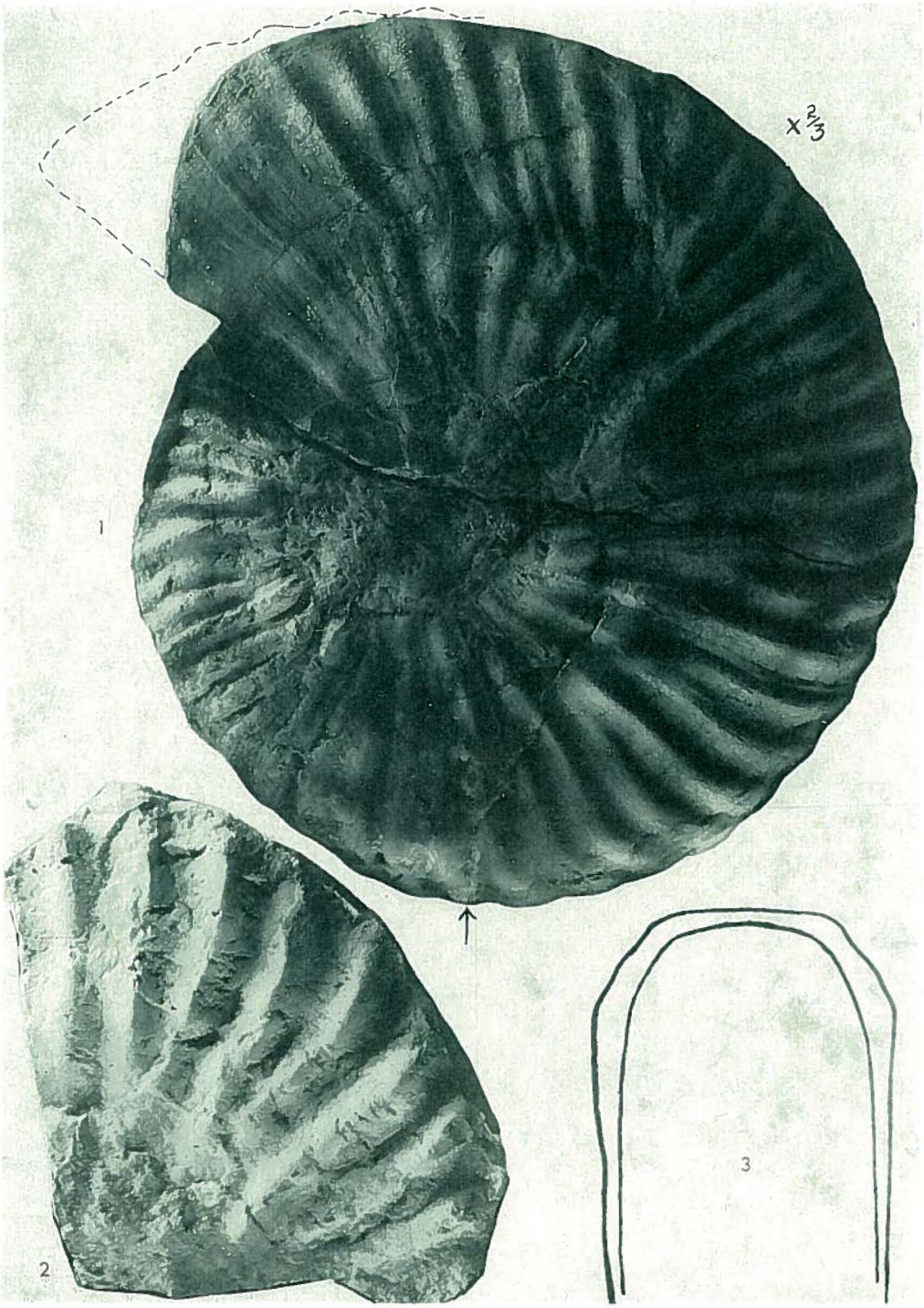


Plate VI—*Irenicoceras bahani* Warren and Stelck.

EXPLANATION OF PLATE VI

Figures 1-3: *Irenicoceras bahani* Warren and Stelck, n.sp., upper St. John shale, northeastern British Columbia; 1—side view of holotype, Ct. 1117, (x⅔); 2—side view of Ct. 1119 (x1); 3—cross-section of venter of paratype, Ct. 1118, at whorl height 14 cm. showing both costal and intercostal section (x1) ..... (p. 38)

Plate VII—*Irenicoceras, Forbesiceras* and *Borissjakoceras.*

EXPLANATION OF PLATE VII

Figure 1: *Irenicoceras bahani* Warren and Stelck, n.sp., Ct. 1120; lateral view of compressed disc and partial external mould, (x1), upper St. John shale, northeastern British Columbia (p. 38)

Figures 2, 5, 6, 7, 8; *Forbesiceras* ? sp. A (x1), side views of several fragments from upper St. John shale, northeastern British Columbia; 2—Ct. 1147a; 5—Ct. 1149; 6—Ct. 1147b; 7—Ct. 1148; 8—Ct. 1146, a, b, c. (p. 44)

Figure 3: *Forbesiceras* ? sp. B, Ct. 1143, (x1), from the *Dunveganoceras* zone of the Smoky formation, Kiskatinaw River, British Columbia (p. 45)

Figure 4: *Borissjakoceras* ?, Ct. 1145, (x1), occuring with *Forbesiceras* ? sp. B. (p. 45)

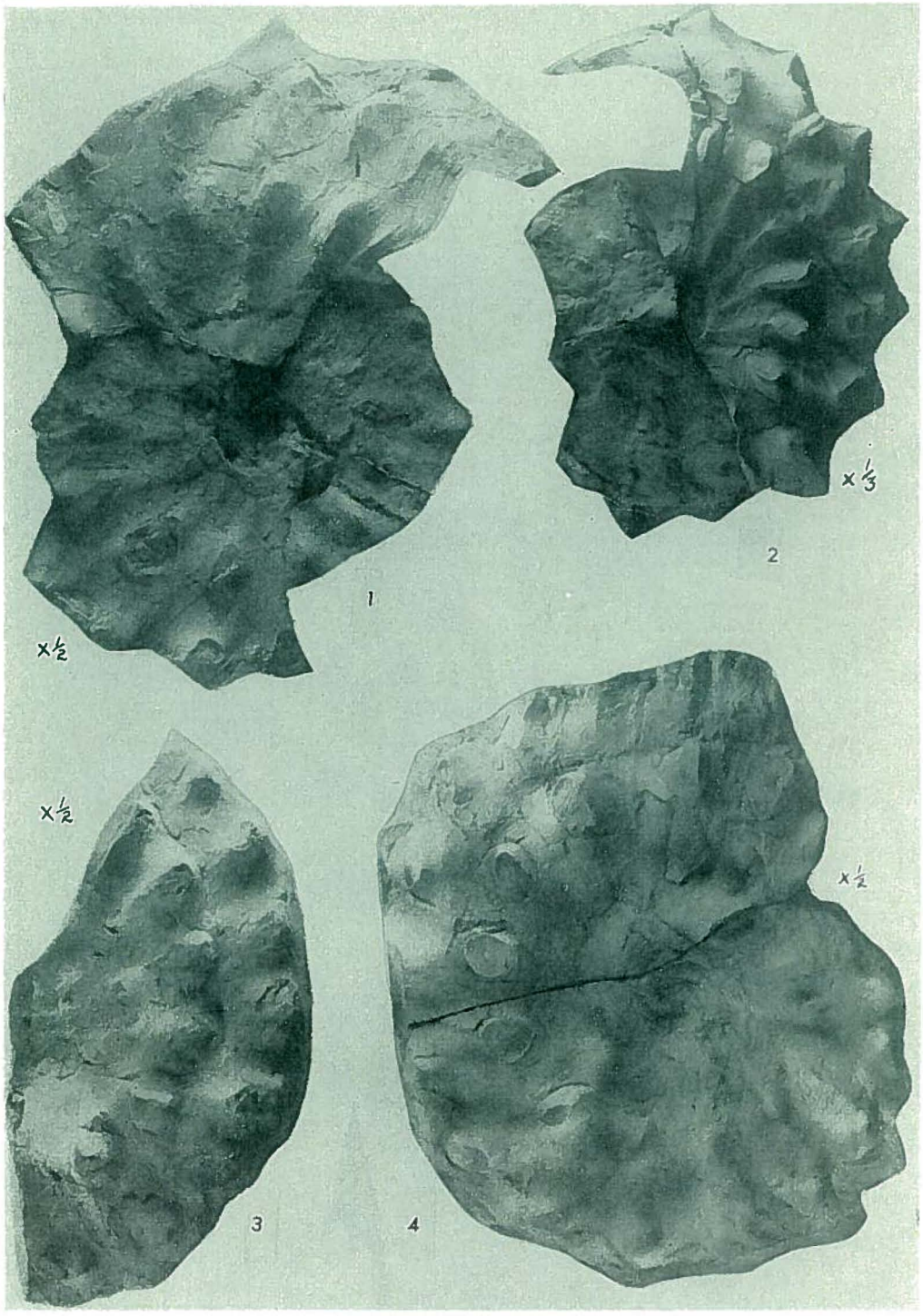


Plate VIII—*Neogastroplites septimus* Warren and Stelck.

EXPLANATION OF PLATE VIII

Figures 1-4: *Neogastroplites septimus* Warren and Stelck, n.sp., upper St. John shale; 1—variant Ct. 1137, (x½), side view, showing elongate rib and ventrolateral nodes, from creek four miles below Alaska Highway bridge, north side of Peace River, British Columbia; 2—holotype, Ct. 1133, (x⅓) from six miles below Alaska Highway bridge, Peace River, British Columbia; 3—living chamber Ct. 1136, (x½), from Septimus Creek, British Columbia, showing usual state of preservation; 4—paratype, Ct. 1135 (x½) from Septimus Creek (p. 43)

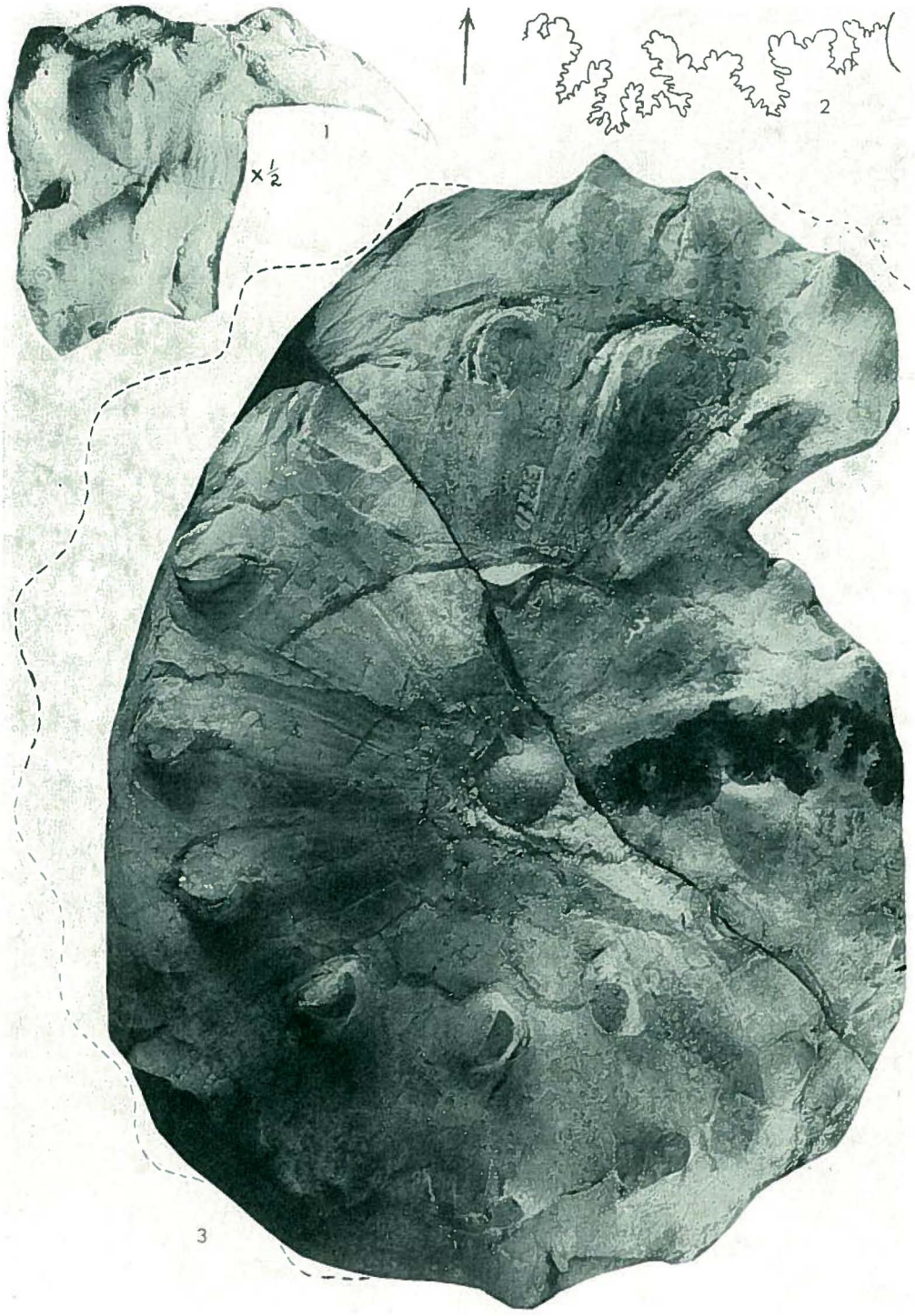


Plate IX—*Neogastroplites septimus* Warren and Stelck.

EXPLANATION OF PLATE IX

Figures 1-3: *Neogastroplites septimus* Warren and Stelck, n.sp., upper St. John shale; 1—fragment of paratype Ct. 1135, (x½) from Septimus Creek, British Columbia, rostrum; 2—paratype, Ct. 1134, suture (x1) at whorl height 7.5 cm.; 3—side view of paratype, Ct. 1134, (x1) (p. 43)

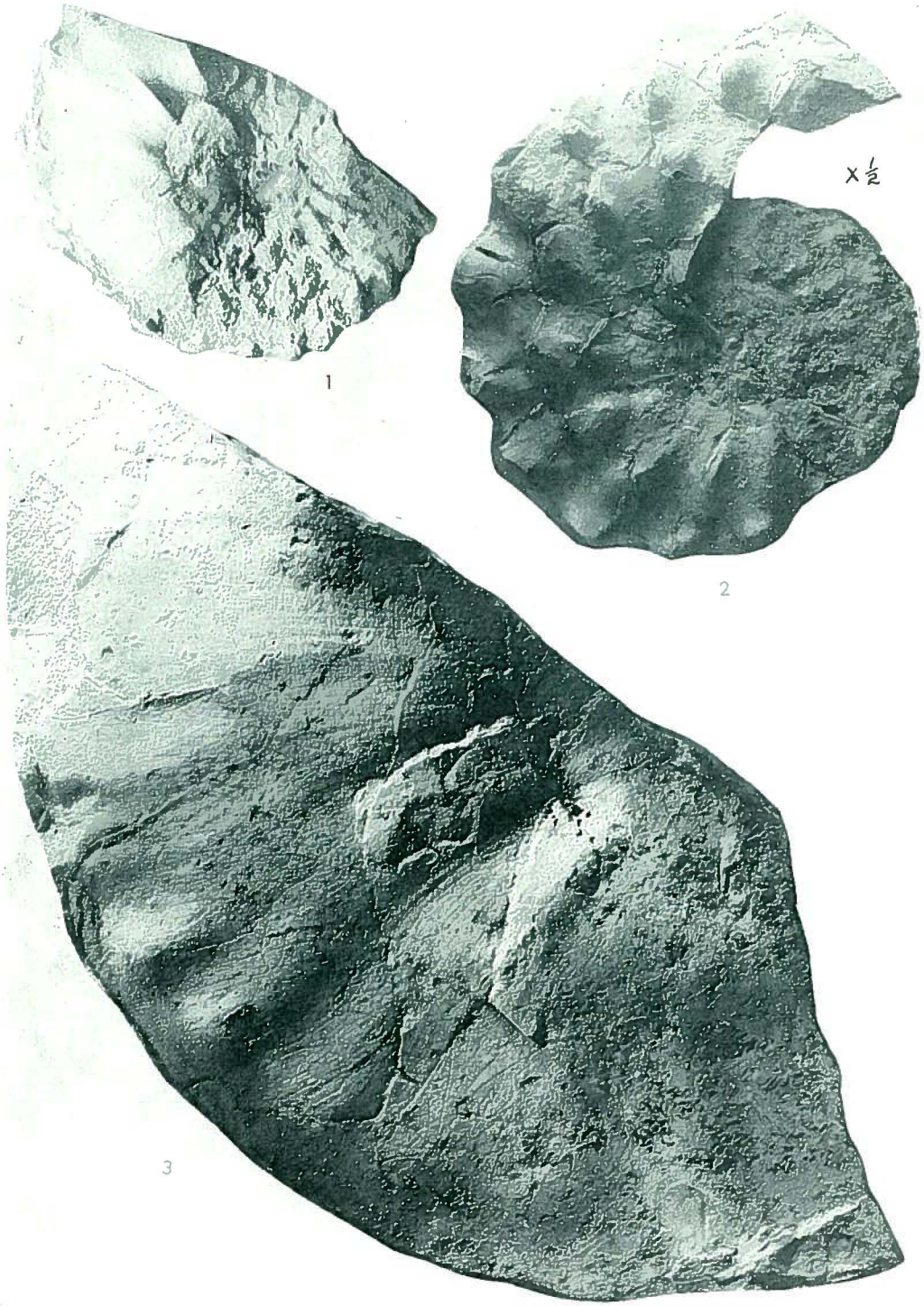


Plate X—*Acompsoceras, Neogastroplites* and *Beattonoceras.*

EXPLANATION OF PLATE X

Figure 1: *Acompsoceras* ? sp. (x1), Ct. 1122, St. John shale, fish-scale sand on Septimus Creek, British Columbia ..... (p. 40)

Figure 2: *Neogastroplites septimus* Warren and Stelck, n.sp., Ct. 1139, (x½) from creek four miles below Alaska Highway bridge, Peace River, British Columbia ..... (p. 43)

Figure 3: *Beattonoceras ontkoi* Warren and Stelck, n.gen., n.sp. paratype, Ct. 1132, (x1), upper St. John shale, six miles below Alaska Highway bridge, Peace River, British Columbia ..... (p. 42)

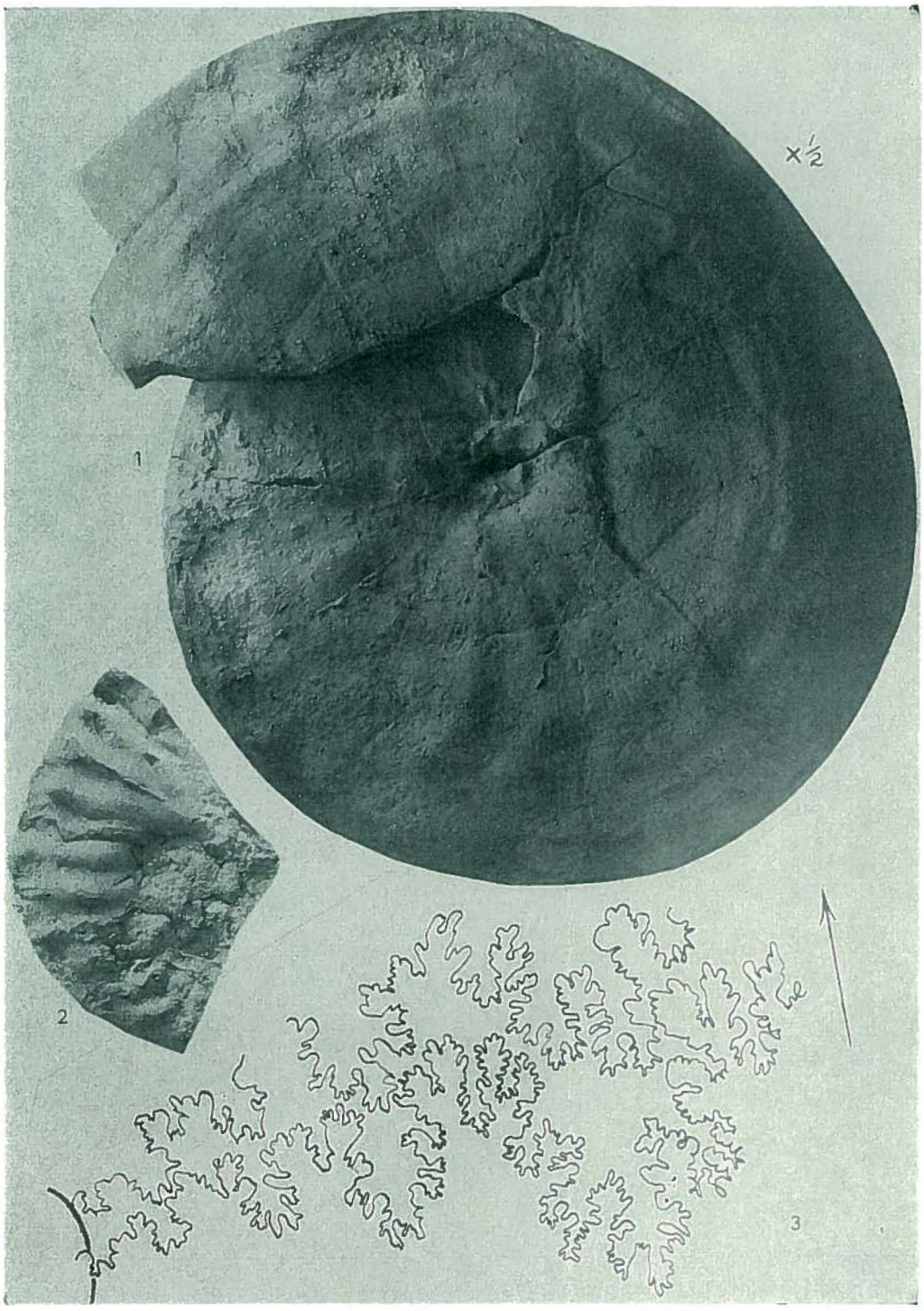


Plate XI—*Beattonoceras* and *Irenicoceras*.

EXPLANATION OF PLATE XI

Figures 1, 3: *Beattonoceras beattonense* Warren and Stelck, n.gen., n. sp., holotype, Ct. 1127, upper St. John shale, lower Beatton River, British Columbia; 1—side view (x½); 3—suture (x1) at whorl height 12 cm. (p. 42)

Figure 2: *Irenicoceras* ? Ct. 1142, (x1) side view of fragment found with *I. bahani* Warren and Stelck (p. 39)

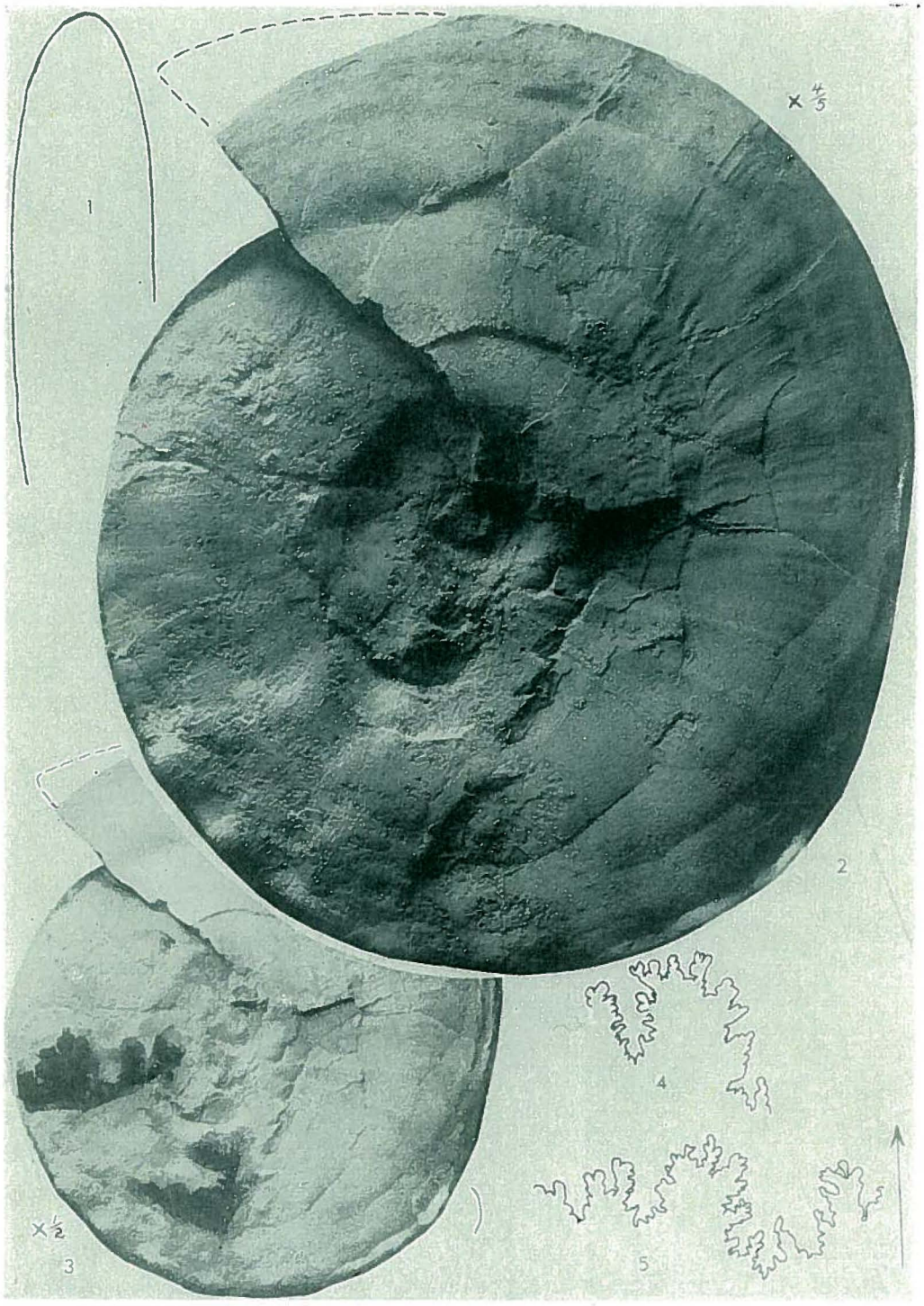


Plate XII—*Beattonoceras ontkoi* Warren and Stelck.

EXPLANATION OF PLATE XII

Figures 1-5: *Beattonoceras ontkoi* Warren and Stelck, n.gen., n.sp.; 1—paratype, Ct. 1131, (x1), profile of venter, upper St. John shale, six miles below Alaska Highway bridge, Peace River, British Columbia; 2-5—holotype, Ct. 1130, same location as above; 2—side view (x$\frac{4}{5}$); 3—side view (x$\frac{1}{2}$) showing position of sutures; 4—first lateral saddle (x1) at whorl height 7.5 cm.; 5—suture (x1) at whorl height 6 cm. (p. 42)

Plate XIII—*Beattonoceras ontkoi* Warren and Stelck.

EXPLANATION OF PLATE XIII

Figures 1-3: *Beattonoceras ontkoi* Warren and Stelck, n.gen., n.sp., paratype, Ct. 1131, upper St. John shale, six miles below the Alaska Highway bridge, Peace River, British Columbia; 1—side view (x½) showing position of suture; 2—side view (x1); 3—suture (x1) at whorl height 8.5 cm. (p. 42)

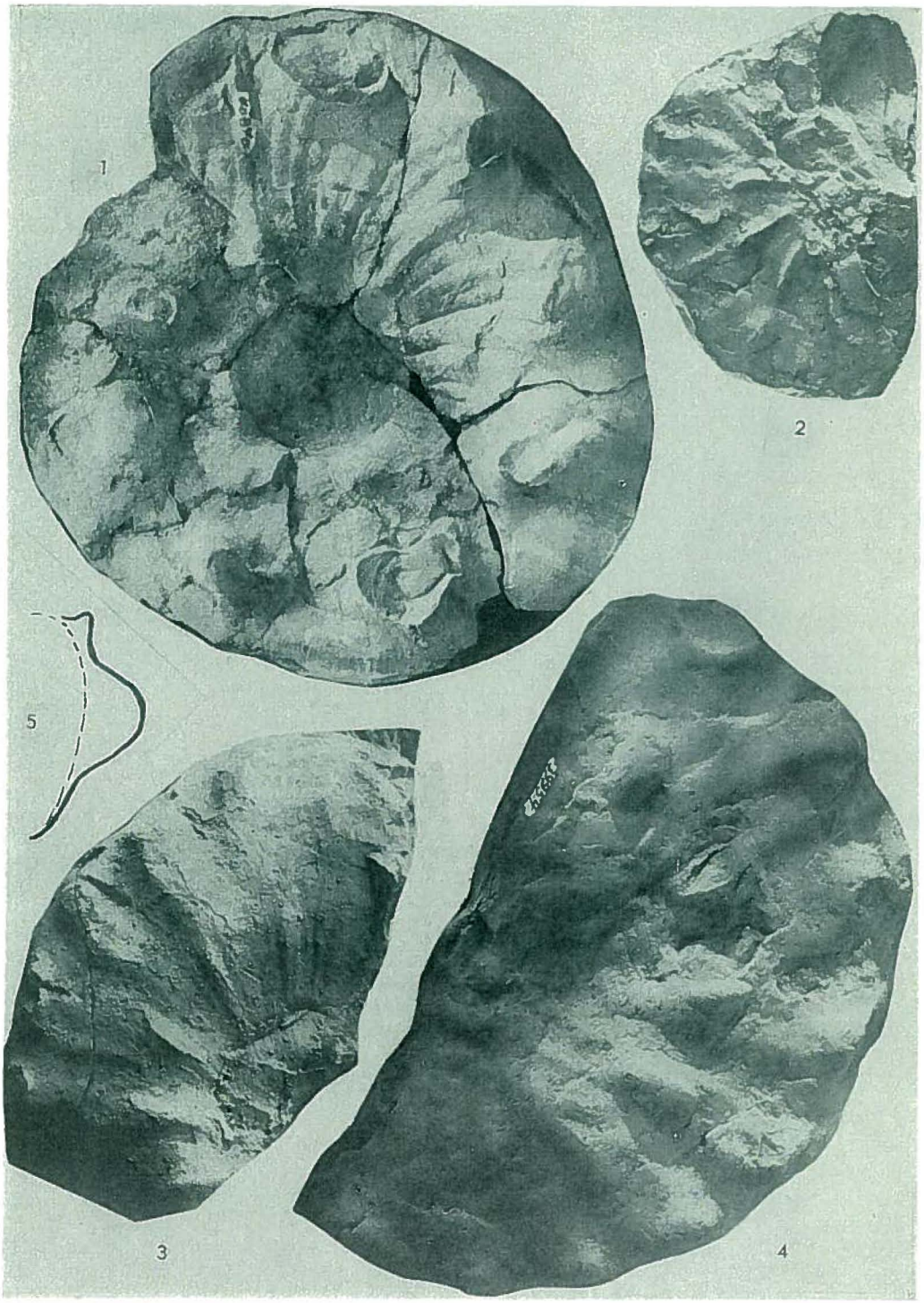


Plate XIV—*Metasigaloceras, Acompsoceras* and *Neogastroplites.*

EXPLANATION OF PLATE XIV

Figures 1, 5: *Metasigaloceras* ? sp. Ct. 1126, six miles east of Alaska Highway bridge, Peace River, British Columbia, from *Irenicoceras* zone, upper St. John shale; 1—side view (x1); 5—lateral profile (x1) at whorl height of 4 cm. showing bullate and intercostal profile, probably somewhat flattened (p. 40)

Figures 2, 3: *Acompsoceras* ? sp., fish-scale beds, St. John formation. 2—Ct. 1123, (x1), north end Alaska Highway bridge, Peace River, British Columbia; 3—Ct. 1124, (x1), fish-scale beds, 20 miles east of Bekami Lake, British Columbia ..... (p. 40)

Figure 4: *Neogastroplites* sp., Ct. 1125, (x1), base of fish-scale beds, Septimus Creek, British Columbia ..... (p. 44)

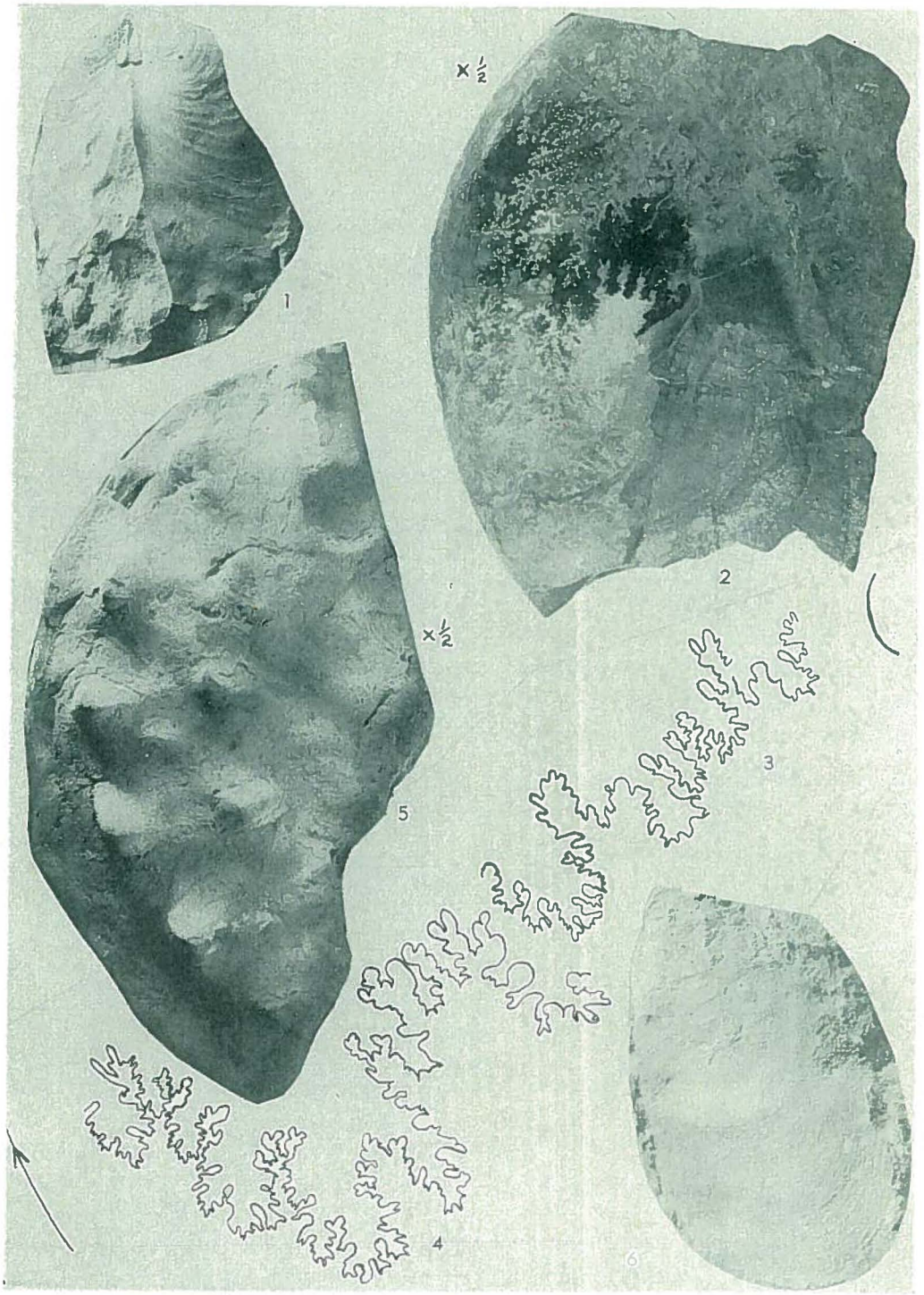


Plate XV—*Inoceramus, Beattonoceras* and *Neogastroplites.*

EXPLANATION OF PLATE XV

Figure 1: *Inoceramus irenensis* Warren and Stelck, n.sp. (x1) from upper St. John shale, 6 miles below Alaska Highway bridge, Peace River, British Columbia; variant, Ct. 1152 c. (p. 48)

Figures 2-4: *Beattonoceras beattonense* Warren and Stelck, n.gen., n.sp., Ct. 1128, paratype, from lower Beatton River, British Columbia, upper St. John shale; 2—fragmentary disc (x½); 3—auxiliary portion of suture (x1) at whorl height 13.5 cm.; 4—lateral portion of suture (x1) at whorl height 13.0 cm. (p. 42)

Figure 5: *Neogastroplites septimus* Warren and Stelck, n.sp., Ct. 1138, (x½), fragment from same locality as holotype (p. 43)

Figure 6: *Inoceramus* ? Ct. 1153, (x1), from same locality as figure 1 (p. 48)

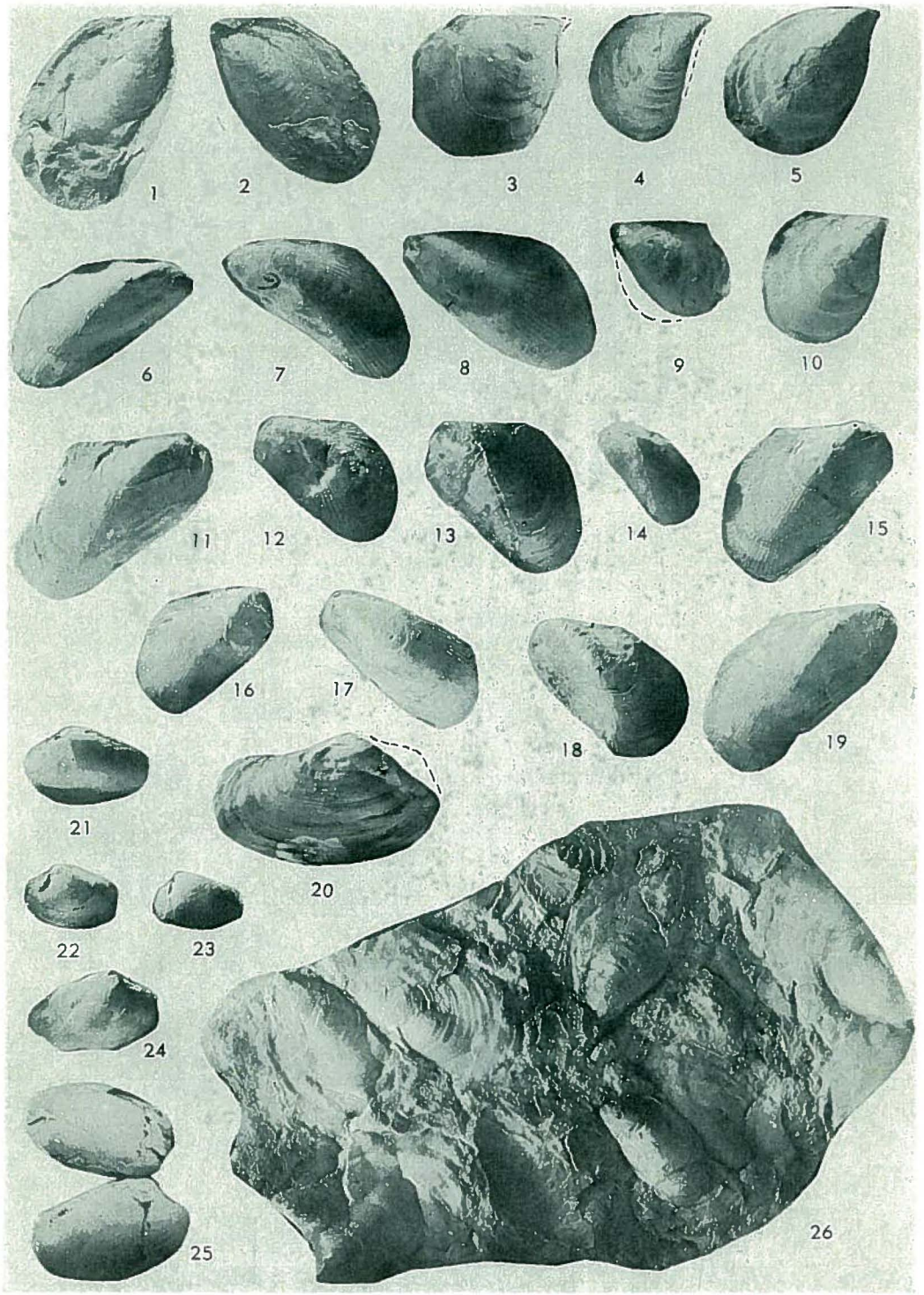


Plate XVI—Lower Cenomanian Pelecypoda.

EXPLANATION OF PLATE XVI

Figures 1, 2, 26: *Inoceramus irenensis* Warren and Stelck, n.sp. (x1), upper St. John shale, six miles below Alaska Highway bridge, Peace River, British Columbia; 1—cotype, right valve, Ct. 1152 a; 2—cotype, left valve, Ct. 1152 b; 26—slab, Ct. 1152, with cotypes (p. 48)

Figures 3, 4, 5, 9, 10: *Inoceramus leithensis* Warren and Stelck, n.sp. (x1), from Dunvegan sandstone, Leith River, Alberta; 3—right valve of cotype, Ct. 1151; 4—right valve of cotype, Ct. 1152; 5—right valve of cotype, Ct. 1153; 9—left valve of cotype, Ct. 1154; 10—right valve of Ct. 1155 (p. 47)

Figures 6-8: *Brachidontes* cf. *fulpensis* Stephenson (x1), from lower part of Dunvegan formation, Peace River near mouth of Hines Creek, Alberta; 6—Ct. 1154; 7—Ct. 526 a; 8—Ct. 526 b. (p. 46)

Figures 11-19: *Brachidontes* cf. *tenuisculpta* (Whiteaves) (x1), from basal sand of the Dunvegan formation, mouth of Pouce Coupe River, Alberta; Ct. 1155 a - i (p. 46)

Figure 20: *Panope* ? sp. (x1), Ct. 1157, from same nodule as figures 11-19 (p. 46)

Figures 21-25: *Pleurobema cruiserensis* Stelck and Warren, n.sp. (x1); 21-23—views of left valves, Ct. 1158 a, b, c, (respectively), from same nodule as figures 11-20; 24—right valve Ct. 1158 d, from same locality; 25—holotype, Ct. 1157, from Stony Creek, Cruiser Mountain, Pine River area, British Columbia from top of Cruiser formation (p. 47)

of a few quartz grains up to 0.04 mm. in diameter and a large amount of fine cementing material failing, however, to completely cover the large grains resulting in a slightly rough surface; aperture not observed, presumed terminal, probably elliptical.

Length of figured specimen: 0.91 mm.; maximum width 0.53 mm.

Locality of figured specimen: Sec. 1, Tp. 85, R. 18, W. 6th Mer., on Beatton River, British Columbia, Canada, from the upper St. John shale, 37 feet above the "cone-in-cone" bed or approximately 63 feet (estimated) below the base of the Dunvegan formation (Map locality C).

Figured specimen: Univ. of Alberta Paleont. Type Coll.

Occurrence: This species has not been observed outside of the above locality and level, where only two specimens have been assigned to it. There are, however, some closely related forms at this level and also below the "cone-in-cone" bed whose outlines deviate somewhat from the barrel-shaped figured specimen.

Genus HYPERAMMINOIDES Cushman and Waters, 1928

HYPERAMMINOIDES sp.

Plate IV, figures 12, 13

Test medium size, somewhat compressed, arrowhead-shaped; exterior of test constricted at five to ten points obliquely to axis at angles up to about 30 degrees; wall arenaceous, mostly rather fine grains but with a sporadic grain to 0.04 mm. in diameter, much cementing material coating all but the few larger grains resulting in a slightly rough surface; aperture terminal, a long elliptical slit traversing nearly the entire width of the test.

Length of figured specimen: 0.55 mm.; maximum width 0.37 mm.

Locality of figured specimen: Sec. 1, Tp. 85, R. 18, W. 6th Mer., on Beatton River, British Columbia, Canada, from the upper St. John shale, 86 feet below the "cone-in-cone" bed (Map locality C).

Figured specimen: Univ. of Alberta Paleont. Type Coll.

Occurrence: About five individuals were assigned to this species at the level and locality of the figured specimen. A few fragmentary specimens found somewhat higher at the same locality may belong to this species.

Genus MILIAMMINA Heron-Allen and Earland, 1930

MILIAMMINA sp. A

Plate III, figures 25, 26

Test roundly elliptical, compressed; chambers in a general spiroloculine arrangement, half coil in length, early chambers slender and obscured, those in final whorl much larger; sutures rather indistinct, depressed; wall finely arenaceous with much cement imparting resinous luster, surface smoothly finished; aperture simple, a restricted opening at the end of the last chamber.

Length of figured specimen: 0.44 mm.; maximum width 0.34 mm.

Locality of figured specimen: S47-12 on the Sikanni Chief River, 2-1/4 miles downstream from the bridge on Alaska Highway, British Columbia, Canada, from the Sikanni formation, 202 feet above the top of the Fourth Sikanni sandstone (Map locality L).

Figured specimen: Stanford Univ. Paleont. Type Coll.

Occurrence: Although only two representatives of this species were found at the level and locality of the figured specimen, more than 25 specimens were observed in two samples of the upper St. John shale taken from three to five feet below the First Tuff bed at the mouth of St. John Creek on the Beatton River (Map locality B).

Remarks: This species does not seem closely related to any previously published. We have not named it because of its obscure chamber arrangement and its rather featureless appearance.

MILIAMMINA sp. B

Plate III, figures 17, 18, 19, 20

Test elliptical, compressed; chambers in a general spiroloculine arrangement, a half coil in length, early chambers small and obscured, those in final whorl much larger; sutures indistinct, slightly depressed; wall arenaceous, grains up to 0.04 mm. in diameter but averaging considerably less, much resinous-appearing cementing material failing, however, to cover some of the grains resulting in a somewhat rough exterior; aperture obscure, simple, a restricted opening at the end of the last chamber.

Length of figured specimen: 0.47 mm.; maximum width 0.27 mm.

Locality of figured specimen: S47-12 on the Sikanni Chief River, 2-1/4 miles downstream from the bridge on Alaska Highway, British Columbia, Canada, from the Sikanni formation, 202 feet above the top of the Fourth Sikanni sandstone (Map locality L).

Figured specimen: Univ. of Alberta Paleont. Type Coll.

Occurrence: About 20 representatives of this species were obtained from the above locality, either from the same level or 21 feet higher. It may be present as well in the upper St. John shale, three to five feet below the First Tuff bed at the mouth of St. John Creek on the Beatton River (Map locality B). At the latter locality, about 12 specimens were observed which, although similar in outline and chamber arrangement to the figured specimen, differ in having a finer-grained wall and smooth surface.

Remarks: This species shows a general similarity to *Miliammina* sp. A, differing from the latter in being more slender and having a coarser-grained, rougher wall. We may have overemphasized the importance of the wall structure in the differentiation of these and other arenaceous species, however, in which case this form may be merely a slender variety of *Miliammina* sp. A.

Genus REOPHAX Montfort, 1808

REOPHAX sp.

Plate III, figures 4, 5, 6

Test small to medium-sized, strongly compressed, tapering, uniserial; test consists of five to six chambers, the first four to five increasing slightly in height and moderately in width as added, the final chamber much longer, one and one-half to two times as long as the penultimate one; sutures indistinct, slightly depressed, slightly arched forward; wall arenaceous, grains to about 0.04 mm., considerable cement

imparting resinous luster, surface somewhat rough; aperture terminal, elliptical.

Length of specimen (fig. 4): 0.38 mm.; maximum width 0.18 mm.

Length of specimen (fig. 5, 6): 0.51 mm.; maximum width 0.26 mm.

Locality of specimen (fig. 4): Sec. 20, Tp. 82, R. 18, W. 6th Mer., on Septimus Creek, British Columbia, Canada, from the upper St. John shale, one foot above the base of the fish-scale sand (Map locality A).

Locality of specimen (fig. 5, 6): S47-12 on the Sikanni Chief River, 2-1/4 miles downstream from the bridge on Alaska Highway, British Columbia, Canada, from the Sikanni formation, 202 feet above the top of the Fourth Sikanni sandstone (Map locality L).

Specimen (fig. 4): Univ. of Alberta Paleont. Type Coll.

Specimen (fig. 5, 6): Stanford Univ. Paleont. Type Coll.

Occurrence: This species is rather common over a 17-foot interval of the upper St. John shale directly overlying the fish-scale sand at Septimus Creek. It is abundant at the level of the figured specimen, with a few individuals also obtained from a sample 21 feet higher at the same locality.

Remarks: These rather featureless forms do not appear closely related to any previously published species. The individuals of the Sikanni River suite seem almost consistently larger than those from the Septimus Creek suite, and possible varietal or greater difference is indicated between the two figured specimens.

Genus SACCAMMINA M. Sars, 1869

SACCAMMINA sp.

Plate IV, figure 11

Test small, a single broadly rounded chamber, somewhat compressed; central area of test depressed on one or both sides; wall mostly finely arenaceous but in some specimens a rare quartz grain as large as 0.04 mm. may be partly protruding, much cementing material; aperture obscure, apparently a terminal elliptical slit; color greyish-white.

Maximum diameter of figured specimen: 0.33 mm.; greatest thickness 0.15 mm.

Locality of figured specimen: S47-5 in Sec. 24, Tp. 82, R. 14, W. 6th Mer. on east bank of mouth of Alces River, British Columbia, Canada, from the upper St. John shale, 62 feet below base of massive basal Dunvegan sandstone bed (Map locality H).

Figured specimen: Univ. of Alberta Paleont. Type Coll.

Occurrence: This species is rather common in the uppermost St. John shale at the above locality where about 30 specimens were obtained from four samples taken over the interval 20 to 96 feet below the base of the massive basal Dunvegan sandstone bed. It is also present but rather rare in the upper Shaftesbury formation above the siltstone member on the east bank of the Smoky River near Judah station, Alberta (Locality S47-29, Map locality K), where five specimens were counted in the interval 99 to 115 feet above the base of the siltstone member. Two specimens probably belonging to this species were observed in a sample taken from the middle portion of the Dunvegan formation at its type locality, one mile west of the mouth of Hines River, Alberta (Locality S47-28, Map locality J).

Remarks: The assignment of this species to *Saccammina* is rather doubtful. Somewhat similar forms from the Cretaceous have been referred to *Pelosina* by authors. The latter genus is supposed to have a distinct neck, whereas only one of our specimens at the locality of the figured specimen, a large individual, displayed such a feature.

Genus TEXTULARIA Defrance, 1824

TEXTULARIA ALCESENSIS Stelck and Wall, n. sp.

Plate IV, figures 19, 20, 21

Test medium size, strongly compressed, tapering; test biserial, of nine to ten pairs of chambers, the earlier pairs regularly increasing in size with sudden increase for the last two pairs; sutures indistinct and slightly depressed in early third of test, faint and more depressed in later portion; wall in early third finely arenaceous with much cement, wall in later portion studded with large quartz grains to 0.08 mm. protruding through cement; aperture apparently a narrow arched slit extending from the base of the last chamber nearly to the outer margin, not readily visible typically.

Length of holotype: 0.62 mm.; maximum width 0.37 mm.

Type locality: S47-5 in Sec. 24, Tp. 82, R. 14, W. 6th Mer., on east bank of mouth of Alces River, British Columbia, Canada, from the upper St. John shale, 96 feet below base of massive basal Dunvegan sandstone bed (Map locality H).

Holotype: Stanford Univ. Paleont. Type Coll.

Unfigured paratypes: Univ. of Alberta Paleont. Type Coll.

Occurrence: Common at the type locality with about 35 specimens observed.

Comparison: This new species is rather similar to *T. duckcreekensis* Tappan from the Lower Cretaceous Washita group of Texas as both species are medium-sized, have the same general arrangement of chambers, rough wall and elongate aperture. The sutures in our species are, however, indistinct and not raised as they are in the Texas species, and there is also a more rapid increase in the size of the later chambers in *T. alcesensis,* n. sp.

The species is named from its occurrence at the mouth of the Alces River, British Columbia.

Genus TRITAXIA Reuss, 1860

TRITAXIA sp.

Plate IV, figures 14, 15, 16, 17

Test rather small, of about seven whorls of chambers typically, essentially triserial but with later chambers added biserially in some individuals such as specimen (fig. 14, 15); early chambers very small, obscure, possibly more than three to a whorl during earliest convolutions in some individuals such as specimen (fig. 16, 17), chambers in later half of test much expanded; sutures indistinct between earlier chambers,moderately distinct and depressed in later whorls; wall rather finely arenaceous, considerable cement, smooth; aperture terminal, simple; color brown.

Length of specimen (fig, 16, 17): 0.48 mm.; greatest width 0.30 mm.

Length of specimen (fig. 14, 15): 0.52 mm.; greatest width 0.25 mm.

Locality of figured specimens: S47-5 in Sec. 24, Tp. 82, R. 14, W. 6th Mer., on east bank of the mouth of Alces River, British Columbia, Canada, from the upper St. John shale, 62 feet below base of massive basal Dunvegan sandstone bed (Map locality H).

Figured specimens: Univ. of Alberta Paleont, Type Coll.

Occurrence: This species is rather common in the uppermost St. John shale at the above locality where about 45 specimens were obtained from four samples taken over the interval 20 to 96 feet below the base of the massive basal Dunvegan sandstone bed. It is present in the upper Shaftesbury formation above the siltstone member on the east bank of the Smoky River near Judah station, Alberta (Locality S47-29, Map locality K), where about 15 specimens were counted in the interval 99 to 115 feet above the base of the siltstone member. This species was also observed in the Dunvegan formation at its type locality, one mile west of the mouth of Hines River, Alberta (Locality S47-28, Map locality J), where eight specimens were obtained from a sample taken from the middle portion of the formation.

Remarks: This species does not resemble any previously published. We are not naming it, however, because of the difficulty in determining its limiting characteristics.

Genus TROCHAMMINA Parker and Jones, 1859

TROCHAMMINA sp. cf. T. RUTHERFORDI Stelck and Wall

Plate IV, figures 6, 7, 8, 9, 10

Trochammina rutherfordi (nomen nudum), 1954, Res. Coun. of Alberta Rept. 68, p. 10, 13.

Trochammina rutherfordi Stelck and Wall, 1955, Res. Coun. of Alberta Rept. 70, p. 56-59, pl. 1, fig. 11, 12, 14, 15, 16; pl. 3, fig. 20, 21, 36, 37.

Test small, periphery rounded but may appear somewhat angular if final chamber distorted; test trochoid, low spire developed, of three whorls with six and one-half chambers in ultimate whorl, about seven in penultimate whorl, and probably about five in obscured primary whorl; ventral side of test with only chambers of final whorl exposed, rather prominently umbilicate; sutures obscure to distinct, somewhat thickened, slightly depressed, very slightly curved dorsally, straight ventrally; wall arenaceous of angular grains to 0.06 mm. in diameter with rather small amount of clear cement giving mosaic appearance to test, exterior fairly smooth; aperture an arched opening at the base of the terminal chamber on the ventral side, about midway between the periphery and umbilicus, obscure in most specimens.

Maximum diameter of specimen (fig. 6, 7, 8): 0.29 mm.; thickness 0.13 mm.

Maximum diameter of immature specimen (fig. 9, 10): 0.22 mm.; thickness 0.08 mm.

Locality of figured specimens: S47-5 in Sec. 24, Tp. 82, R. 14, W. 6th Mer., on east bank of mouth of Alces River, British Columbia, Canada from the upper St. John shale, 96 feet below base of massive basal Dunvegan sandstone bed (Map locality H).

Specimen (fig. 6, 7, 8): Univ. of Alberta Paleont. Type Coll.

Specimen (fig. 9-10): Stanford Univ. Paleont. Type Coll.

Occurrence: There are about 20 individuals identical with the speci-

men (fig. 6, 7, 8) at the above locality and level. It is less common and not readily distinguishable from *T. rutherfordi s.l.* in the 76 feet of section above this level.

Remarks: The specimen (fig. 6, 7, 8) differs from *T. rutherfordi s.s.* in possessing considerably coarser grains and clear cementing material in its wall structure. There are, however, many specimens at this locality which appear identical with *T. rutherfordi* variety 2.

TROCHAMMINA RUTHERFORDI Variety 2 Stelck and Wall

Plate IV, figures 1, 2, 3, 4, 5

Trochammina rutherfordi variety 2 Stelck and Wall 1955, Res. Coun. of Alberta Rept. 70, p. 58, pl. 1, fig. 15, 16; pl. 3, fig. 36,37.

Test rather small, periphery narrowly rounded, peripheral margin lobulate; test trochoid, low spire developed, of three to four whorls with about six chambers in ultimate whorl, seven in penultimate whorl, six in antepenultimate whorl, and a smaller number in obscure primary whorl; ventral side of test with only the six chambers of final whorl exposed, moderately umbilicate; sutures rather indistinct, slightly depressed, gently curved dorsally, straight ventrally; wall arenaceous, most grains no larger than 0.01 mm. in diameter but with a sporadic grain to 0.05 mm., considerable cement, surface fairly smooth; aperture not observed, probably a low slit on the ventral side at the base of the terminal chamber.

Maximum diameter of hypotype (fig. 1, 2, 3): 0.32 mm.; minimum diameter 0.28 mm.; maximum thickness 0.11 mm.

Maximum diameter of hypotype (fig. 4, 5): 0.36 mm.; minimum diameter 0.32 mm.; maximum thickness 0.11 mm.

Locality of hypotypes: S47-28 in Sec. 13, Tp. 80, R. 5, W. 6th Mer., on the north bank of the Peace River, one mile west of the mouth of Hines River, Alberta, Canada, from middle portion of the Dunvegan formation at its type locality, 548 feet below the Howard Creek sandstone member of the Kaskapau formation (Map locality J).

Hypotype (fig. 1, 2, 3): Univ. of Alberta Paleont. Type Coll.

Hypotype (fig. 4, 5): Stanford Univ. Paleont. Type Coll.

Occurrence: This form is abundant at the level and locality of the hypotypes with more than 50 specimens observed. The varietal unit was established on the basis of material from basal Kaskapau beds of Cenomanian age at Spirit River and Doe Creek, Alberta. Representatives of this variety appearing even closer to the Kaskapau type material than the hypotypes were recorded in the uppermost St. John shale at the mouth of Alces River (Locality S47-5, Map locality H.)

Remarks: The specimens from the Dunvegan formation are slightly smaller, have a somewhat lower spire and a more lobulate peripheral margin than those from the Kaskapau formation. The last two features are, however, probably caused at least in part by processes of fossilization.

TROCHAMMINA sp.

Plate III, figures 7, 8, 9, 10, 11, 12

Test medium size, periphery rounded, peripheral margin lobulate; test trochoid, rather low to moderate spire developed, of three whorls with only three chambers of primary whorl readily visible, seven chambers in

penultimate whorl and six in ultimate whorl; ventral side showing only the six chambers of outer whorl, moderately umbilicate; chambers distinct, slightly inflated and enlarging gradually in earlier whorls, more prominently inflated and much larger in ultimate whorl; sutures distinct, depressed, nearly straight; wall finely arenaceous with much cement, smooth; aperture a narrow arched opening on the peripheral face near the middle of the base of the last chamber.

Maximum diameter of specimen (fig. 7, 8, 9): 0.36 mm.; minimum diameter 0.33 mm.; maximum thickness 0.18 mm.

Maximum diameter of sinistral specimen (fig. 10, 11, 12): 0.36 mm.; minimum diameter 0.32 mm.; maximum thickness 0.09 mm.

Locality of figured specimens: Test hole in NW. 1/4, Sec. 26, Tp. 80, R. 17, W. 6th Mer., on the Kiskatinaw River, British Columbia, Canada, from core at depth of 530 feet, in the upper St. John shale, about 450 feet below the base of the Dunvegan formation (Map locality E).

Figured specimens: Univ. of Alberta Paleont. Type Coll.

Occurrence: Abundant at the above level and locality with about 100 specimens observed.

Comparison: This species seems of the same general stock as *T. albertensis* Wickenden from the Upper Cretaceous Bearpaw formation of southern Alberta. It lacks the high spiral development of the latter, however, and has one or more additional chambers per whorl.

Remarks: Most of the tests of this species are collapsed, reddish-brown, and rather featureless such as the specimen (fig. 10, 11, 12). Only about five percent of the tests are pyritized such as the specimen (fig. 7, 8, 9), thus retaining their presumed original shapes and showing distinct characters.

PART II

Lower Cenomanian Ammonoidea and Pelecypoda from Peace River Area, Western Canada

ABSTRACT

Nine species of Cenomanian ammonites and six of pelecypods are described and figured from the Peace River area of Western Canada. Two new ammonite genera, *Beattonoceras* and *Irenicoceras* are proposed; four new ammonite species and three pelecypod species are named.

INTRODUCTION

The upper portion of the St. John formation in type section near Fort St. John, British Columbia, carries a molluscan assemblage of an indicated Lower Cenomanian stratigraphic position. The writers have previously described (1955) Upper Cenomanian ammonites from the same general region, and F. H. McLearn (1933) has treated the Upper Albian assemblages of the *Neogastroplites* zone in the area. The ammonites herein discussed are found stratigraphically between these previously described faunas.

The formations involved in the Cenomanian - Albian transition in northeastern British Columbia are, in descending order:

Kaskapau formation
Dunvegan formation
Fort St. John group (Shaftesbury formation)

The Cenomanian - Turonian stage boundary is placed within the base of the Kaskapau formation. The Albian - Cenomanian stage boundary is placed at the top of a fish-scale sand within the Shaftesbury formation. *Neogsatroplites americanum* (Reeside and Weymouth) occurs in the base of the fish-scale beds with several aberrant derivatives of *Neogastroplites*. Other descendants from the pre-fish-scale assemblage are found above the fish-scale beds and give rise in part to the Lower Cenomanian suites described here.

The upper Shaftesbury shale (about 700 feet thick) in the Fort St. John area has several marker-beds:

Base of Dunvegan—top of Shaftesbury
300-340 feet of shaly beds
First Tuff marker-bed (6 inches thick)
80-96 feet of shaly beds
Second Tuff marker-bed (8 inches thick)
138 feet of shaly beds
160 feet of shaly beds carrying abundant fish-scales
"Fish-scale" sandstone and bone-bed (12-18 inches thick)
Top of *Neogastroplites* zone of lower Shaftesbury formation.

Only smooth ammonites have been found in the Shaftesbury formation above the Second Tuff marker-bed in stratigraphic proximity to the First Tuff marker-bed. The varied assemblage of ammonites from

Irenicoceras (new genus) zone occurs below the Second Tuff marker-bed. A poorly preserved suite of ribbed ammonites occurs in the lower 250 feet of beds at the base of the upper Shaftesbury shale, above the fish-scale sands.

The complete megafaunal list of the upper Shaftesbury formation represented in our collections is as follows:

Brachidontes sp.
Beattonoceras beattonense n. gen., n. sp.
Beattonoceras ontkoi n. sp.
Irenicoceras bahani n. gen., n. sp.
Metasigaloceras ? sp.
Forbesiceras sp. A.
Neogastroplites septimus n. sp.
Inoceramus irenensis n. sp.

and from the fish-scale sand (restricted):

Acompsoceras ? sp.
Plesiosaur vertebra
Fish-scales and bones

The following additional Mollusca from the lower Dunvegan formation are also described here as their relationships seem to be Lower Cenomanian, viz.:

Inoceramus leithensis n. sp.
Brachidontes cf. *fulpensis* Stephenson
Brachidontes cf. *tenuisculpta* (Whiteaves)
Unio (*Pleurobema*) *cruiserensis* n. sp.
Panope ? sp.

Psammosolen dunveganensis Warren from the same nodule as *Inoceramus leithensis* n. sp. was previously described (Rutherford, 1930, p. 63).

FORMAL DESCRIPTIONS

Order *Ammonoidea*

Genus IRENICOCERAS Warren and Stelck, new genus

Type species—*Irenicoceras bahani* Warren and Stelck, new species

Diagnosis: Large, completely involute, compressed, closely ribbed with lateral bifurcation common and ribs continuous over the venter, with slight inflations of the ribs in lateral and ventro-lateral positions; suture distinctive, moderately incised with the first lateral lobe wide and split into two limbs by a well-defined shallow indentation.

Comparison: This new genus seems to have developed out of *Neogastroplites* as the sutures are very similar in basic design and the ribbing is reminiscent of the *Gastroplites* stock. Close spacing of ribs is often encountered in the *Neogastroplites* of the latest Albian. *Irenicoceras* however lacks the bullate tuberculation of *Neogastroplites* although retaining the involution.

Irenicoceras resembles, in general appearance, the genera *Metoicoceras* and *Utaturiceras* but lacks the definite clavi, the wider umbilication and the narrow lateral lobes of the sutures in these genera. Its extreme involution separates it from such genera as *Calycoceras, Eucalycoceras* and *Stoliczkaia.*

The relationship of *Irenicoceras* to these other Cenomanian genera is problematical. *Metoicoceras* could have developed out of *Irenicoceras* by the reduction and simplification of suture. *Utaturiceras* could have arisen from *Neogastroplites,* via a form somewhat similar to *Irenicoceras,* by becoming slightly less involute and by fading of the ribs across the venter while retaining the *Irenicoceras*-like suture. The inner whorls of *Irenicoceras* have not been recognized and definite indication of phylogeny is not possible. However a fragment (plate XI, fig. 2) that occurs with *Irenicoceras* may well represent the inner whorls at whorl height 3.5 cm. A relative strengthening of lateroventral nodes is indicated.

IRENICOCERAS BAHANI Warren and Stelck, n. sp.

Plate V, figures 1, 2; plate VI, figures 1, 2, 3; plate VII, figure 1

Description: Conch large, thin-shelled, involute with tiny umbilicus; outer whorls closely ribbed and very slightly nodose; both costal whorl-section and intercostal section flattened on the sides and rounded on the venter; living chamber two-thirds of ultimate whorl.

Dimensions of holotypes and paratypes:

	Ct. 1117	Ct. 1118	Ct. 1119
Maximum diameter	20.0 cm.	29.5 cm.	13.5 cm.
Minimum diameter	18.0 cm.	24.0 cm.	11.5 cm.
Height of shell, beginning living chamber	8.0 cm.	12.0 cm.	7.0 cm.
Maximum thickness of conch	.....	4.4 cm.	.....

The last whorl shows closely spaced bifurcating ribs with occasional solitary ribs or trifurcate pattern. The holotype shows 43 ribs reaching the ventral shoulder in the ultimate whorl. Ribs and intercostal spaces

are ornamented with fine growth lines which are preserved on the interior mold showing about seven or eight costellae per rib interval. The costellae are parallel to the ribbing. Ribs on the living chamber are relatively stout, arising at the umbilical margin and becoming fully developed at a point midway on the flank between the umbilicus and the venter. Here the rib develops an incipient longitudinal swelling for the apicad portion of the living chamber with bifurcation of the rib occurring near or just beyond the mediolateral swelling. On the last quarter of the ultimate whorl this mediolateral swelling is reduced to absent. Bifurcation is irregular with insertion of a lateroventral rib often substituted for true dichotomy. In the earlier whorls the dichotomy takes place almost at the umbilical margin.

Venter as seen on the paratype shows ribs crossing with no diminution but with a slight flattening in the ventral portion. The ribs are slightly flexed forward at the lateroventral shoulder but directly cross the venter itself. In the penultimate whorls an incipient ventrolateral longitudinal swelling is noted on the ribs.

The suture is slightly reduced with a well-defined first lateral lobe and is gastroplitan in design. The ventrolateral saddle is broad, divided by a blunt adventitious lobe; the first lateral lobe is deep, spreading and irregularly divided by a saddle as broad as the two prongs. The second lateral saddle is as broad as the first lateral lobe and twice as wide as the second lateral lobe. There are three or four auxiliary lobes.

Types: Univ. of Alberta Geol. Museum, holotype Ct. 1117; paratypes Ct. 1118, Ct. 1120.

Occurrence: St. John formation, 20 to 25 feet below the Second Tuff marker-bed (about 400 feet below the Dunvegan sandstone contact or about 275 feet above the fish-scale sand). Figured types from six miles below the Alaska Highway bridge on the north side of the Peace River, British Columbia (Map locality G). Unfigured specimens from two miles below mouth of Cameron River, Halfway River, British Columbia, from same horizon (Map locality F).

Comparison: This species shows a very close relationship in both involution and ribbing to *Utaturiceras* ? sp. figured by Young (1958, plate 40, fig. 1) from the Cenomanian of Trans-Pecos Texas, but the latter is much smaller and has clearly defined ventrolateral nodes. We would tentatively assign Young's form to *Irenicoceras*. *Irenicoceras bahani* might be confused with flattended discs of *Gastroplites liardense* (Whiteaves) (*Placenticeras liardense*) from the base of the Shaftesbury equivalents, but the definite umbilicus and early bifurcation on the ribs of the latter are critical.

Patronym: W. G. Bahan, geologist, Sun Oil Company, Calgary, Alta.

IRENICOCERAS (?)

Plate XI, figure 2

This small, closely ribbed fragment (Univ. of Alberta Geol. Museum, Ct. 1142), showing lateroventral and ventrolateral incipient tuberculation is believed to represent the juvenile whorl of *Irenicoceras*. At this stage the morphology is a little closer to *Utaturiceras*.

From the same locality and horizon as the holotype of *I. bahani* Warren and Stelck n. sp.

Genus ACOMPSOCERAS Hyatt, 1903

ACOMPSOCERAS ? sp.

Plate X, figure 1; plate XIV, figures 2, 3

Description: Shell large, involute with tiny umbilicus, shell material thin; outer whorls flattened on the sides, distantly ribbed, nodose; venter somewhat flattened to rounded.

Earlier whorls show unevenly spaced sharp ribs near the umbilicus, strengthening in lateroumbilical position, fading somewhat in outer flanks and developing a clavate node on the ventral shoulder; expression of ribs not apparent or much reduced crossing the venter; with growth of the shell the median portion of the ribs becomes prominent as a transversely elongate node which becomes almost bullate in the ultimate whorl. That portion of the ribs near the umbilicus fades out and the outer portion of the ribs between the bullate and clavate tubercles disappears.

Ribs in the early portion occasionally branch from the umbilical margin (as in *Gastroplites*), and extra ribs may be intercalated closer to one of the primary ribs. In the later stages occasional extra nodes appear on the ventral shoulder but both the ventral and lateral tubercles have a more regular spacing than found in earlier stages. Venters of studied specimens are poorly preserved but there does not appear to be any keel or ventral development in the late stages.

Partial suture is known only from a fragment but shows about the same amount of incision and the phylloid habit of the type of the genus.

At a diameter of 6.5 cm., there are six primary ribs per half-whorl with eleven tubercles at the ventral shoulder and an umbilicus about 1 cm. in diameter. At a diameter of 12.5 cm. there are nine shoulder tubercles per half-whorl and seven lateral tubercles.

Fragmentary preservation has precluded any naming of a species.

Figured specimens: Univ. of Alberta Geol. Museum, Ct. 1122, Ct. 1123, Ct. 1124.

Occurrence: Fish-scale sands, St. John formation, uppermost Albian? or Lower Cenomanian?, Septimus Creek (Ct. 1122), and the north end of Alaska Highway bridge, Peace River, British Columbia (Ct. 1123), and 20 miles east of Bekami Lake, British Columbia (Ct. 1124).

Comparison: These fragments have been referred to *Acompsoceras* with considerable hesitancy as the morphology shows too much involution to agree with the generic diagnosis. It appears to be developed out of *Gastroplites* stock and could well be ancestral to *Acompsoceras* (restricted) by a widening of the umbilicus.

Genus METASIGALOCERAS Hyatt, 1903

METASIGALOCERAS ? sp.

Plate XIV, figures 1, 5

Description: Shell medium size, angustumbilicate, bullate with stout whorl-section. Ornament consists of a lateral row of stout, very large, blunt tubercles and a row of small, low, ventrolateral, clavate tubercles with a ratio of one lateral tubercle to two ventrolateral tubercles. The dorsal portion of the sides is ornamented with suppressed rib-like growth lines. There are eight lateral tubercles in the ultimate whorl. Living

chamber is at least one-half (possibly more) of the last whorl. Suture is unknown.

Figured specimen: Univ. of Alberta Geol. Museum, Ct. 1126.

Occurrence: Only the one specimen has been collected. From the same horizon as *Irenicoceras,* below the Second Tuff marker-bed of the St. John formation, six miles east of the Alaska Highway bridge, Peace River, British Columbia.

Remarks: The solitary specimen has been badly crushed and only one side has been preserved. The only genus approaching this form is Hyatt's genus *Metasigaloceras.* Sharpe's figure that served as type for the genus is poorly preserved and strict comparison is difficult.

Genus BEATTONOCERAS Warren and Stelck, new genus

Type species: *Beattonoceras beattonense* Warren and Stelck, new species

Shells large to very large (up to 45 cm.), involute, smooth, flattened discs, *Beudanticeras*-like in appearance with tiny umbilicus and abruptly rounded venter; living chamber up to three-quarters of ultimate whorl; penultimate whorl showing incipient ribbing with a row of faint ventrolateral nodes expressed as undulatory swellings of the ventral shoulder. Growth line ornament is transverse, straight, and on the living chamber has a slight apicad flexure in the ventral portion only. The suture is strongly frilled with open lobes closely resembling the sutures of *Pseudouhligella calabarense* Reyment.

Beattonoceras apparently is derived from *Gastroplites* stock as the rib and node arrangements and the sutures are of the same basic design. Smooth Upper Albian derivatives of *Neogastroplites* may have provided the nodal developmental stage, but until the inner whorls are better known the specific ancestry cannot be determined. The genus apparently ranges from Upper Albian to Lower Cenomanian.

Beattonoceras may be distinguished from Middle Albian *Beudanticeras* by the narrower umbilicus, the wider lateral lobe on the suture, and the incipient ventrolateral nodes on the earlier whorls of the former. Although the suture of Upper Albian *Beudanticeras,* such as *B. beudanti* (Brongn.), shows the widening of the lateral saddles, the nodes and narrower umbilicus still serve to distinguish the genera.

Beattonoceras is distinguished from *Pseudouhligella* as the former lacks the rounded constrictions, the larger umbilicus and the growth lines flexed strongly forward at the ventral shoulder.

The genus *Cleoniceras* which may be in ancestral position to *Beattonoceras* has a markedly reduced suture and has falciform ornament which is lacking on the new genus.

The suture of the new genus keeps it distinct from both *Placenticeras* and *Phylloceras.*

The new genus has been separated from *Neogastroplites* and *Gastroplites* as the University of Alberta collections contain Albian species of these genera that have developed smooth living chambers without a long intermediate stage of ornament reduction such as characterizes *Beattonoceras.* Only the two species described below have been assigned to the genus so far.

BEATTONOCERAS BEATTONENSE Warren and Stelck, n. sp.

Plate XI, figures 1, 3; plate XV, figures 2, 3, 4

Description: Shell large, involute, tiny umbilicus, compressed, smooth, lacking ornament on the living chamber, venter appears to be abruptly rounded.

	Ct. 1127	Ct. 1128	Ct. 1129
Maximum diameter	29.5 cm.	.....	42.5 cm.
Minimum diameter	23.5 cm.	30.0 cm.	34.0 cm.

The living chamber shows closely spaced fine growth lines that are straight across the flank and flex slightly apicad at the ventral shoulder. Part of the apertural margin, preserved on an unfigured specimen (Ct. 1129), is parallel to the growth lines.

The penultimate whorl shows faint rib-like swellings on the flanks, fading outward, and reappearing as faint node-like swellings in ventrolateral position with about two nodes to every rib. Inner whorls have not been identified.

The suture (plate XI, fig. 3; plate XV, fig. 3, 4) is strongly frilled and is marked by a broad unbalanced first lateral lobe and a stout lateral saddle.

Types: Univ. of Alberta Geol. Museum, holotype Ct. 1127; figured paratype Ct. 1128; unfigured paratype Ct. 1129.

Occurrence: Holotype and paratypes are all from the Lower Beatton River, British Columbia, about 30 feet below the First Tuff marker-bed of the St. John formation, i.e. about 350 feet below the base of the Dunvegan sandstone.

Comparison: *B. beattonense* differs from *B. ontkoi* n. sp. in being larger and in loss of ornament on the living chamber. It occurs about 100 feet stratigraphically higher than the latter.

BEATTONOCERAS ONTKOI Warren and Stelck, n. sp.

Plate X, figure 3; plate XII, figures 1-5; plate XIII, figures 1-3

Description: Shell large, involute, tiny umbilicus; outer whorl faintly nodose, with faint suggestion of ribs; whorl-section slightly rounded on the flanks and rounded on the venter; aperture unknown but growth lines straight to slightly sigmoid.

	Ct. 1130	Ct. 1131	Ct. 1132
Maximum diameter	17 cm.	.....	.....
Minimum diameter	14.5 cm.	21 cm.	ca 21 cm.
Umbilical diameter	1.5 cm.	2.0 cm.	.....

At least three-quarters of the ultimate whorl is living chamber. Ornament consists of a row of faint umbilical and lateroumbilical expression of ribbing and a row of faint, though large, ventrolateral nodes expressed as undulatory swellings on the ventral shoulder. There are seven ribs on the half-whorl, against thirteen ventrolateral nodes in the same interval. The umbilical rib expression fades on the living chamber but the ribs are fairly well-defined on the inner whorls. The ventrolateral nodal swellings continue farther out onto the living chamber than do the ribs.

The suture shows a more reduced design than the type species of the genus, but the suture follows the general *Gastroplites* design of the genus.

Types: Univ. of Alberta Geol. Museum, holotype Ct. 1130; paratypes Ct. 1131, Ct. 1132.

Occurrence: Six miles below Alaska Highway bridge, north bank of Peace River, British Columbia, from below the Second Tuff marker-bed of the St. John formation, i.e. about 400 feet below the base of the Dunvegan sandstone.

Comparison: The ornament on the chambered portion of *B. ontkoi* is much reduced from that found on species of *Neogastroplites* with smooth living chambers. It differs from *B. beattonense,* the genus type, in having a more reduced suture and in carrying the nodal ornament forward onto the living chamber. *B. ontkoi* is usually smaller than *B. beattonense.* It occurs about 100 feet stratigraphically lower than the latter.

Patronym: J. Ontko, geologist, formerly with Pacific Petroleums Limited, who assisted in the collection of this genus.

Genus NEOGASTROPLITES McLearn, 1931

NEOGASTROPLITES SEPTIMUS Warren and Stelck, n. sp.

Plate VIII, figures 1-4; plate IX, figures 1-3; plate X, figure 2; plate XV, figure 5

Description: Shell large, involute, tiny umbilicus, outer whorl nodose with ribs subordinated; internodal whorl-section slightly rounded on the flanks and broadly rounded on the venter; aperture rostrate, with sigmoidal margin.

	Ct. 1133	Ct. 1134	Ct. 1135	Ct. 1136	Ct. 1137	Ct. 1138	Ct. 1139
Maximum diam. (cm.)	20.5	20.0	24.0	20.0	22.0	19.5	16.0
Minimum diam. (cm.)	16.5	14.0	19.0	.....	14.0	.....	12.5

More than three-quarters of the last whorl is living chamber. Ornament on the living chamber consists of a row of stout mediolateral nodes, slightly elongate transversely, and expressing suppressed rib development, and a row of stout lateroventral nodes obliquely elongated, trending forward at the ventral shoulder, and a further row of stout siphonal nodes slightly bullate in design. Strong growth lines are present with about seven or eight per node interval. The number of mediolateral nodes on the ultimate whorl is 13 to 15 and the number of siphonal and lateroventral nodes is 17 to 19 in both cases, with the extra lateroventral and siphonal nodes added about one per quarter-whorl. Where the extra ventral nodes are added, the ornament is typically that of type *Neogastroplites.*

The camerate portion of the shell shows a proportionate increase in the number of ventral nodes relative to the number of mediolateral nodes and the ratio approaches the Albian *Neogastroplites* in design, i.e. the ratio approaches 2:1 reflecting the *Gastroplites* bifurcate rib origin.

A variety exemplified by Ct. 1137 (plate VIII, fig. 1) is very similar to the holotype but differs in having the lateroventral nodes thin and obliquely elongate rather than stout tuberculate shape.

The suture is somewhat reduced and shows a broad lateral lobe broken into three unequal segments with a dissection and arrangement similar to that of *Neogastroplites cornutus* as illustrated by McLearn (1933, plate 4).

Types: Univ. of Alberta Geol. Museum, holotype Ct. 1133; paratypes Ct. 1134, Ct. 1135; figured specimens Ct.1136, Ct. 1137, Ct. 1138, Ct. 1139.

Occurrence: *Neogastroplites septimus* has been collected from the Fort St. John area in several localities and has been collected from the Kantah River, British Columbia, all from the upper part of the St. John formation above the fish-scale sand and below the Second Tuff marker-bed. Holotype Ct. 1133, paratype Ct. 1134, and figured specimen Ct. 1138 are all from six miles below the Alaska Highway bridge on Peace River, British Columbia. Ct. 1137 and Ct. 1139 are from a creek four miles below Alaska Highway bridge; Ct. 1135 and Ct. 1136 are from Septimus Creek, British Columbia.

Comparison: This form is differentiated from previously described *Neogastroplites* by the reduction in the ratio of lateroventral to mediolateral nodes from the typical 2:1 ratio of the type species to almost 1:1. This latter feature and siphonal nodes are found also on the Acanthoceratidae and, superficially, the new species might belong to that family but the extreme involution precludes this. *Neogastroplites septimus* has undoubtedly developed out of *Neogastroplites cornutus* (Whiteaves) as both have the strong tuberculation and siphonal nodes in common.

NEOGASTROPLITES sp.

Plate XV, figure 4

An odd fragment was found near the base of the fish-scale sand of the St. John formation on Septimus Creek, British Columbia. This fragment seems to hold an intermediate position between the late Albian *Neogastroplites* and *N. septimus* Warren and Stelck, n. sp.

Figured specimen: Univ. of Alberta Geol. Museum, Ct. 1125.

Genus FORBESICERAS Kossmat, 1897

FORBESICERAS ? sp. A

Plate VII, figures 2, 5, 6, 7, 8

Description: The collections studied included six poorly preserved fragments ascribed to this genus. The description is a composite from these. Shell medium size.

The whorl- section is very compressed, the flanks very slightly convex; the venter is narrow and somewhat flattened. The ornament consists of numerous flatly rounded, moderately strong sickle-shaped ribs that become much stronger and thicker toward the venter and fade out in crossing the venter itself; many of the ribs fade out in mediolateral position and only two-thirds of the ribs reach the ventral shoulder. There is a row of blunt subordinate ventrolateral tubercles on each side of the periphery with a suggestion, in earlier stages only, of a slight elongate, umbilicolateral tuberculation on some of the ribs. The form is completely involute.

At a diameter of 2.5 cm. there are 13 ribs per quarter-whorl at the umbilicus and nine only at the ventral shoulder. There is approximately the same number of ribs at diameters of 1.5 cm. and 3.5 cm. However at a diameter of 6.5 cm. there are 11 or 12 ribs per quarter-whorl at the periphery and something around 20 at the umbilical position. The ribs at the umbilicus are of the fineness of growth lines. Umbilicus is very tiny, less than 1.5 mm. at a diameter of 3.0 cm.

The apertural margin is parallel in design to the shape of the ribs with a forward projection at the venter.

Assuming that the fragments do represent one species and the smaller fragments the earlier stages, then the ontological development shows an increase in chamber height at half-whorl intervals of 0.5 cm., 1.0 cm., 1.7 cm., *ca* 3.0 cm. Maximum diameter of largest specimen is an estimated 7.0 cm. The ventrolateral tubercles are not too apparent until whorl height of about 1.0 cm., then strengthen and become slightly clavate forward by whorl height of 3.0 cm. Living chamber apparently makes up most of the ultimate whorl. Suture is unknown.

Figured specimens: Univ. of Alberta Geol. Museum, Ct. 1146a,b,c, Ct. 1147, Ct. 1148, Ct. 1149.

Occurrence: Six miles below Alaska Highway bridge, north bank of Peace River, British Columbia, from St. John shale near the horizon of the Second Tuff marker-bed.

Comparison: The species represented by the St. John specimens differs from previously named species of *Forbesiceras*. It lacks the median line of ventral nodes of *F. obtectus* (Sharpe) and the ribs of the latter are not flexed forward to the same degree although somewhat similar in the earlier portion. *F. largillietianum* (d'Orb.) is much more finely ribbed, as is *F. conlini* Stephenson. *Forbesiceras* sp. listed by Stelck and Wall (1955, p. 21) from above the Dunvegan formation in British Columbia lacks the strong lateral indication of ribs of the St. John species, although similar in rib count. The St. John species lacks the sharp clavate tubercles of *F. sculptum* Crick. Until the suture is known the writers wish to leave the species unnamed.

FORBESICERAS ? sp. B

Plate VII, figure 3

Forbesiceras sp. Stelck and Wall 1955, Res. Coun. of Alberta Rept. 70, p. 21, unfigured and undescribed.

This record of *Forbesiceras* is based on a small portion of a phragmacone and a living chamber, Ct. 1144 and Ct. 1143, (Univ. of Alberta Geol. Museum) respectively. Living chamber is illustrated to compare with the illustration of *Forbesiceras* ? sp. A (plate VII, figure 5). The living chamber of *F.* sp. B seems to be only about one-third of the ultimate whorl.

Forbesiceras ? sp. B occurs with *Borissjakoceras?* and *Scaphites* cf. *aequalis* Sowerby from the *Dunveganoceras* zone of the Smoky shale on Kiskatinaw River east of Progress, British Columbia.

Genus BORISSJAKOCERAS Arkangelsky, 1916

BORISSJAKOCERAS ? sp.

Plate VII, figure 4

This is a living chamber fragment of a small ammonite occurring with *Forbesiceras* ? sp. B and with *Scaphites* cf. *aequalis* J. Sowerby from the *Dunveganoceras* zone of the basal Smoky shale. The flat unornamented sides with ribs expressed only at the ventral shoulder, and the low rounded venter are suggestive of *Borissjakoceras* but no suture was obtainable. This form is somewhat suggestive of *Metoicoceras* ? sp., figured by Stephenson (1952, plate 44, fig. 3-5) from the Woodbine of Texas.

Figured specimen: Univ. of Alberta Geol. Museum, Ct. 1145, from Kiskatinaw River east of Progress, British Columbia, from *Dunveganoceras* zone of Smoky shale.

Class *Pelecypoda*

Genus BRACHIDONTES Swainson, 1840

BRACHIDONTES cf. FULPENSIS Stephenson

Plate XVI, figures 6, 7, 8

Brachidontes fulpensis Stephenson, 1952, U.S. Geol. Surv. Prof. Paper 242, p. 84, pl. 20, fig. 10-13.

Except for the smaller size these specimens agree with Stephenson's species. If the skirt were extended the bifurcation indicated by the costae on the margin would give the same fine costation as found on the skirt of *B. fulpensis*. These forms have previously been referred to *B. multilinigerus* Meek by the senior writer (Rutherford, 1930, p.22) but the creation of Stephenson's new species provides a better taxonomic niche.

Figured specimens: Univ. of Alberta Geol. Museum, Ct. 1154 and Ct. 256, a, b, from the lower part of the Dunvegan formation near the mouth of Hines Creek, Peace River, Alberta.

BRACHIDONTES cf. TENUISCULPTA (Whiteaves)

Plate XVI, figures 11-19

Modiola tenuisculpta Whiteaves, 1889, Geol. Surv. Can. Contrib. to Can. Paleont., vol. 1, pt. II, p. 188, pl. XXVI, fig. 2, 2a.

These specimens are referred to Whiteaves' species as the ornament is about the same weight as in *B. tenuisculpta* and the anterior margin extends some distance in front of the beak. This latter feature serves to separate them from *B. fulpensis* and *B. multilinigera.*

The holotype is from the Swan River group of Manitoba, usually assigned to the Lower Cretaceous.

Figured specimens: Univ. of Alberta Geol. Museum, Ct. 1155 a - i, come from a single nodule in a shale lense in the basal sand of the Dunvegan formation at the mouth of the Pouce Coupe River, Alberta.

Genus PANOPE Ménard, 1807

PANOPE ? sp.

Plate XVI, figure 20

This small pelecypod is from the same nodule as *Pleurobema cruiserensis* n. sp. and *Brachidontes* cf. *tenuisculpta* (Whiteaves). It is illustrated to complete the faunule.

Figured specimen: Univ. of Alberta Geol. Museum, Ct. 1157, is from the basal sand of the Dunvegan formation at the mouth of the Pouce Coupe River, Alberta.

Genus PLEUROBEMA Rafinesque, 1819

PLEUROBEMA CRUISERENSIS Warren and Stelck, n. sp.

Plate XVI, figures 21-25

Description: Shell of small size, relatively thick, equivalved, elongate ovoid outline. Beaks low, placed one-quarter of shell length from anterior end. Anterior dorsal margin concave, steeply sloping; anterior margin well rounded; ventral margin broadly convex; posterior dorsal margin straight, sloping from beak; posterior margin rounded with slight truncation. Shell ornamented with very fine growth lines only. Narrow escutcheon? Strong unionid blade-like tooth anterior to beak and long posterior lateral tooth or margin to the ligamentary groove.

Length of holotype 2.2 cm.; height 1.4 cm. Length of figured specimens 1.5 - 2.0 cm.; height 0.9 - 1.2 cm.

Types: Univ. of Alberta Geol. Museum, holotype Ct. 1157; figured specimens Ct. 1158 a - d.

Occurrence: Holotype from top of Cruiser shale, Stony Creek, Pine River area, British Columbia. Other figured specimens from basal sand of the Dunvegan formation at the mouth of Pouce Coupe River, Alberta. Unfigured specimens from basal Dunvegan transition beds, Cherry Point ferry, British Columbia.

Comparison: The only other named Dunvegan species is *Unio dowlingi* McLearn, but the new species is much smaller and relatively more elongate and the shell substance is much thinner. The tooth on *Unio dowlingi* is much stouter. This new species ranges lower in stratigraphic section than *Unio dowlingi* but appears to overlap variants of the latter species. The difference in relative range of the two species may reflect in part tolerance to marine or brackish conditions on the part of the new species.

Genus INOCERAMUS Sowerby, 1814

INOCERAMUS LEITHENSIS Warren and Stelck, n. sp.

Plate XVI, figures 3, 4, 5, 9, 10

Description: Small, thin-shelled, valves nearly equal, oblique, subquadrate to subovate in outline; strongly convex, a little longer than high. Beaks terminal at the anterior end of the hinge line, sharp, not rising above the hinge line; umbonal ridge well-defined on upper portion, oblique and curved forward to the hinge line. Skirt continuous with the postumbonal slope and blending with the preumbonal slope, giving a submytiloid appearance to the species. The anterior slope is abrupt near the hinge and the anterior margin makes an angle of 90 degrees or less with the hinge line. Lower and posterior margin regularly rounded.

Ornamentation consists of regular well-defined concentric ridges and/or undulations, poorly defined on the dorsal portion of the umbo. Very fine, closley spaced radial lines overlie the concentric ornament on the outermost layer of shell.

Figured specimens show a length of 21 - 23 mm., height 20 - 22 mm., length of hinge line 11 mm., thickness 8 - 10 mm.

Types: Univ. of Alberta Geol. Museum, cotypes Ct. 1151, Ct. 1152, Ct. 1153, Ct. 1154, Ct. 1155, Ct. 1156.

Occurrence: All figured specimens from Dunvegan sandstone, Leith River, Lsd. 12, Sec. 18, Tp. 80, R. 1, W. 6th Mer., Alberta.

Comparison: A much larger specimen (height 45 mm.) that might well be assigned to this species, was collected from Dunvegan talus on Racing Creek, Alberta, and suggests that the cotypes are immature or somewhat dwarfed.

This new species differs from *Inoceramus mcconnelli* Warren by being smaller, having low beaks and lacking the convex anterior margins. This appears to have some relation (ancestral?) to the *I. fragilis* group in the succeeding Smoky formation but lacks the convex concentric ornament of that group.

Inoceramus leithensis does, however, reflect the obliquity, thin shell and low beak of *I. irenensis* n. sp.

INOCERAMUS IRENENSIS Warren and Stelck, n. sp.

Plate XV, figure 1; plate XVI, figures 1, 2, 26

Description: Small, thin-shelled, valves equal, obliquely elliptical, moderately convex, length less than height. Beaks terminal at the anterior end of the hinge line, not rising above the hinge line; poorly defined umbo continuous with skirt and postumbonal slope; anterior slope gradual and the anterior margin makes an angle of 90 degrees or a little less with the hinge line. Lower and posterior margin regularly rounded, hinge line short about half the length of the shell.

Ornamentation consists of fine irregular concentric ridges on posterior portion, becoming more regular on anterior portion.

	Ct. 1152 a	Ct. 1152 b	Ct. 1152 c
Height cm.	2.9	2.5	3.3+
Length cm.	2.5	2.5	3.5+
Length of hinge	1.2	1.2	1.6+
Convexity	.....	.....	.4+

The dimensions are slightly misleading as the obliquity makes for a more lingulate shape.

Types: Univ. of Alberta Geol. Museum, cotypes Ct. 1152 a, b; figured variant Ct. 1152 c.

Occurrence: From St. John shale near the Second Tuff marker-bed, from six miles below Alaska Highway bridge, north bank of Peace River, British Columbia.

Comparison: This species is somewhat similar to *I. leithensis* n. sp. from the overlying Dunvegan formation, but is more lingulate in outline and there is a forward twist to the beaks in the latter species. The ornament is likewise more irregular on the posterior portion of *I. irenensis*. The ornament and shape is reminiscent of *I. comancheanus* Cragin, but *I. irenensis* is a much more delicate shell and smaller.

Superficially this species might be confused with *Posidonia nawhisi* var. *moberliensis* (McLearn) from the underlying Sikanni sandstone, but on well preserved material the terminal position of the beak would indicate its proper generic assignment.

INOCERAMUS ?

Plate XV, figure 6

This fragment, Ct. 1153, (Univ. of Alberta Geol. Museum), is possibly a large variant of *Inoceramus irenensis* n. sp. as it comes from the same location as the cotypes of that species.

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