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Foraminifera of the Cenomanian Dunveganoceras Zone from Peace River Area of Western Canada

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With Appendix
New Cenomanian Ammonites from Alberta
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FOREWORD

The Research Council of Alberta publishes the following report as the second in a series dealing with the microfaunal dating of the oil- and gas-bearing Cretaceous sequence of Alberta. (The first report in the series was Research Council of Alberta Report No. 68.) There is continuing need for these essential tools of research as more intensive subsurface data become available to the Alberta oil industry.

These studies are based on surface collections made by the writers in 1947 while under assignment from Imperial Oil Limited, Calgary. Research on these collections was carried out at Stanford University and later at the University of Alberta by the senior author. The junior author carried out research not only on these original collections but also on later collections gathered from subsurface drilling by Imperial Oil Limited. The primary results of all these studies were incorporated in reports to Imperial Oil Limited, Calgary, and academically developed as university theses at Stanford University and the University of Alberta.

Financial assistance was granted to the senior author through an Imperial Oil Graduate Fellowship and the Eric Knight Jordan Fellowship at Stanford University. Technical assistance was received from the staff of the reproduction department of Imperial Oil Limited, Calgary, and from the staff of the Research Council of Alberta at Edmonton. Mrs. N. Stover of the Department of Geology, University of Alberta, typed much of the final manuscript. Field collections studied included those of the writers and some made by J. Gleddie of Imperial Oil Limited, Calgary, and W. L. Clemis, formerly of Imperial Oil Limited (now of Petrofina). Megafaunal collections include those made by the Research Council of Alberta, Hudson Bay - Marland Oil, Union Oil Company, and California Standard Company, deposited in the Museum of the Department of Geology at the University of Alberta.

Foraminifera of the Cenomanian Dunveganoceras Zone from Peace River Area of Western Canada

ABSTRACT

Thirty-three species and subspecies of Foraminifera from the lower and central part of the Upper Cretaceous Kaskapau formation from the Peace River area of Alberta are figured and described. Of these, twenty-five are new. Microfaunal zones are equated to megafaunal sequences of the upper Cenomanian and lower Turonian stages. The late Cenomanian portions of the lower Kaskapau formation are correlated in part with the basal portion of the Alberta shale of southern Alberta, the lower part of the Cody shale of Wyoming, the Coleraine formation of Minnesota and the Woodbine formation of Texas. The foraminiferal assemblages are over 95% arenaceous. They indicate a gradual environmental change from cool shallow brackish water to slightly deeper water with opening seaway connections.

Three new species of critical Cenomanian ammonites from Alberta—two *Dunveganoceras*, one *Acanthoceras*—are described in the Appendix.

INTRODUCTION

The Peace River area of western Canada carries early Upper Cretaceous strata characterized by the ammonite genus *Dunveganoceras*. *Dunveganoceras* is a form apparently restricted for the most part to the interior of the North American continent, although strays have been reported from the uppermost Cenomanian beds of England (Wright and Wright, 1951, p. 29). The upper Cenomanian dating of this genus is based on this latter occurrence but the pelecypod faunas of the *Dunveganoceras*-bearing beds of Canada have close counterparts in the Cenomanian strata of the Gulf Coast region of the United States of America. Some slight parallelism may be observed between the Cenomanian microfaunas from the Gulf Coast and equivalent strata of western Canada.

Dunveganoceras itself is found in the basal portion of the Kaskapau formation of the Peace River area. The microfaunas from the lower portions of the Kaskapau formation are mainly shallow benthonic forms with many brackish species. The ancestry of these assemblages is found in the faunas of the underlying Dunvegan and upper Shaftesbury formations from boreal stock. The Cenomanian assemblages so far collected are arenaceous, and are dominated by members of the families Lituolidae, Verneuilinidae, and Trocham-

minidae with the principal genera *Haplophragmoides, Trochammina, Ammobaculites,* and *Verneuilina.*

The species of these assemblages from the *Dunveganoceras* zone are in large measure local and somewhat dwarfed, resulting in many new species; it is hoped that the descriptions of these faunas will serve for recognition of this horizon in similar brackish biotopes outside western Canada. Certain species common to the overlying Turonian strata have been described in the first paper of this series, Report No. 68 of the Research Council of Alberta.

Studies of these arenaceous groups of Foraminifera of western Canada have led the writers to a realization of the distinctness of arenaceous species. This is in sharp contrast to the customary attitude that arenaceous species are not stratigraphically restricted and are extremely variable. Hans Höglund (1947, p. 16) in dealing with Recent arenaceous Foraminifera under natural conditions, states that long-range species "are by no means as common as the literature dealing with Foraminifera appears to show". Hofker's observations (1953) on the wall make-up of fossil Foraminifera tend to support Höglund's statement. The experiments of D. C. Slama (1954), however, indicate that in living forms of *Ammobaculites,* wall-variability is possible within species under stringently-controlled artificial conditions. The writers suggest that such wall-variability, if occurring naturally, occurs only in species having such variation as a prime diagnostic character.

STRATIGRAPHY

The boundary problem between the Cenomanian and overlying Turonian stages of the Upper Cretaceous in western Canada is outlined in a previous paper by the writers (Stelck and Wall, 1954). The Upper Cenomanian beds of the Peace River area of western Canada, from the top of the continental Dunvegan formation to the introduction of the pelagic faunas of the "second white-specks" horizon of the Turonian stage, show a steady deepening of depositional phase and attendant transition from fresh to normally saline waters. This shift from fresh to saline waters is accompanied in the megafauna by the disappearance of oysters and forms tolerant to low salinity, and the introduction of *Inoceramus* and the ammonite *Dunveganoceras. Dunveganoceras* marks the end of the Cenomanian stage in western Canada, and it is fortunate that since its original description (Warren and Stelck, 1940) it has been recognized not only in the United States of America but also in England and establishes a basic form for international correlation.

Although *Dunveganoceras* is found in the northern part of America, it is lacking as yet from the Gulf Coast faunas. However, the more tolerant pelecypods that are found with the early forms of *Dunveganoceras* in the Peace River area are also found within the brackish faunas of the Woodbine sandstone and provide a continuity of correlation with the Gulf Coast area. This correlation is reflected

in the similarity of the brackish Cenomanian microfaunas of the Gulf Coast and those of the Peace River area of western Canada.

The *Dunveganoceras* zone is best developed in Canada in the Pouce Coupe River area of Alberta and westward to the Murray River area of British Columbia. However, nomenclature of formations has obscured somewhat the true vertical extent of this zone from place to place. For this reason, a succession of lithologic markers from the lower Turonian to the Cenomanian stage is given from the Pouce Coupe River area (thicknesses are approximate):

Formation	*Members and markers*
"Central" Kaskapau	..... Second white speckled shale member
	..... "White chalcedonic bed" or "white nodular member"
	50′ Shale
	..... Cenomanian-Turonian contact
	20′ Shale
	..... Howard Creek sand top
	130′ Sandy and tuffaceous shales
"Lower" Kaskapau	30′ Pouce Coupe sandstone
	74′ Shale with ironstone
	6′ Doe Creek sandstone
	190′ Sandy shales
Dunvegan formation	..... Sandstones and shales

Species of *Dunveganoceras* have been found from beds shortly above the Doe Creek sandstone, to well up in the shaly interval between the Pouce Coupe and Howard Creek sands. The name *Dunveganoceras* has led to some slight difficulty in international literature and has given such writers as Haas (1951) trouble in interpreting the stratigraphy of the Peace River country. The collections of the University of Alberta carry several specimens of *Dunveganoceras* from Dunvegan creek, just south of Dunvegan crossing in Alberta. This is also the type area of the Dunvegan formation, and it seems apropos here to review the history of the Dunvegan-Kaskapau formation contact.

Dunvegan-Kaskapau Formation Contact

The formation name "Dunvegan" was first used by G. M. Dawson in 1879 (1881, p. 115B) for what he called the "lower sandstones and shales of the lower forks of the Pine river and parts of the Peace River valley", thereby including the group of fresh-water sandstones and shales occurring at Dunvegan crossing on the Peace river in Alberta. There are but 340 feet of the formation (*s.s.*) exposed here, as the basal portion is below river level. The lower part of the overlying Smoky group (Kaskapau formation) is likewise exposed at the Dunvegan crossing locality. However, the type section of the Smoky River shales is on the Smoky river and the contact with the Dunvegan formation on this latter river is drawn

on maps by the Geological Survey of Canada (Russell, 1943) crossing the Smoky river near Watino, Alberta. The lowest diagnostic ammonite collected to date from the Smoky River formation at the Watino locality has been the genus *Watinoceras*. The genotype was collected from the lower 50 feet of the Smoky group at this locality.

In the above lies the stratigraphic discrepancy involving the definition of the Dunvegan-Kaskapau formation boundary. *Watinoceras* comes from well above the "white chalcedonic bed" marker and the genus *Dunveganoceras* from below the Howard Creek sand equivalents, in the vicinity of the "lower forks of the Pine river" (now East Pine, B.C.). In the East Pine area the top of the Dunvegan has usually been placed at the top of the plant-bearing beds, which here is a Pouce Coupe sand equivalent.

This, in summary, means that:

(1) The base of the Kaskapau formation as mapped at Watino on the Smoky river is about the same horizon as the top of the Howard Creek member.

(2) The base of the Kaskapau formation at Dunvegan on the Peace river is usually placed about 190 feet below the top of the Howard Creek sand.

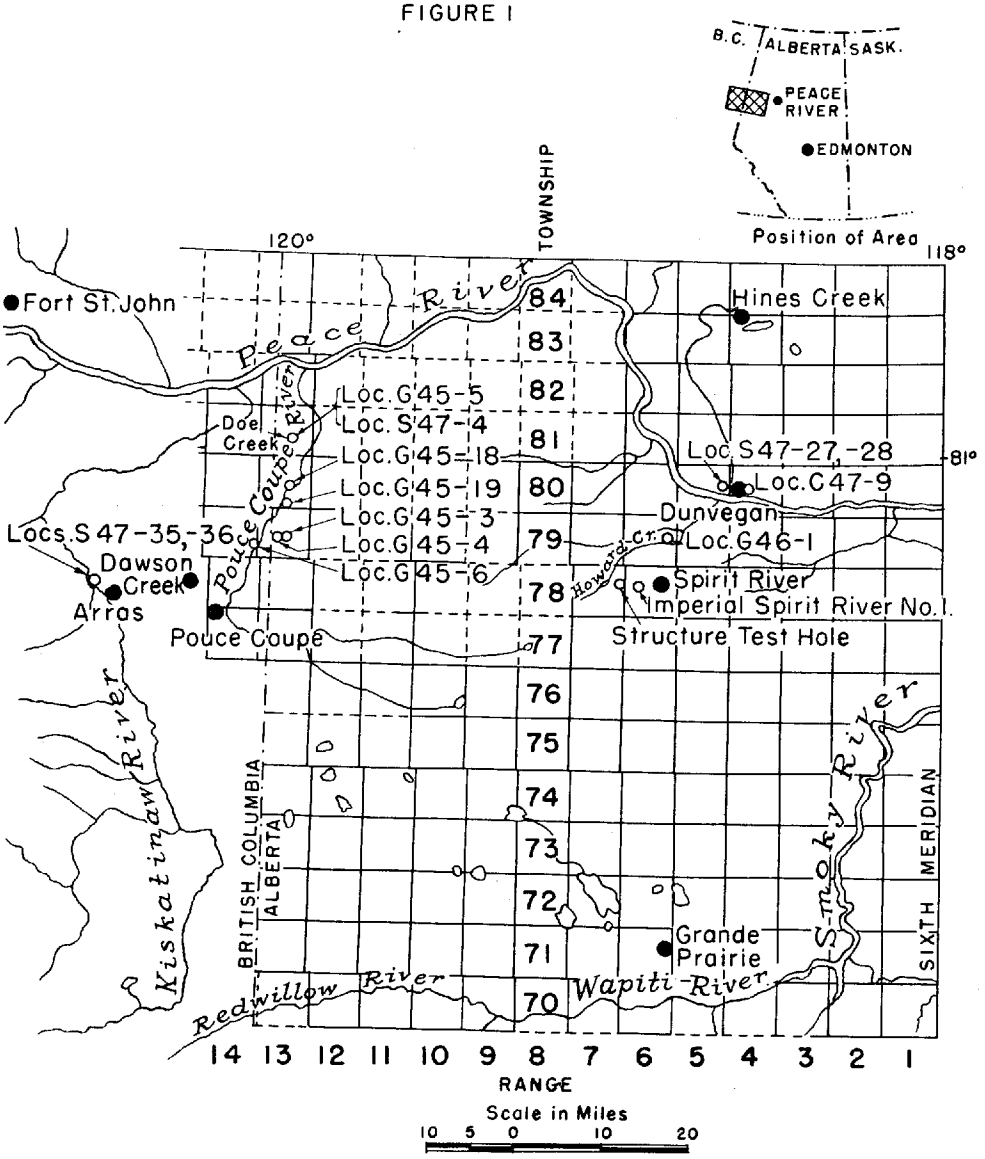
(3) The base of the Kaskapau formation on the Pouce Coupe river, west of Bonanza, Alberta, is mapped (Crickmay, 1944) 300 feet below the top of the Pouce Coupe sand member.

(4) The base of the Kaskapau formation on the Pine river near East Pine is often placed at the top of the Pouce Coupe sand member, as the latter is plant-bearing in this area with some thin coal seams.

The brackish nature of the Dunvegan-Kaskapau transition, which is primarily responsible for this diachronic correlation, is readily illustrated by the following section from Doe Creek, Alberta, taken for 300 feet below the Pouce Coupe sand member into definitely continental-type beds:

LOCALITIES OF MICROFAUNAL SUITES IN WESTERN PEACE RIVER AREA

FIGURE 1



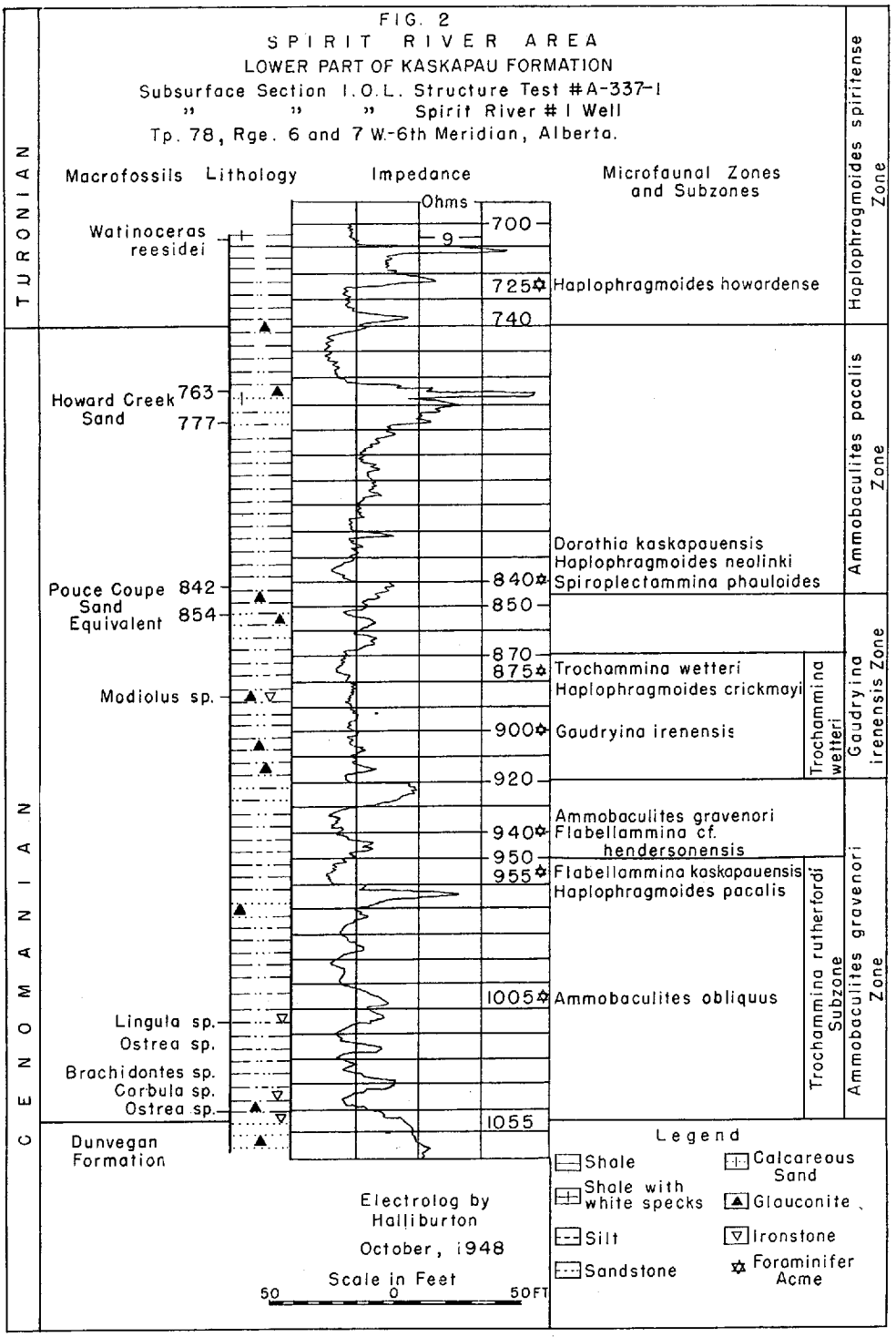


FIG. 2
SPIRIT RIVER AREA
LOWER PART OF KASKAPAU FORMATION
Subsurface Section I.O.L. Structure Test #A-337-I
" " " Spirit River #1 Well
Tp. 78, Rge. 6 and 7 W.-6th Meridian, Alberta.
TURONIAN
CENOMANIAN
Macrofossils
Lithology
Impedance
Ohms
Microfaunal Zones and Subzones
Watinoceras reesidei
Howard Creek Sand
Pouce Coupe Sand Equivalent
Modiolus sp.
Lingula sp.
Ostrea sp.
Brachidontes sp.
Corbula sp.
Ostrea sp.
Dunvegan Formation
763
777
842
854
700
9
725
740
840
850
870
875
900
920
940
950
955
1005
1055
Haplophragmoides howardense
Dorothia kaskapauensis
Haplophragmoides neolinki
Spiroplectammina phauloides
Trochammina wetteri
Haplophragmoides crickmayi
Gaudryina irenensis
Ammobaculites gravenori
Flabellammina cf. hendersonensis
Flabellammina kaskapauensis
Haplophragmoides pacalis
Ammobaculites obliquus
Haplophragmoides spiritense Zone
Ammobaculites pacalis Zone
Gaudryina irenensis Zone
Trochammina wetteri
Ammobaculites gravenori Zone
Trochammina rutherfordi Subzone
Electrolog by Halliburton
October, 1948
Scale in Feet
50 0 50FT
Legend
Shale
Shale with white specks
Silt
Sandstone
Calcareous Sand
Glauconite
Ironstone
Foraminifer Acme

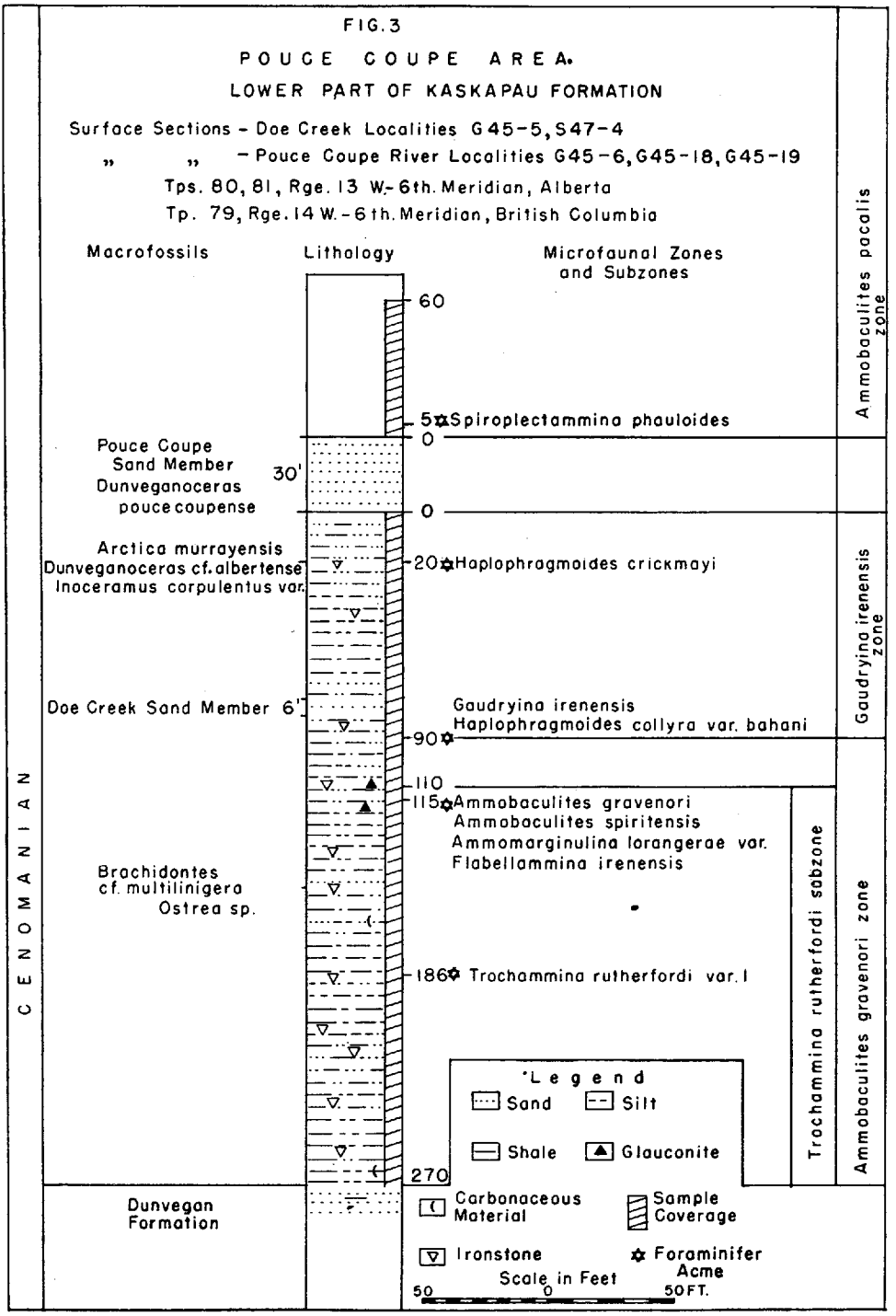


FIG. 3
POUCE COUPE AREA.
LOWER PART OF KASKAPAU FORMATION
Surface Sections - Doe Creek Localities G45-5, S47-4
" " - Pouce Coupe River Localities G45-6, G45-18, G45-19
Tps. 80, 81, Rge. 13 W.-6th. Meridian, Alberta
Tp. 79, Rge. 14 W.-6th. Meridian, British Columbia
Macrofossils
Lithology
Microfaunal Zones and Subzones
60
5 Spiroplectammina phauloides
0
Pouce Coupe Sand Member
Dunveganoceras pouce coupense
30'
0
Arctica murrayensis
Dunveganoceras cf. albertense
Inoceramus corpulentus var.
20 Haplophragmoides crickmayi
Doe Creek Sand Member 6'
Gaudryina irenensis
Haplophragmoides collyra var. bahani
90
110
115 Ammobaculites gravenori
Ammobaculites spiritensis
Ammomarginulina lorangerae var.
Flabellammina irenensis
Brachidontes cf. multilinigera
Ostrea sp.
186 Trochammina rutherfordi var. I
270
Dunvegan Formation
Legend
Sand
Silt
Shale
Glauconite
Carbonaceous Material
Sample Coverage
Ironstone
Foraminifer Acme
Scale in Feet
50 0 50 FT.
CENOMANIAN
Ammobaculites pacalis zone
Gaudryina irenensis zone
Trochammina rutherfordi subzone
Ammobaculites gravenori zone

LOCALITY S47-4—DOE CREEK CANYON

Basal Kaskapau formation: section from Pouce Coupe sandstone member to base, Doe Creek canyon at northernmost point of the big bend, east of Doe Creek P.O., British Columbia. (The section itself is in Alberta.)

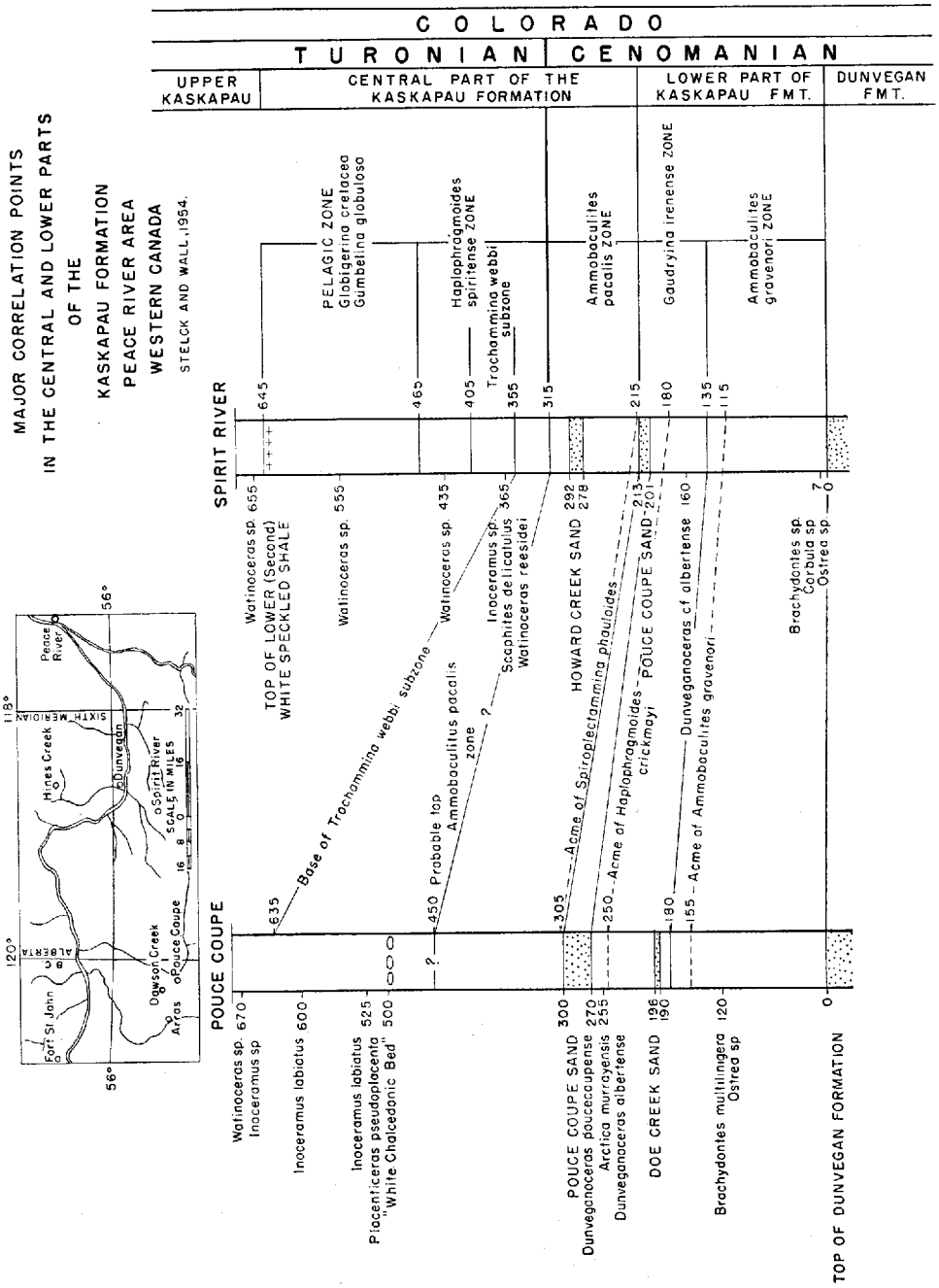
Feet	
.....	Base of cliff-forming Pouce Coupe sandstone—massive sandstone, fine-grained, clean.
3.0	Sandstone, shaly, grey, argillaceous.
9.0	Sandstone, argillaceous, grading downward into sandy shales, interstreaked with sand.
4.0	Shale, sandy.
2.0	Siltstone, sandy.
1.0	Ironstone nodules 1′x2′ dimensions at 3′ centres.
7.5	Shale, sandy, with sand as streaks and worm burrows.
0.5	Ironstone, sandy concretions at 3′ centres.
1.7	Shale, silty and sandy.
0.1	Ironstone, nodular band.
1.5	Siltstone, argillaceous, shaly.
0.2	Ironstone, sandy.
7.0	Siltstones, thin argillaceous, interbedded with shaly argillaceous sandstone.
0.2	Sandstone, fine, dark argillaceous.
1.0	Shale, very silty.
5.0	Shale, silty.
0.5	Ironstone nodules, dimensions 6″x14″ at 6′ centres.
11.5	Shale, silty, slightly sandy at top.
7.0	Shale, silty.
0.2	Sandstone, ferruginous.
1.5	Siltstones and sandstones interbedded.
6.5	Sandstone, medium-fine to medium.
2.0	Shale, black with small 1″ lenticles of sandstone.
3.0	Shale.
0.5	Sandstone, ferruginous with worm borings to ¼″ diameter.
4.0	Sandstone (top of Doe Creek member), yellow, fine, with ferruginous bands carrying *Ostrea*.
1.0	Sandstone, fine, argillaceous, inter-crossbedded with medium-fine shaly sandstone.
0.2	Shale, soft, black with small lenses of sand.
0.3	Sandstone, soft, argillaceous.
0.3	Sandstone, ferruginous, concretionary.
4.0	Shale, sandy and argillaceous sandstone, intermixed.
0.7	Ironstone, sandy as concretionary nodules in argillaceous sandstone.
6.5	Shale, very sandy, grading up into argillaceous sandstone.
1.0	Shale, finely sandy with some worm burrowings filled with sand.
5.5	Shale, silty to finely sandy.

Feet

3.5 Sandstone, soft, argillaceous, shaly with some sandy shale intermixed.
3.0 Shale, sandy with sandstone streaks.
2.0 Siltstone, argillaceous with ironstone nodules of dimensions 5″x10″ at 4′ centres near top.
0.5 Ironstone, in irregular nodular bands.
0.5 Siltstone.
3.0 Shale, sandy, glauconitic.
1.5 Shale, silty, slightly sandy.
0.5 Siltstone.
0.3 Ironstone, 6″x12″ nodules at 6′ centres.
10.5 Shale, silty, slightly sandy, glauconitic.
1.0 Siltstone, argillaceous, shaly.
3.5 Shale, silty.
2.0 Siltstone, argillaceous, shaly.
6.0 Shale, silty.
0.3 Ironstone, nodules 4″x6″ at 4′ centres.
0.5 Shale, sandy.
0.3 Ironstone, nodules 4″x12″ at 3′ centres.
0.5 Siltstone, sandy.
4.0 Shale, silty.
2.0 Sandstone, lenticular with ironstone and shaly content, sometimes clears up to yellow fine clean sand.
7.5 Sandstone, soft, argillaceous, shaly with sandy concretions at top, oysters.
0.5 Ironstone, uneven band.
7.0 Shale, sandy with sand-filled worm borings and small sandy lenticles.
4.0 Shale, slightly sandy.
0.3 Sandstone, brown nodular
3.0 Sandstone, thin-bedded, micaceous, carbonaceous, finely cross-bedded, interlensing with siltstone.
1.0 Siltstone, argillaceous, interbedded with fine argillaceous sandstone lenticles.
4.0 Shale, sandy with siltstone and very fine sandstone.
1.0 Shale, silty.
1.0 Shale, slightly sandy.
3.0 Shale, sandy.
0.5 Shale, sandy with occasional ironstone nodules 6″x14″.
1.5 Shale, silty.
0.2 Sandstone, fine, calcareous.
1.0 Shale, silty.
1.0 Shale.
4.0 Shale, silty.
2.0 Shale, black.
1.0 Sandstone, soft, argillaceous, shaly.
0.2 Ironstone, nodular band.
0.2 Siltstone.
0.1 Ironstone and siltstone as lenses.

Feet	
3.5	Siltstone, grey with 30% argillaceous thin sandstone.
4.0	Siltstone, grey with 30% sandy shale interbedded.
2.0	Shale, dark grey.
0.1	Ironstone band.
6.0	Shale, slightly silty.
0.3	Ironstone, sporadic, uneven nodules.
5.0	Shale, sandy with 50% of sand in the form of thin streaks with occasional small sandy ferruginous concretions.
0.5	Ironstone band, nodules irregular in juxtaposition.
0.5	Siltstone, sandy.
0.5	Sandstone, ferruginous, argillaceous, shaly.
1.0	Sandstone, soft, argillaceous, shaly.
3.0	Shale, sandy with 30% sandstone in the form of worm borings and thin lenses and streaks.
3.0	Shale, sandy.
1.0	Ironstone nodules 12″x24″ at 3′ centres.
7.5	Sandstone, shaly, argillaceous with admixture of sandy shale.
1.0	Sandstone, soft, argillaceous with sand-iron concretions 8″x18″ developed.
3.0	Shale, sandy.
1.0	Shale, sandy with ferruginous concretions at top.
2.5	Shale, black, silty with 5% sand content.
0.5	Shale, sandy.
0.5	Shale, sandy with irregular ferruginous concretions.
2.5	Siltstone, shaly, argillaceous.
0.5	Shale, sandy.
0.5	Ironstone, irregular concretions 6″x18″ at 3′ centres.
2.0	Shale, sandy.
0.05	Ironstone, nodules.
1.0	Shale, fissile, black, silty.
0.5	Shale, with occasional 1″x8″ concretion.
0.2	Ironstone band.
12.0	Shale, silty, flaky.
0.3	Ironstone, sutured composite nodules 3″x3′ at 10′ centres.
3.0	Shale, silty, fissile.
0.05	Ironstone.
1.0	Siltstone, shaly laminated.
0.05	Ironstone.
0.5	Siltstone, fine, argillaceous.
2.5	Shale, sandy.
0.5	Shale, silty, black.
0.5	Ironstone, sandy, nodules in sandy shale.
2.5	Shale, silty, carbonaceous.
0.5	Shale, black with coaly streaks.
0.1	Ironstone.
4.5	Shale, dark grey, silty.
3.0	Sandstone of Dunvegan formation proper, argillaceous, grey, fine-grained, crossbedded with carbonaceous material.
.....	Base of section—creek level.

FIG. 4
MAJOR CORRELATION POINTS
IN THE CENTRAL AND LOWER PARTS
OF THE
KASKAPAU FORMATION
PEACE RIVER AREA
WESTERN CANADA
STELCK AND WALL, 1954.



Zonation by Megafossils

Megafossils assist in part to outline certain details of the stratigraphy of the Kaskapau-Dunvegan formation transition. To avoid local nomenclatural prejudice and possible stratigraphic hiati, it has been found necessary to calibrate the abbreviated sections of the Peace River plains with the thicker sections present in the foothills of the Peace River drainage area.

The zones of the Colorado shale of Montana for Lower Turonian and Cenomanian stages are outlined to serve as a gross standard of reference (Cobban 1951, p. 2197).

Turonian	*Watinoceras reesidei* Warren, *I. labiatus* (Schlotheim) *Sciponoceras gracile* (Shumard), *Metoicoceras whitei* Hyatt
Cenomanian	*Dunveganoceras* aff. *D. albertense* (Warren), *Metoicoceras* sp. *Dunveganoceras pondi* Haas, *Metoicoceras praecox* Haas *Acanthoceras* n. sp. *Acanthoceras* ? *amphibolum* Morrow *Calycoceras* sp.

In Alberta, the senior author has collected *Sciponoceras* cf. *gracile* on the upper part of Hat mountain in the Kakwa River area, and on Lynx creek at the foot of Hat mountain near the water-level *Dunveganoceras* cf. *albertense* is present in the lower part of the shale section. This implies an interval of over 500 feet between the two ammonite horizons. Other megafossils are needed as stratigraphic guides in the Peace River country and a local auxiliary zonation is necessary for the pre-*Watinoceras reesidei* horizons. A tentative sequence from the "second white specks" zone of the Colorado to the base of the Dunvegan formation is as follows:

Turonian	*Watinoceras reesidei* Warren *Collignoniceras* n. sp.
Cenomanian	*Inoceramus* aff. *I. fragilis* Hall and Meek *Dunveganoceras hagei* Warren and Stelck, n. sp. *Dunveganoceras* cf. *parvum* Cobban *Dunveganoceras albertense* (Warren), *I. allani* *Dunveganoceras* cf. *conditum* Haas, *Inoceramus fragilis mesabiensis* Bergquist *Ostrea aurea* (Warren and Stelck) *Hillites* cf. *septarianus* (Cragin), *Ostrea anomiodes* Meek *Inoceramus dunveganensis, I. athabaskensis* McLearn *Inoceramus rutherfordi* Warren, *Ostrea dunveganensis* Warren *Brachidontes* cf. *fulpensis* Stephenson *Brachidontes* cf. *tenuisculpta* (Whiteaves)

The top of the Dunvegan formation *s.s.* as defined by Crickmay (1944) and Gleddie (1954) for the Pouce Coupe area comes at about the horizon of *Inoceramus dunveganensis.*

Watinoceras reesidei comes from the second white specks zone of the Colorado shales and serves as a common datum for a horizon within the lower Turonian stage. *Collignoniceras* n. sp. comes from about 200 feet above the "white chalcedonic bed" and is assumed to belong to the *Sciponoceras gracile* zone of the Colorado shale in Montana. *Inoceramus* sp. aff. *I. fragilis* Hall and Meek comes from the Howard Creek sand equivalents in the Pine River area. *Dunveganoceras hagei* Warren and Stelck, n. sp. comes from 130 feet above the Pouce Coupe sand equivalent in the Pine River area. *Inoceramus* cf. *tenuiumbonatus* Warren and *Dunveganoceras* cf. *parvum* Cobban come from 20 to 30 feet above the Pouce Coupe sand equivalent in the Pine River area, and it is not until the Pouce Coupe sand itself is reached that the genotype of *Dunveganoceras* is found. The genotype *D. albertense* (Warren) acts as the second marker below *Watinoceras,* to serve as calibration against the Colorado shale standard of zonation (Cobban 1951, p. 2197).

Inoceramus athabaskensis acts as a partial link indirectly with the Cenomanian zones. On the Athabasca river *I. athabaskensis* is reported (McLearn, 1945) to occur in association with *Acanthoceras athabascense* Warren and Stelck, n. sp. This *Acanthoceras* is very closely related to *Euomphaloceras euomphalum* (Sharpe) (= *A. cunningtoni* Sharpe) of the Cenomanian stage of England. *Hillites* cf. *septarianus* (Cragin) and *Ostrea aurea* (Warren and Stelck) belong to the upper Cenomanian as well. *Ostrea aurea* comes from the Doe Creek member and *Hillites* cf. *septarianus* from the interval between the Doe Creek sandstone and the underlying Dunvegan sandstone on the Pouce Coupe river.

Stratigraphic Assignment of Certain Brackish Faunas

There is a strange anomaly developed that much of the described "Dunvegan" fauna actually comes from the overlying Smoky River shales, as redefined by the Geological Survey (Crickmay, 1944) for the Pouce Coupe area. This is an outgrowth of the natural history of the Dunvegan formation. A regional consideration of the Dunvegan sandstone wedge may be outlined briefly.

The Dunvegan sands in Alberta represent the outer margins of a delta built out as a broad apron skirting an upland centering on the southern Mackenzie mountains and the Cassiar mountains of northern British Columbia. A major river system, apparently draining through the general Liard plateau area, spilled arkosic beds into northeastern British Columbia with the more conglomeratic phases present northward toward the Liard gap.

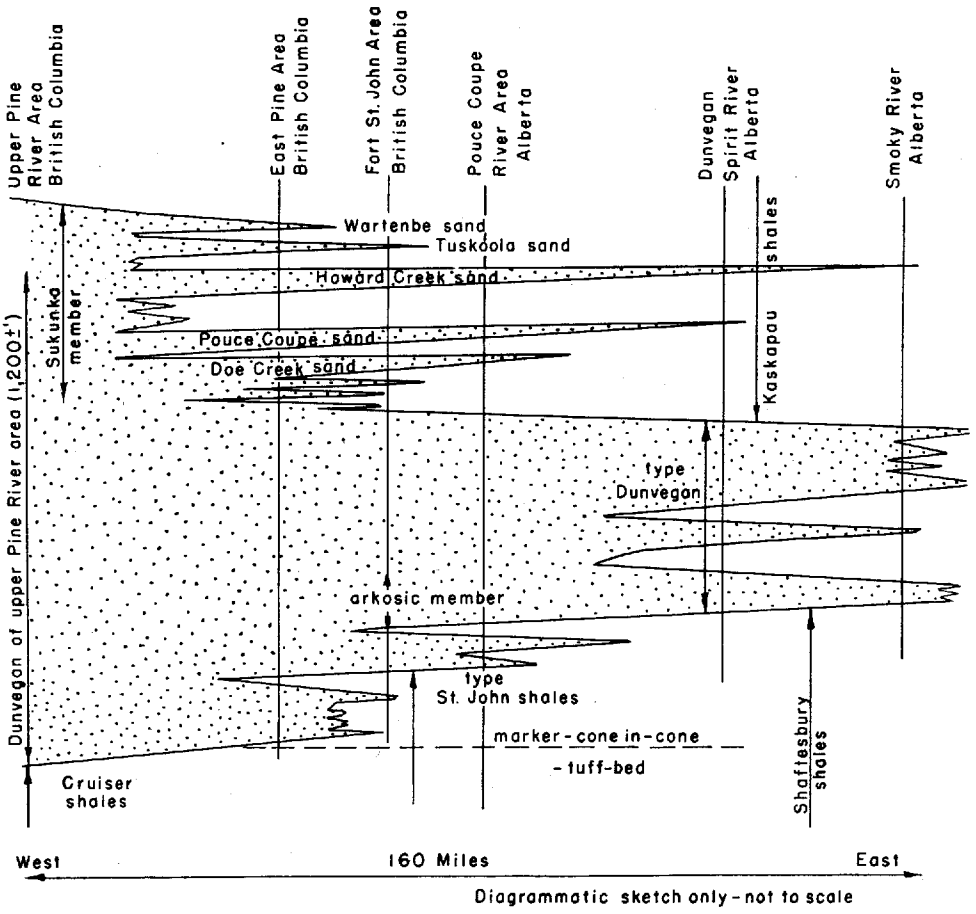
Continued uplift of the source area involved the upper reaches of the delta in the erosional cycle and the later sandy beds of the early Upper Cretaceous find their source, in part, in the reworked Dunvegan deltaic material. The implied tilting moved the late

Cenomanian shoreline southeastward and, consequently, the farthest southward expression of these "deltaic" Dunvegan deposits is considerably younger than the main arkosic beds of northeastern British Columbia. In offshore facies, only the latest Cenomanian beds appear in sandy phase, and the outermost latest margins of the "Dunvegan" delta carry marine (?) coal-seams interbedded with beds carrying oysters. Coal seams are found at the base of the Smoky (Kaskapau) shales at Watino, Alberta; thin coal seams are present in the type section area of the Pouce Coupe marine sand member on the Pouce Coupe river, Alberta; and beds shortly above and below the Pouce Coupe sand carry thin coal seams in the Murray River area of British Columbia.

The intertonguing relationships of the marine shales and deltaic sandy tongues of the Cenomanian beds are shown in schematic form in Figure 5.

FIG. 5

SCHEMATIC DIAGRAM TO ILLUSTRATE FACIES CHANGES IN DUNVEGAN FORMATION



The following fossil forms are known to be present in the Dunvegan formation in the restricted sense used by Crickmay (1944) and Gleddie (1954) for the Pouce Coupe and Dunvegan areas of Alberta:

Unio dowlingi McLearn
Psammosolen dunveganensis Warren
Brachidontes cf. *tenuisculpta* (Whiteaves)
Brachidontes cf. *fulpensis* Stephenson
Callista cf. *orbiculata* (H. and M.)
Mactra sp.
Inoceramus rutherfordi Warren
Ostrea dunveganensis Warren
Ostrea sp.
Rhytophorus? caurinus McLearn

The following fossils are assumed to come from the Dunvegan *s.s.* formation, but data on the exact stratigraphic horizon of collection are lacking for the Dunvegan or Pouce Coupe areas:

Inoceramus dunveganensis McLearn
Ostrea anomiodes Meek
Inoceramus athabaskensis McLearn
Modiolus silentiensis McLearn

This leaves such "Dunvegan" forms as the following, listed by Rutherford (1930), Warren and Stelck (1940), McLearn (1945), Gleddie (1954), and others as coming from beds now assigned to post-Dunvegan *s.s.* strata:

Barbatia micronema (Meek)
Ostrea soleniscus Meek
Parmicorbula dunveganensis (McLearn)
Unio (Elliptio) sulfuriensis McLearn
Melania sp.
Ostrea aurea (Warren and Stelck)
Inoceramus corpulentus McLearn
Dunveganoceras spp.

Many of the forms from the above suites have brackish facies connotation and are sufficiently sporadic in occurrence to suggest the need for a faunal zonation that could be used in subsurface studies as well as in outcrop studies. A microfaunal zonation has already been suggested in a previous paper by the writers (1954) for post-Dunvegan *s.s.* strata.

Zonation by Microfauna

The Dunvegan-Kaskapau transition beds yield an excellent set of diagnostic arenaceous foraminifera that may be used for identification of stratigraphic horizon. Stelck and Wall (1954, p. 7) outline a zonation based on foraminiferal faunistic changes from the upper part of the Cenomanian strata into the lower Turonian stage, as follows:

Turonian	"Central" Kaskapau	Pelagic microfaunal zone (lower or second white speckled shale) *Haplophragmoides spiritense* zone (includes "white chalcedonic bed")
Cenomanian		*Ammobaculites pacalis* zone (includes Howard Creek sand)
	"Lower" Kaskapau	*Gaudryina irenensis* zone (includes Pouce Coupe sand at top and Doe Creek member near base) *Ammobaculites gravenori* zone
	Dunvegan restricted	unnamed microfaunal zone

The lower Turonian zones have been discussed in a previous paper by Stelck and Wall (1954). The upper Cenomanian microfaunal zones of the Kaskapau formation are discussed separately here.

AMMOBACULITES PACALIS Zone

The *Ammobaculites pacalis* zone extends from immediately above the Pouce Coupe sand to a short distance above the Howard Creek sand member of the Kaskapau formation in the Spirit River area. The zone is characterized by the following microfauna:

Ammobaculites pacalis Stelck and Wall
Ammobaculites albertensis Stelck and Wall
Ammobaculites albertensis var.
Haplophragmoides eocalcula n. sp.
Haplophragmoides hendersonensis Stelck and Wall
Haplophragmoides neolinki n. sp.
Spiroplectammina phauloides n. sp.
Dorothia kaskapauensis n. sp.
Dorothia kaskapauensis var. *gracilis* n. sp., n. var.
Gümbelitria cretacea var. *spiritensis* n. var.
Textularia gravenori n. sp.
Trochammina wetteri var. n. sp.

The fauna of the microfaunal suites betray the opening seaways of the following Turonian stage through the pelagic *Gümbelitria*. The remainder of the fauna is arenaceous and may indicate marine waters, slightly diluted by the rivers that built out the marine delta. The megafauna of the *Ammobaculites pacalis* zone carries deep water forms such as *Placenticeras* cf. *pseudoplacenta* in the upper part and shallow water forms such as *Dunveganoceras* cf. *hagei* in the lower part, and below this—almost at the base—*Dunveganoceras* cf. *parvum* Cobban. *Inoceramus* sp. aff. *I. fragilis* is present in the Howard Creek sand and *Inoceramus* cf. *tenuiumbonatus* is present near the base of the *A. pacalis* zone. Other mollusca are rare, although a *Pecten* and a few gastropods have been noticed in ironstone nodules in the Pine River area. In the Dunvegan area the Howard Creek sand carries a suite of *Arctica* cf. *murrayensis* with *Inoceramus* sp. aff. *I. fragilis* Hall and Meek. *Dunveganoceras hagei* n. sp.

comes from shortly below the Howard Creek sand on Dunvegan creek.

The age of the *Ammobaculites pacalis* zone is left as latest Cenomanian, as two species of *Dunveganoceras* are found within the stratigraphic limits of this zone.

GAUDRYINA IRENENSIS Zone

The *Gaudryina irenensis* zone extends from the top of the Pouce Coupe sandstone member of the Kaskapau formation, to slightly below the Doe Creek sand member of the Pouce Coupe area. The zone is characterized by the following microfossils:

Gaudryina irenensis n. sp.
Gaudryina spiritensis n. sp.
Ammobaculites gravenori (rare) n. sp.
Ammobaculites cf. *gravenori*
Haplophragmoides crickmayi n. sp.
Trochammina wetteri n. sp
Trochammina rutherfordi n. sp.
Verneuilinoides perplexus (Loeblcih) var. *gleddiei* n. var.

The above arenaceous fauna suggests a slight reduction in salinity and the brackish facies is still further indicated by the tolerant oysters that appear in the *G. irenensis* zone. The Pouce Coupe sand member at the top of the zone in the Pouce Coupe area carries a shallow marine megafauna:

Dunveganoceras albertense (Warren)
Dunveganoceras poucecoupense Warren and Stelck
Pinna sp.
Arctica murrayensis Warren
Exogyra columbella levis Stephenson
Protocardia sp.
Inoceramus corpulentus McLearn var. A
Inoceramus allani Warren
Inoceramus prefragilis Stephenson

The Pouce Coupe sand equivalent in the Murray River area carries in addition:

Ostrea soleniscus Meek
Inoceramus sp.

The Doe Creek sand member at the base carries another *Arctica* aff. *A. murrayensis* Warren with *Ostrea aurea* (Warren and Stelck) as the most abundant form.

In the central part of the *G. irenensis* zone, the following forms are recognized from the Pouce Coupe - Kiskatinaw areas:

Forbesiceras sp.
Dunveganoceras aff. *D. albertense* (Warren)
Dunveganoceras aff. *D. conditum* Haas
Inoceramus allani Warren

Inoceramus corpulentus var. B
Inoceramus fragilis mesabiensis Bergquist
Arctica murrayensis Warren

The *Gaudryina irenensis* zone may be considered late Cenomanian from the presence of *Dunveganoceras* and *Forbesiceras.*

AMMOBACULITES GRAVENORI Zone

The *Ammobaculites gravenori* zone extends above the Dunvegan formation (restricted) to within ten feet of the Doe Creek sand member in the Pouce Coupe area. This amounts to a total of 180 feet of stratigraphic interval in this area, but the lower 20 feet seem barren of microfossils. The microfauna of the lower part of the zone carries reduced numbers of those forms that are present. The fauna is fairly extensive when listed for the total zone:

Ammobaculites gravenori n. sp.
Ammobaculites spiritensis n. sp.
Ammobaculites obliquus Loeblich and Tappan
Ammomarginulina lorangerae n. sp.
Ammomarginulina lorangerae var.
Flabellammina kaskapauensis n. sp.
Flabellammina warreni n. sp.
Flabellammina webbi n. sp.
Flabellammina webbi var.
Flabellammina irenensis n. sp.
Flabellammina cf. *hendersonensis* Stelck and Wall
Trochammina rutherfordi n. sp.
Trochammina rutherfordi var. 1 & 2
Haplophragmoides collyra var. *bahani* n. var.
Haplophragmoides pacalis n. sp.
Verneuilinoides perplexus (Loeblich)
Proteonina cf. *alexanderi* Loeblich and Tappan
Bathysiphon sp.

The megafauna of the upper part of the *A. gravenori* zone is not quite as extensive, but carries:

Hillites cf. *septarianus* (Cragin)
Nucula
Parmicorbula sulfuriensis (McLearn)
Brachidontes cf. *filisculptis* (Cragin)
Brachidontes cf. *multilinigera* Meek
Ostrea anomioides Meek

The lower part of the *A. gravenori* zone carries the additional forms:

Ostrea dunveganensis Warren
Brachidontes cf. *arlingtonanus* Stephenson

At the mouth of the Hines river in Alberta, *Ostrea dunveganensis* is found in association with *Inoceramus rutherfordi* in the top

of the Dunvegan formation *s.s.* This seems to indicate that the Dunvegan formation at Dunvegan crossing, Alberta, is slightly higher stratigraphically than the top of the Dunvegan formation (restricted) on the Pouce Coupe river. However, the microfauna indicates no radical change and for practical purposes, the first massive sand below the Doe Creek member by at least 100 feet or more may be considered a mappable top of the Dunvegan formation.

Still farther to the west, this zone on Murray river carries:

Elliptio sulfuriensis McLearn
Barbatia micronema (Meek)
Corbula cf. *pyriformis* Meek

The *A. gravenori* zone is difficult to date, as no diagnostic ammonites have been recovered from this zone. Its correlative limits seem to place it within the upper portion of the Cenomanian stage.

REGIONAL CORRELATIONS

General Statement

Stratigraphers, considering paleogeographic distribution of the late Cenomanian seas in America, will take some real interest in the apparently widespread distribution of the early Kaskapau formation megafaunas. Little help is obtained from the microfauna itself, as the forms are in large part undifferentiated in previous literature. However, much of the brackish megafauna has a distribution far beyond that normally expected for shallow water forms. The three microfaunal zones of the late Cenomanian stage are placed in the late portion of that European time-stratigraphic subdivision on the basis of the genus *Dunveganoceras*, an ammonite genus common to both English strata (Wright and Wright 1951, p. 29) and the central parts of North America. The boundary between the Cenomanian and Turonian stages is arbitrarily set between the *Haplophragmoides spiritense* zone and the underlying *Ammobaculites pacalis* zone, on the change over from dominantly near-shore environment in the latter zone to a neritic deeper water facies in the *H. spiritense* zone. This would indicate the world-wide shift to deeper water in the Turonian age.

AMMOBACULITES PACALIS Zone Correlation

The *Ammobaculites pacalis* zone of the late Cenomanian has not been recognized as yet from the internal part of North America, north of the Peace River area. In late Cenomanian time the Mackenzie Mountain area was still high, and in late Turonian time the Mackenzie Mountain area was re-elevated to the point of undergoing erosion; therefore, if the latest Cenomanian seas did transgress in part on the margins of the Mackenzie Mountain upland, the evidence has since been removed. In all of our extensive collections at the University of Alberta from the Northwest Territories, no megafaunal element of this *A. pacalis* zone is present. At Bear

Rock on the Mackenzie river near Fort Norman, the lower Turonian beds with *Watinoceras reesidei* lie directly on Devonian strata. There are Cenomanian beds in Alaska, but these are in areas of transgressive overlap from the Arctic Coastal Plain, and the exact identification of the faunas is still tentative. However, in continuing south from the Peace River area of western Canada, such correlative forms as *Inoceramus* cf. *tenuiumbonatus* Warren are found in the lower portion of the Blackstone shales in the Monkman Pass area in the vicinity of Stony lake, British Columbia.

The *Ammobaculites pacalis* zone is represented more or less continuously along the foothills of Alberta. *Inoceramus* cf. *tenuiumbonatus* is found at the base of the Alberta (Blackstone) shale shortly above the Pouce Coupe sand member in the Kakwa River area, accompanied by *Metoicoceras* cf. *muelleri* Cobban. In the Cadomin area of the central Alberta foothills, *Dunveganoceras* cf. *parvum* Cobban is found shortly above the Pouce Coupe sand member. In the southern Alberta foothills in the Castle River area, there seems to be some stratigraphic shortening of section as the Turonian ammonite *Watinoceras* comes from the shales immediately overlying the volcanic ash beds (Crowsnest?) and *Dunveganoceras clowi* n. sp. comes from below the tuffaceous beds within the 100-foot section of shale lying immediately above the Blairmore formation. Webb and Hertlein (1934, p. 1409) report the horizon of the *Dunveganoceras* on the Castle river as 50 feet above the Blairmore formation, so it is difficult to determine whether the *Ammobaculites pacalis* zone is severely condensed or missing.

In Montana, in the United States, *Dunveganoceras parvum* Cobban (1953) is recorded as coming from the Mosby sandstone member of the Colorado shale, along with *Dunveganoceras albertense montanense* Cobban. There seems to be no record as yet of this fauna south of Montana, and in Texas this zone seems to be represented only by the hiatus between the Woodbine formation and the overlying Eagle Ford shale.

GAUDRYINA IRENENSIS Zone Correlation

The *Gaudryina irenensis* zone has widespread development in the North American picture. The *G. irenensis* zone is as yet unrecognized north of the Peace River area in North America.

The zone in western Canada has an easily identified sandstone member, viz. the Pouce Coupe sandstone, to help in its recognition. The Pouce Coupe sandstone can be recognized over most of the Peace River area by *Inoceramus* cf. *corpulentus* McLearn and *Dunveganoceras albertense* (Warren). *Exogyra columbella levis* Stephenson serves for ready identification of this sand in the areas of outcrop along the foothills of Alberta and British Columbia. In the foothills of the Monkman Pass area of British Columbia, both *Inoceramus* cf. *corpulentus* and *Exogyra columbella levis* indicate this horizon. On Stetson (Deep) creek, tributary of the

Narraway-Torrens River drainage area of Alberta, *Dunveganoceras albertense* and *Exogyra columbella levis* are present in the Pouce Coupe sandstone. On the Kakwa River drainage, Alberta, *Dunveganoceras albertense* is present in the Pouce Coupe sandstone member. At Cadomin, Alberta, the Pouce Coupe sandstone member carries *Inoceramus allani,* and *Dunveganoceras* aff. *conditum* Haas occurs at a distance of 25 feet below the Pouce Coupe sandstone. The writers have not, as yet, traced the Pouce Coupe sand equivalent south of Cadomin, Alberta, but it may well be expected to continue south, as the Mosby sandstone of Montana is in homotaxial equivalence and carries a variety of *Dunveganoceras albertense.*

The faunas of that portion of the *Gaudryina irenensis* zone from below the Pouce Coupe sandstone itself have a much wider recognition. For correlation within the north-central parts of the United States, one basic assumption is here made, viz. both *Dunveganoceras pondi* Haas and *Dunveganoceras conditum* Haas are assumed to be correlative with the lower portions of the *Gaudryina irenensis* zone. In the Montana-Wyoming area, Cobban (1953, p. 47) indicates the following sequence of *Metoicoceras* from the lower part of the Colorado shale:

Metoicoceras whitei
Metoicoceras mosbyense, Dunveganoceras montanense, D. parvum
Metoicoceras n. sp., *Dunveganoceras conditum*
Metoicoceras praecox, Dunveganoceras pondi

Dunveganoceras conditum comes from the upper 50 feet of the Frontier formation near the south end of the Bighorn mountains in Wyoming (Haas 1951, p. 14). In the area northeast of Greybull, Wyoming, *D. pondi* is found in the lower portion of the Cody shale (Haas, 1949), in equivalents of the Torchlight sandstone member of the Frontier formation.

On the northern flank of the Black Hills, *Dunveganoceras* cf. *D. pondi* is reported from the base of the Greenhorn formation (Cobban 1953, p. 47).

Harlan R. Bergquist (1944) reports the following forms from the Coleraine formation of Minnesota, that may be equated to mollusca of the *G. irenensis* zone and part of the underlying *A. gravenori* zone: *Inoceramus fragilis mesabiensis* Bergquist, *Barbatia micronema* (Meek), *Ostrea soleniscus* Meek, *Brachidontes arcturusensis* Bergquist. Haas (1951, p. 5) indicates that *Dunveganoceras* cf. *pondi* may also be added to this suite. E. J. Bolin (1954) reports *Globigerina washitensis* and nine new species of microfauna from the Coleraine formation, distributed among the genera *Ammobaculites, Ammobaculoides, Haplophragmoides* and *Trochammina,* which may well contribute to a more refined correlation. The Coleraine formation carries coarse heavy molluscs of a conglomeratic shoreline facies and, as these biofacies are lacking in the Peace River area, correlation relies on the more tolerant brackish shells.

Correlative faunas are found in the Woodbine formation of Texas. Stephenson (1952, p. 5) records the following members of the Woodbine formation and the present authors suggest the following correlation with the Peace River area:

Texas		Pouce Coupe River area, Alberta	
Woodbine	Templeton member	Pouce Coupe member	Lower Kaskapau formation
	Tarrant member		
	Lewisville member	Doe Creek member	
	Pepper shale?		
	Euless member	Dunvegan formation *s.s.*	
	Dexter member		

AMMOBACULITES GRAVENORI Zone Correlation

The *Ammobaculites gravenori* zone is unknown from north of the Clear Hills of the Peace River area in western Canada. In part, this is a result of erosional stripping, but the zone is clearly missing in the Northwest Territories. In the foothills of British Columbia the zone of *A. gravenori* may be easily recognized from the brackish fauna in the upper part of the Dunvegan formation. Mollusca such as *Elliptio sulfuriensis* and *Parmicorbula sulfuriensis* have been collected by the senior writer and act as an index to the upper part of the "Dunvegan" formation on Pine river above East Pine, below Wartenbe (Table) mountain; on the Murray river above the mouth of Coldbrook creek; on the Wolverine river near the mouth; on Prairie creek south of the Wapiti river. Crossing southeastward into Alberta, this same fauna (*supra*) has been collected by the senior writer from the upper Dunvegan formation on the Narraway river below Flume creek; on Torrens river both above and below Sherman's Flats; on the Kakwa river above Lynx creek and on Lynx creek itself; on Copton creek about ten miles above the mouth; on Sulphur river west of Grande Cache; on the Berland river above the mouth of Persimmon creek.

The *Elliptio sulfuriensis* fauna, as far as may be determined, has not been reported from south of the Athabasca river along the foothills of Alberta. However, the lower part of the "Dunvegan" formation throughout the foothills of Alberta north of Athabasca river carries a fauna of *Inoceramus athabaskensis* McLearn that is

almost contemporaneous with the *Inoceramus dunveganensis* fauna from the topmost beds of the Dunvegan sandstone or the lowest beds of the Kaskapau formation on the Peace river at Dunvegan crossing. On the lower stretches of the Athabasca river in northeastern Alberta, *Inoceramus athabaskensis* McLearn occurs with *Acanthoceras athabascense* Warren and Stelck, n. sp. in the lower part of the Labiche formation, shortly above the fish-scale horizon.

Inoceramus athabaskensis provides a correlation with the Woodbine formation of Texas as the Euless member of the latter formation carries *Inoceramus eulessanus* Stephenson, a form found with *I. athabaskensis* in the lower Dunvegan formation of the Alberta foothills. Several species of *Acanthoceras* are found in Texas in the Lewisville member of the Woodbine formation, lying above the Euless member. *Hillites septarianus* (Cragin) has been described from the Lewisville member (Tarrant) as well, so it appears that the lower part of the Lewisville member of the Woodbine formation should be equated with the *Ammobaculites gravenori* zone of Alberta. This correlation seems supported as *Verneuilinoides perplexus* (Loeblich) found in the *A. gravenori* zone is described from the Pepper shale of Texas, which is a correlative of the lower Lewisville member of the Woodbine formation.

If the correlations with Texas are valid, then the *Ammobaculites gravenori* zone should be represented in the upper part of the Belle Fourche formation of South Dakota and northeastern Wyoming. Fox (1954, p. 112) has described a *Trochammina* sp. 1 from the very top of the Belle Fourche shale that is very similar to *Trochammina wetteri* n. sp. from the *Gaudryina irenensis* zone, immediately overlying the *Ammobaculites gravenori* zone in the Peace River area.

ECOLOGY

The Upper Cenomanian microfauna of the basal Kaskapau shale in the Peace River country has a large number of genera involved, and is almost exclusively arenaceous. The dominant genera in gross are *Haplophragmoides* making up 40 per cent of the fauna, *Trochammina* 20 per cent, and *Ammobaculites* 18 per cent. The fauna tends to have a provincial appearance but this may, in part, be attributed to the slight attention paid so far to Cretaceous arenaceous suites. The dwarfed nature of some of the arenaceous species would lead one to believe that the fauna is of local nature. The following species are particularly tiny forms: *Haplophragmoides crickmayi, Haplophragmoides* cf. *pacalis, Haplophragmoides pacalis, Textularia gravenori, Trochammina rutherfordi* var. 1, *Verneuilinoides perplexus* (Loeblich). In addition, most of the remainder of the species are considerably smaller than the Upper Cretaceous forms of the Gulf Coast region.

The environment of the above fauna is regarded as being very near-shore, and probably cold and brackish in part. There is an abundance of coarsely arenaceous forms, generally indicative of

shallow water. The replacement of the original wall-cement of many specimens by pyrite seems to indicate a rather toxic condition, such as might be encountered in a lagoonal environment. There are no exclusively deep water forms in the fauna, except for the pelagic *Gümbelitria*. Some of the genera such as *Dorothia* have been reported only from shallow water deposits elsewhere, and nearly all of the remaining genera of the Upper Cenomanian assemblages are definitely associated with shallow water habitat. The almost total absence of any calcareous forms, such as might be expected in a warm water environment, seems to indicate cooler conditions similar to those found along the Canadian Atlantic shoreline today.

Except for the appearance of *Gümbelitria* in the latest Cenomanian, there is little indication to be found in the microfauna of the deepening seaways of the approaching Turonian stage.

The megafauna of the late Cenomanian does help in the reading of ecology. The megafauna of the *Ammobaculites gravenori* zone in the Peace River area carries oysters, *Brachidontes* and only forms tolerant to lowered salinity. The *Gaudryina irenensis* zone shows the introduction of more normally marine forms with lesser tolerance to freshening such as *Inoceramus*, and with this fauna, an intermingling of the heavy-ribbed shallow-water types of ammonites such as *Dunveganoceras*. The *Ammobaculites pacalis* zone carries the deep water smooth ammonite *Placenticeras*.

The general picture shows a slowly deepening water, turning in composition from almost fresh to normally saline throughout the lower part of the Kaskapau formation deposition. The low salinity of the *Ammobaculites gravenori* zone is sufficient in the Pine River area of British Columbia to introduce such fresh water genera as *Unio* (*Elliptio*) into the assemblage. In the Pine River area the assemblage of the *Gaudryina irenensis* zone shows the same relative ecology as the underlying *A. gravenori* zone of the Pouce Coupe River area. However, the oysters of the one zone are specifically different from the oysters of the succeeding zone, so the homotaxy of genera does not obscure the time-stratigraphic correlation. This change in species in the brackish faunas indicates that the rate of deposition of sediments at no time was excessive, and that the source area must have lowered somewhat, accompanying the deepening of the late Cenomanian seas.

FORMAL DESCRIPTIONS

Order *Foraminifera*

Genus AMMOBACULITES Cushman, 1910

AMMOBACULITES ALBERTENSIS Stelck and Wall

Plate 2, figures 12, 13, 14, 18, 19

Ammobaculites albertensis Stelck and Wall, 1954, Research Council of Alberta Report No. 68, p. 18, pl. 1, figs. 21, 22.

A large variant form, which is considerably more robust than any of the other figured specimens, is shown on Plate 2, figure 14. The variant exhibits clearly the terminal position of the aperture characteristic of the genus.

Length of paratype (fig. 12): 0.33 mm.; length of ultimate chamber 0.17 mm.; width of ultimate chamber 0.22 mm.

Length of paratype (fig. 13): 0.45 mm.; length of ultimate chamber 0.21 mm.; width of ultimate chamber 0.25 mm.

Length of variant form (fig. 14): 0.68 mm.; length of ultimate chamber 0.34 mm.; width of ultimate chamber 0.38 mm.

Length of holotype (fig. 18): 0.5 mm.; diameter of coiled portion 0.29 mm.; length of ultimate chamber 0.15 mm.; width of ultimate chamber 0.22 mm.

Length of paratype (fig. 19): 0.47 mm.; diameter of coiled portion 0.32 mm.; length of ultimate chamber 0.18 mm.; width of ultimate chamber 0.24 mm.

Holotype and paratype (fig. 19) locality: Imperial Oil Limited Spirit River Structure Test A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 745 feet, 18 feet above the top of the Howard Creek sand in the Kaskapau formation.

Paratype (fig. 12) locality: G45-19 in Lsd. 8, Sec. 4, Tp. 80, Rge. 13, W. 6th Meridian, on the east bank of the Pouce Coupe river, Alberta, Canada, from Kaskapau shales, in a sample taken from 0 to 5 feet above the Pouce Coupe sand.

Paratype (fig. 13) locality: Imperial Oil Limited Spirit River Structure Test A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 816 feet, 26 feet above the top of the Pouce Coupe sand equivalent in the Kaskapau formation.

Variant (fig. 14) locality: As above, at a depth of 747.5 feet, 15.5 feet above the top of the Howard Creek sand in the Kaskapau formation.

Holotype, paratypes and variant: Univ. of Alberta Pal. Type Coll.

AMMOBACULITES ALBERTENSIS HINESENSIS

Stelck and Wall, n. var.

Plate 3, figure 35

Test robust ,earlier portion coiled with slight umbilicus developed, later portion slightly curved; chambers and sutures obscured; wall coarsely arenaceous, angular grains of quartz to 0.15 mm. length studding and partly embedded in a matrix of more finely arenaceous cementing material of grains 0.015 mm. to finer; aperture terminal, not clearly defined.

Length of holotype: 0.84 mm.; diameter of coiled portion 0.45 mm.; diameter of ultimate chamber 0.3 mm.

Holotype locality: S47-27 in Sec. 13, Tp. 80, Rge. 5, W. 6th Meridian, one and one-half miles west of the ferry crossing at Dunvegan, Alberta, Canada, from Kaskapau shales, 2 feet above the Howard Creek sand equivalent.

Holotype: Stanford Univ. Pal. Type Coll.

Remarks: The large size of this form, together with its much coarser wall structure, seem to merit the establishment of a variety.

Name: After Hines River, Alberta.

AMMOBACULITES GRAVENORI Stelck and Wall, n. sp.

Plate 1, figures 1, 2, 3; Plate 3, figure 7

Ammobaculites gravenori (*nomen nudum*), 1954, Research Council of Alberta Report No. 68, pp. 10, 13.

Test somewhat compressed, subcylindrical in cross-section, early part not tightly coiled with five chambers visible in ultimate whorl, later portion in straight series of three to four chambers, occasionally five; sutures distinct, depressed, at right angles to long axis or slightly oblique; wall finely arenaceous, grains averaging 0.015 mm., a few up to 0.03 mm., with a considerable amount of cement, giving a smooth exterior finish; aperture, terminal, at end of short collar, simple, appearing elliptical in compressed specimens.

Length of holotype (Plate 1, fig. 1): 0.44 mm.; diameter of coiled portion 0.17 mm.; length of ultimate chamber 0.15 mm.; width of ultimate chamber 0.14 mm.

Length of paratype (Plate 1, fig. 2): 0.44 mm.
Length of paratype (Plate 1, fig. 3): 0.76 mm.
Length of hypotype (Plate 3, fig. 7): 0.65 mm.

Holotype locality: Imperial Oil Limited Spirit River Structure Test A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 930 feet, 125 feet above the projected base of the Kaskapau formation.

Paratype (Plate 1, fig. 2) locality: G45-5 in Lsd. 13, Sec. 10, Tp. 81, Rge. 13, W. 6th Meridian, on Doe creek, Alberta, Canada, from

Kaskapau shales, at a footage of 165 below the base of the Pouce Coupe sand.

Paratype (Plate 1, fig. 3) locality): Same as for holotype, at a depth of 937.5 feet.

Hypotype locality: S47-4, geographically identical with locality G45-5, from Kaskapau shales, 172 feet below Pouce Coupe sandstone member.

Holotype and paratypes: Univ. of Alberta Pal. Type Coll.

Hypotype: Stanford Univ. Pal. Type Coll.

Horizon: This species is restricted to the basal portion of the Kaskapau formation at all localities, rarely occurring above the top of the *Ammobaculites gravenori* zone, and unrecorded to date above the top of the *Gaudryina irenensis* zone, that is, the top of the Pouce Coupe sand. Maximum development occurs in the Spirit River section at a footage of 115 above the base of the Kaskapau; at the Dunvegan locality of C47-9 at a footage of 95 above the base; at the Doe Creek localities of G45-5 and S47-4 at a footage of approximately 155 above the base of the Kaskapau.

Comparison: This species is similar to *Ammobaculites tyrrelli* Nauss, in having the same type of wall structure, transverse sutures, and an apertural accentuation. However, *A. tyrrelli* is a much more robust form than this species, and differs also in having a more involute coiled portion. Furthermore, the chamber dimensions in the two species are different, with the length and width of the chambers in the uniserial portion of *A. gravenori* being approximately equal, whereas in *A. tyrrelli* the length is much shorter than the width.

Name: After Dr. Conrad P. Gravenor, Assistant Professor, Department of Geology, University of Alberta.

AMMOBACULITES cf. A. GRAVENORI

Plate 3, figures 16, 17

Test small, earlier portion closely coiled revealing five to six chambers, later portion straight series of three chambers, ultimate chamber longer than the preceding chambers, ultimate chamber with slight pyriform shape; sutures indistinct on later portion, impressed on earlier coiled portion; wall arenaceous with much finely arenaceous cement embedding variously sized sand grains to 0.02 mm. in size, aperture simple, terminal, about 0.03 mm. in diameter.

Length of figured specimen: 0.34 mm.; diameter of coiled portion 0.15 mm.; diameter of ultimate chamber 0.13 mm.; length 0.13 mm.

Locality of figured specimen: S47-4 in Lsd. 13, Sec. 10, Tp. 81, Rge. 13, W. 6th Meridian, on Doe creek, Alberta, Canada, from Kaskapau shales, 37 feet below Pouce Coupe sandstone.

Figured specimen: Stanford Univ. Pal. Type Coll.

Comparison: This form is close to *A. gravenori*, but the coiled portion of the former is more involute, and its sutures are indistinct. The finish of *A. gravenori* is much smoother than this form which is being referred to the species provisionally.

AMMOBACULITES OBLIQUUS Loeblich and Tappan

Plate 1, figures 7, 8; Plate 3, figures 18, 19

Ammobaculites obliquus Loeblich and Tappan, 1949. Jour. Washington Acad. Sci., vol. 39, p. 90.

Ammobaculites obliquus Loeblich and Tappan, 1949. Jour. Paleontology, vol. 23, p. 250, pl. 46, figs. 4-5.

Ammobaculites obliquus Loeblich and Tappan, 1950, Univ. of Kansas Paleontological Contrib., Protozoa, Article 3, p. 7, pl. 1, figs. 14-17.

Ammobaculites obliquus Loeblich and Tappan. Frizzell, 1954, Texas Bureau of Econ. Geol. Rept. of Investigations No. 22, p. 62, pl. 2, fig. 29.

Test somewhat compressed, with early portion close coiled revealing five chambers in ultimate whorl; later portion, of three to four chambers, in slightly curved unilinear series, nearly equal in size except for ultimate one which is considerably longer and pyriform; sutures indistinct in non-pyritized forms, oblique, slightly arcuate to arcuate; wall finely arenaceous with grains averaging 0.015 mm., a few up to 0.03 mm., amount of cement not great; aperture elliptical, terminal.

Length of specimen (Plate 1, fig. 7): 0.64 mm.

Length of specimen (Plate 1, fig. 8): 0.74 mm.; diameter of coiled portion 0.25 mm.; length of ultimate chamber 0.22 mm.; width of ultimate chamber 0.24 mm.

Length of specimen (Plate 3, figs. 18, 19): 0.5 mm.; vertical diameter of coiled portion 0.15 mm.

Locality of specimen (Plate 1, fig. 7): Imperial Oil Limited Spirit River Structure Test A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 956 feet, 99 feet above the projected base of the Kaskapau formation.

Locality of specimen (Plate 1, fig. 8): Imperial Oil Limited Spirit River No. 1 Well in Lsd. 12, Sec. 20, Tp. 78, Rge. 6, W. 6th Meridian, Alberta, Canada, at a depth of 1062 feet, 47 feet above the base of the Kaskapau formation.

Locality of specimen (Plate 3, figs. 18, 19): S47-4 in Lsd. 13, Sec. 10, Tp. 81, Rge. 13, W. 6th Meridian, on Doe creek, Alberta, Canada, from Kaskapau shales, 196 feet below Pouce Coupe sandstone.

Specimens (Plate 1, figs. 7, 8): Univ. of Alberta Pal. Type Coll.

Specimen (Plate 3, figs. 18, 19): Stanford Univ. Pal. Type Coll.

Horizon: At Spirit River, this pre-Pouce Coupe form is restricted to the *Ammobaculites gravenori* zone, with maximum development occurring at a footage of 45 above the base of the Kaskapau formation. At the Doe Creek locality of S47-4, the strongest occurrence of this species was recorded at a footage of 72 above the base of the Kaskapau.

AMMOBACULITES PACALIS Stelck and Wall

Plate 2, figures 20, 21; Plate 3, figures 3, 4, 5

Ammobaculites pacalis Stelck and Wall, 1954, Research Council of Alberta Report No. 68, p. 18, pl. 1, fig. 19.

Length of holotype (Plate 2, fig. 21): 0.64 mm.; width of coiled portion 0.23 mm.; length of coiled portion 0.18 mm.; length of ultimate chamber 0.22 mm.; width of ultimate chamber 0.17 mm.

Length of paratype (Plate 2, fig. 20): 0.4 mm.; width of coiled portion 0.2 mm.; length of coiled portion 0.13 mm.

Length of hypotype (Plate 3, figs. 3, 4, 5): 0.5 mm.; diameter of coiled portion 0.23 mm; length of ultimate chamber 0.21 mm.; diameter 0.2 mm.

Holotype locality: Imperial Oil Limited Spirit River Structure Test A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 747.5 feet, 15.5 feet above the top of the Howard Creek sand in the Kaskapau formation.

Paratype locality: G45-4 in Lsd. 3, Sec. 16, Tp. 79, Rge. 13, W. 6th Meridian, at Henderson creek, Alberta, Canada, from Kaskapau shales, at a footage of 55 below the "white chalcedonic bed" or approximately 145 feet above the projected top of the Pouce Coupe sand.

Hypotype locality: S47-28 in Sec. 13, Tp. 80, Rge. 5, W. 6th Meridian, one and one-half miles west of the ferry crossing at Dunvegan, Alberta, Canada, from Kaskapau shales, 9 feet below the Howard Creek sand equivalent.

Holotype and paratype: Univ. of Alberta Pal. Type Coll.

Hypotype: Stanford Univ. Pal. Type Coll.

AMMOBACULITES SPIRITENSIS Stelck and Wall, n. sp.

Plate 1, figure 4

Ammobaculites spiritensis (*nomen nudum*), 1954, Research Council of Alberta Report No. 68, p. 10.

Test roughly square in outline, compressed, consisting only of a closely coiled early portion with seven chambers visible in ultimate whorl; wall coarsely arenaceous, with sharply angular grains of about 0.04 mm. in maximum diameter, very little cement present giving mosaic appearance to the test, and a transparent glaze to the exterior; sutures slightly curved, slightly raised, thickened; aperture simple, near the peripheral margin on the ultimate face.

Maximum diameter of holotype: 0.42 mm.; thickness 0.15 mm.

Holotype locality: G45-5 in Lsd. 13, Sec. 10, Tp. 81, Rge. 13, W. 6th Meridian, on Doe creek, Alberta, Canada, from Kaskapau shales, at a footage of 110 below the base of the Pouce Coupe sand.

Holotype: Univ. of Alberta Pal. Type Coll.

Horizon: Most of the specimens of this rather rare species are found at the Doe Creek localities G45-5 and S47-4, where maximum

development occurs at a footage of 155 above the base of the Kaskapau formation, with the species rarely being observed above this level.

Only one positive identification was made in the Spirit River Structure Test hole at a footage of 94 above the base of the Kaskapau. Excessive pyritization of many lower Kaskapau forms in the Spirit River area renders any further identifications of this species questionable.

Comparison: This species is similar to *Haplophragmoides rugosa* Cushman and Waters from the Upper Cretaceous Navarro formation of Texas in having an identical wall structure, that is, one composed of neatly fitting angular grains. However, the Canadian species is much compressed, thinner, and is readily distinguished by its broad sutures. The position of the aperture retains this species in *Ammobaculites*.

Name: After the village of Spirit River, Alberta.

Genus AMMOMARGINULINA Wiesner, 1931

AMMOMARGINULINA LORANGERAE Stelck and Wall, n. sp.

Plate 1, figures 13, 27

Ammomarginulina lorangerae (*nomen nudum*), 1954, Research Council of Alberta Report No. 68, p. 10.

Test compressed, flat, wide, with early portion close coiled and comprising one-third to one-half of test, five chambers in ultimate whorl; uncoiled portion consisting of two chambers, penultimate one trapezoid-shaped; sutures indistinct in non-pyritized specimens, depressed, oblique, very slightly arcuate, with ultimate suture extending back almost to coiled portion; wall finely arenaceous, grains averaging 0.03 mm., amount of cement not great; aperture elliptical, terminal.

A variant form (fig. 27) differs from the species *sensu stricto* in having much more cement in the wall, thus imparting to it a smoother external appearance. The ultimate suture in the variant is definitely arcuate and bends back to the first chamber of the coiled portion.

Length of holotype (fig. 13): 0.58 mm.; diameter of coiled portion 0.33 mm.

Length of variant (fig. 27): 0.45 mm.; diameter of coiled portion 0.26 mm.

Holotype locality: Imperial Oil Limited Spirit River Structure Test A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 956 feet, 99 feet above the projected base of the Kaskapau formation.

Variant locality: G45-5 in Lsd. 13, Sec. 10, Tp. 81, Rge. 13, W. 6th Meridian, on Doe creek, Alberta, Canada, from Kaskapau shales, at a footage of 105 below the base of the Pouce Coupe sand.

Holotype and variant: Univ. of Alberta Pal. Type Coll.

Horizon: At Spirit River, the species *s.s.* occurs more commonly in the *Ammobaculites gravenori* zone (with almost equal numbers of specimens being recorded at footages of 47 and 96 above the base of the Kaskapau formation) than in the overlying *Gaudryina irenensis* zone, and is not found above the Pouce Coupe sand equivalent. One questionable specimen is found at the Dunvegan locality of C47-9, from a footage of 115 above the base of the Kaskapau. At the Doe Creek localities of G45-5 and S47-4, maximum development occurs at footages of approximately 75 above the base of the Kaskapau.

The variant form has been recognized only at the Doe Creek localities of G45-5 and S47-4, where it is restricted to the *Ammobaculites gravenori* zone of the basal Kaskapau formation, with maximum development occurring at footage of 155 above the base of the Kaskapau.

Name: After Diane M. Loranger, Micropaleontologist, Imperial Oil Limited, Calgary.

AMMOMARGINULINA cf. A. LORANGERAE

Plate 3, figures 27, 28

Test compressed, earlier portion closely coiled, later portion in straight serial design with later chambers obliquely embracing previous chamber, five chambers visible in coiled portion, three chambers in straight portion; sutures indistinct, later sutures strongly oblique with sigmoid trace on straight portion; wall finely arenaceous with much siliceous cement obscuring the surface of grains and giving a slightly pustulose appearance to the external wall; aperture terminal, simple, diameter 0.06 mm.

Length of figured specimen: 0.55 mm.; diameter of coiled portion 0.24 mm.; length of ultimate chamber 0.25 mm.; width of ultimate chamber 0.23 mm.; length of penultimate chamber 0.24 mm.; visible length of penultimate chamber 0.12 mm.

Locality of figured specimen: S47-4 in Lsd. 13, Sec. 10, Tp. 81, Rge. 13, W. 6th Meridian, on Doe creek, Alberta, Canada, from Kaskapau shales, 196 feet below Pouce Coupe sandstone member.

Figured specimen: Stanford Univ. Pal. Type Coll.

Horizon: This form has not been differentiated from *A. lorangerae* in the various localities studied. It appears to be confined to the basal Kaskapau beds.

Comparison: This form is very close to *A. lorangerae*, but has a larger straight portion where the later chambers obliquely embrace the previous chamber.

A. cf. *lorangerae* is similar in some respects to *Ammobaculites obliquus* Loeblich and Tappan, but is wider and flatter than the latter form which also lacks the peculiar embracing relationship of the later chambers in *A.* cf. *lorangerae*.

Genus BATHYSIPHON M. Sars, 1872

BATHYSIPHON sp.

Plate 3, figure 6

Test elongate, a straight cylindrical chamber open at both ends, with thick walls composed of finely arenaceous cement material, with a smooth finish on the exterior, slightly oblique transverse weaknesses act as fracture points determining the lengths of specimens recovered.

Length of figured specimen: 0.32 mm.; diameter 0.07 mm.; distance between transverse partings 0.05 mm.

Locality of figured specimen: S47-4 in Lsd. 13, Sec. 10, Tp. 81, Rge. 13, W. 6th Meridian, on Doe creek, Alberta, Canada, from lower Kaskapau shales, 129 feet below Pouce Coupe sandstone member.

Figured specimen: Stanford Univ. Pal. Type Coll.

Horizon: No occurrences recorded other than at the type locality and level.

Remarks: This is an extremely thin *Bathysiphon* of one-third the diameter of *Bathysiphon alexanderi* Cushman but similar in wall make-up to the latter species.

Genus DOROTHIA Plummer, 1931

DOROTHIA KASKAPAUENSIS Stelck and Wall, n. sp.

Plate 2, figure 7

Dorothia kaskapauensis (*nomen nudum*), 1954, Research Council of Alberta Report No. 68, p. 11.

Test rather stubby, usually found in a pyritized or partially pyritized state, rarely non-pyritized; first two whorls of four to five chambers each, followed by about one and one-half whorls of chambers in triserial arrangement, last three or four chambers added biserially; sutures slightly depressed, fairly distinct in pyritized forms; wall finely arenaceous, grains of 0.01 mm. or smaller, considerable amount of cement; aperture an arch at the inner margin of the terminal face.

Length of holotype: 0.31 mm.; maximum width of holotype 0.13 mm.

Holotype locality: Imperial Oil Limited Spirit River Structure Test A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 830 feet, 12 feet above the top of the Pouce Coupe sand equivalent in the Kaskapau formation.

Holotype: Univ. of Alberta Pal. Type Coll.

Horizon: This post-Pouce Coupe species has not been recognized outside of the Spirit River area, where it is confined to the *Ammobaculites pacalis* zone, with maximum development occurring in the interval 2 to 12 feet above the Pouce Coupe sand equivalent.

Name: After the Kaskapau formation.

DOROTHIA KASKAPAUENSIS GRACILIS

Stelck and Wall, n. var.

Plate 2, figure 8

Dorothia kaskapauensis var. *gracilis* (*nomen nudum*), 1954, Research Council of Alberta Report No. 68, p. 11.

Test slender, elongate, generally preserved as a pyritized or partially pyritized replacement; first two whorls of four to five chambers each, followed by about four twisted whorls of much larger chambers arranged triserially, final two chambers added biserially; sutures slightly depressed, fairly distinct in pyritized forms; wall finely arenaceous, grains of 0.01 mm. or smaller, considerable amount of cement; aperture an arch at the inner margin of the terminal face.

Length of holotype: 0.34 mm.; maximum width 0.1 mm.

Holotype locality: Imperial Oil Limited Spirit River Structure Test A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 834 feet, 8 feet above the top of the Pouce Coupe sand equivalent in the Kaskapau formation.

Holotype: Univ. of Alberta Pal. Type Coll.

Range: This post-Pouce Coupe form has not been recognized outside of the Spirit River area where, in close association with *Dorothia kaskapauensis* Stelck and Wall n. sp., it is confined to the *Ammobaculites pacalis* zone. Maximum development occurs at the same level as does *D. kaskapauensis*, that is in the interval 2 to 12 feet above the Pouce Coupe sand equivalent.

Comparison: This varietal form differs from *D. kaskapauensis* in being more slender, and in having a longer triserial portion.

Genus FLABELLAMMINA Cushman, 1928

FLABELLAMMINA cf. F. HENDERSONENSIS Stelck and Wall

Plate 1, figure 24

Flabellammina hendersonensis Stelck and Wall, 1954, Research Council of Alberta Report No. 68, p. 20, pl. 2, figs 17, 18.

Test compressed, large, periphery broadly rounded, coiled portion small, with three or four chambers visible; later portion of five chambers, with four chambers of approximately equal size, first three elongate triangular-shaped, fourth elongate rectangular, followed by a considerably larger ultimate trapezoid chamber, giving truncated appearance to distal end of test; sutures slightly depressed, not too distinct, arcuate, all extending back to about the same point in coiled section, save ultimate one, which fails to reach early portion; wall of sharply angular quartz grains, averaging about 0.04 mm., but some almost twice this size, neatly placed in a flat mosaic on the later chambers, embedded in a matrix of much finer, light orange, arenaceous cementing material; aperture terminal, elliptical.

Length of figured specimen: 0.89 mm.; maximum width 0.6 mm.

Locality of figured specimen: C47-9 in Sec. 8, Tp. 80, Rge. 4, W. 6th Meridian, on the north bank of the Peace River, about one-half mile downstream from the ferry at Dunvegan, Alberta, Canada, from Kaskapau shales, 95 feet above the base of the formation.

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

Horizon: This form is restricted to the *Ammobaculites gravenori* zone of the lower Kaskapau formation at Dunvegan and Spirit River. It occurs most commonly at the Dunvegan locality of C47-9, with maximum development being recorded at a footage of 95 above the base of the formation. At Spirit River the acme of this form occurs at a footage of 111 above the base of the Kaskapau. Several questionable occurrences are noted from the Doe Creek locality G45-5 at various footages above the Kaskapau base.

Comparison: This form differs from *F. hendersonensis* Stelck and Wall in having two or three more chambers in the later portion of the test, in the truncated appearance of the distal end of the test, and in the neat flat mosaic arrangement of the quartz grains in the wall, as compared to the rough and uneven surface in *F. hendersonensis.* The form is being retained provisionally in *F. hendersonensis,* although further detailed biostratigraphic studies may well warrant the establishment of another taxonomic unit.

FLABELLAMMINA IRENENSIS Stelck and Wall, n. sp.

Plate 1, figures 17, 20; Plate 3, figures 1, 2

Flabellammina irenensis (nomen nudum), 1954, Research Council of Alberta Report No. 68, pp. 10, 13.

Test elongate, rectangular in cross-section in well preserved specimens, usually found considerably flattened, early portion tightly coiled and involute, with three chambers visible; later uncoiled portion consisting of three chambers, antepenultimate one roughly triangular-shaped, with last two rhomboidal; sutures flush in coiled portion, slightly depressed in uniserial part, last two slightly arcuate with penultimate one extending back to initial chamber of coiled portion; wall of variable size quartz grains, with the odd one up to 0.11 mm., embedded in a matrix of much finer, yellow and grey, arenaceous cementing material, giving a smooth over-all finish to the exterior; aperture terminal, elliptical, slit-like.

Length of holotype (Plate 1, fig. 20): 0.72 mm.; width of coiled portion 0.27 mm.

Length of immature form (Plate 1, fig. 17): 0.44 mm.; width of coiled portion 0.29 mm.

Length of hypotype (Plate 3, figs. 1, 2): 0.6 mm.; width 0.3 mm.; length of ultimate chamber 0.43 mm.; length of penultimate chamber 0.15 mm.

Holotype locality: G45-5 in Lsd. 13, Sec. 10, Tp. 81, Rge. 13, W. 6th Meridian, on Doe creek, Alberta, Canada, from Kaskapau shales at a footage of 110 below the base of the Pouce Coupe sand.

Locality of immature form: As above, at a footage of 105 below the base of the Pouce Coupe sand.

Hypotype locality: S47-4, geographically identical with G45-5, from Kaskapau shales, 97 feet below the base of the Pouce Coupe sand.

Holotype and immature form: Univ. of Alberta Pal. Type Coll.

Hypotype: Stanford Univ. Pal. Type Coll.

Horizon: This form has not been identified outside of the Doe Creek locality G45-5, where it reaches its acme at a footage of 175 above the base of the Kaskapau formation, and also occurs sporadically in the overlying *Gaudryina irenensis* zone.

Comparison: This species seems closely related to *Flabellammina warreni* Stelck and Wall, n. sp., as both forms are elongate, have similar tightly coiled, early portions, and the same suture pattern. *F. irenensis*, however, is rectangular in cross-section and only slightly compressed, has one less chamber in its later portion, and shows a much greater range of grain size in its wall structure.

FLABELLAMMINA KASKAPAUENSIS Stelck and Wall, n. sp.

Plate 1, figures 22, 23

Flabellammina kaskapauensis (nomen nudum), 1954, Research Council of Alberta Report No. 68, pp. 10, 13.

Test compressed, nearly flat, periphery rounded in mature specimens, early portion fairly small, closely coiled with about five chambers visible; later portion of four rapidly enlarging chambers, first three triangular in shape, ultimate trapezoid; sutures flush or slightly depressed, obscure, arcuate, all reaching back to coiled portion; wall arenaceous, with grains averaging about 0.02 mm. in mature specimens, moderate amount of cement (younger specimens and some outcrop forms have smaller grains and more cement), finish not too smooth; aperture terminal, elliptical, at the distal end of the final chamber in mature specimens, below the outer point of the ultimate chamber in young forms.

Length of holotype (fig. 22): 0.75 mm.; diameter of coiled portion 0.29 mm.

Length of paratype (fig. 23): 0.45 mm.

Holotype locality: Imperial Oil Limited Spirit River No. 1 Well in Lsd. 12, Sec. 20, Tp. 78, Rge. 6, W. 6th Meridian, Alberta, Canada, at a depth of 1013 feet, 96 feet above the base of the Kaskapau formation.

Paratype locality: Imperial Oil Limited Spirit River Structure Test A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 937.5 feet, 117.5 feet above the projected base of the Kaskapau formation.

Holotype and paratype: Univ. of Alberta Pal. Type Coll.

Horizon: This species occurs most characteristically in the *Ammobaculites gravenori* zone of the lower Kaskapau formation,

being restricted to this zone at Spirit River where the greatest number of specimens, particularly of the younger forms, are found at the extreme base of the formation, only 5 feet above the Dunvegan-Kaskapau contact. More mature forms occur most frequently at levels about 100 feet above the base of the formation at Spirit River. At the Doe Creek localities of G45-5 and S47-4, maximum development occurs at a footage of 90 above the base of the formation, with some specimens being found in the *Gaudryina irenensis* zone. Only one specimen has been identified at the Dunvegan locality of C47-9 from a footage of 95 above the base of the Kaskapau.

Comparison: This species is similar in some respects to *Flabellammina warreni* Stelck and Wall, n. sp. but has a more evolute early portion, and a curved later portion with sutures which extend back to the coiled portion, as opposed to the elongate later portion of *F. warreni*. The finish of *F. kaskapauensis* is not as smooth as in *F. warreni*.

F. kaskapauensis may well represent the ancestral stage of *F. warreni*.

FLABELLAMMINA WARRENI Stelck and Wall, n. sp.

Plate 1, figures 25, 26

Flabellammina warreni (*nomen nudum*), 1954, Research Council of Alberta Report No. 68, p. 10.

Test much compressed, oblong, elongate, early portion close coiled, indistinct, about three chambers visible; later portion of four chambers, ultimate chamber somewhat larger than penultimate one, but often distorted and appearing much larger than its true size (as in paratype, fig. 26); sutures slightly depressed, faint in subsurface forms, generally more distinct in surface specimens, oblique and slightly arcuate, extending back towards coiled portion, but ultimate one and usually penultimate one also failing to reach same; wall arenaceous, grains of about 0.015 mm. in subsurface forms, 0.02 mm. in surface forms, with a moderate amount of cement, apparently more in surface specimens which usually have a smoother finish; aperture terminal, elliptical.

Length of holotype (fig. 25): 0.82 mm.

Length of paratype (fig. 26): 0.82 mm.; maximum length of ultimate chamber 0.44 mm.

Holotype locality: Imperial Oil Limited Spirit River Structure Test A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 937 feet, 118 feet above the projected base of the Kaskapau formation.

Paratype locality: G45-5 in Lsd. 13, Sec. 10, Tp. 81, Rge. 13, W. 6th Meridian, on Doe creek, Alberta, Canada, from Kaskapau shales, at a footage of 105 below the base of the Pouce Coupe sand.

Holotype and paratype: Univ. of Alberta Pal. Type Coll.

Horizon: At Spirit River, this species is restricted to the *Ammobaculites gravenori* zone of the basal Kaskapau formation, with maximum development being noted at a footage of 115 above the base. This form occurs more commonly in the *Ammobaculites gravenori* zone at the Doe Creek locality of G45-5, with maximum development occurring at a footage of 155 above the base of the Kaskapau, but with some specimens being observed in the overlying *Gaudryina irenensis* zone.

Comparison: This species is similar to *Flabellammina irenensis* Stelck and Wall, n. sp., in that both forms are elongate, have similar tightly coiled early portions, and the same suture pattern. *F. warreni* differs from *F. irenensis* in being much more compressed, in having an additional chamber in its later portion, and in possessing a consistently finely arenaceous wall.

Again, this species is similar to *F. kaskapauensis* Stelck and Wall, n. sp., but possesses a more involute early portion and an elongate, nearly straight, later portion, compared to the curved later portion of the latter species. The finish of *F. warreni* is smoother than that of *F. kaskapauensis.*

Name: After Dr. Percival S. Warren, Head, Department of Geology, University of Alberta.

FLABELLAMMINA WEBBI Stelck and Wall, n. sp.

Plate 1, figures 18, 19, 21

Flabellammina webbi (*nomen nudum*), 1954, Research Council of Alberta Report No. 68, p. 10.

Test compressed, usually found as a pyritized replacement, periphery narrowly rounded, early portion small, close coiled with four or five chambers visible; later portion of six gradually enlarging, sickle-shaped chambers; sutures flush, fairly distinct in pyritized or partly pyritized forms, obscure in non-pyritized forms, strongly arcuate in later portion, extending back toward coiled portion, but failing to reach same; wall, in non-pyritized forms, arenaceous, grains averaging about 0.015 mm., moderate amount of cement; in pyritized forms, appearing much more smoothly finished with grain size imperceptible; aperture terminal, elliptical, slightly produced.

A variant form (fig. 21) differs from the species *sensu stricto* in being less compressed and in having fewer chambers in both the early and later portions of the test. The sutures in the later portion of the variant extend back to reach the coiled portion, whereas they fail to do so in the species proper.

Length of holotype (fig. 18): 0.79 mm.; diameter of coiled portion 0.2 mm.

Length of paratype (fig. 19): 0.73 mm.

Length of variant (fig. 21): 0.75 mm.; maximum width 0.37 mm.

Holotype locality: Imperial Oil Limited Spirit River No. 1 Well in Lsd. 12, Sec. 20, Tp. 78, Rge. 6, W. 6th Meridian, Alberta, Canada,

at a depth of 1011 feet, 98 feet above the base of the Kaskapau formation.

Paratype locality: As above, at a depth of 1013 feet, 96 feet above the base of the Kaskapau formation.

Variant locality: G45-5 in Lsd. 13, Sec. 10, Tp. 81, Rge. 13, W. 6th Meridian, on Doe creek, Alberta, Canada, from Kaskapau shales, at a footage of 115 below the base of the Pouce Coupe sand.

Holotype, paratype and variant: Univ. of Alberta Pal. Type Coll.

Horizon: The species *s.s.* is restricted to the *Ammobaculites gravenori* zone of the lower Kaskapau formation, attaining its acme at an approximate footage of 100 above the base of the formation at Spirit River. It has not been recognized at any of the other localities.

The variant form has not been positively recognized outside of the Doe Creek locality of G45-5, where it is confined to the *Ammobaculites gravenori* zone of the lower Kaskapau formation, with maximum development occurring at a footage of 115 below the base of the Pouce Coupe sand, or 155 feet above the base of the Kaskapau. At Spirit River, several questionable specimens were recovered at a footage of 113 above the base of the Kaskapau.

Name: After J. B. Webb, Exploration Manager, Anglo-Canadian Oil Company, Limited, Calgary, formerly of Imperial Oil Limited.

Genus GAUDRYINA d'Orbigny, 1839

GAUDRYINA IRENENSIS Stelck and Wall, n. sp.

Plate 2, figures 4, 5

Gaudryina irenensis (*nomen nudum*), 1954, Research Council of Alberta Report No. 68, pp. 10, 13.

Test elongate, early portion stubby, triserial, of about nine chambers (some forms, probably microspheric specimens, have an additional two whorls of tiny chambers at the base); intermediate triserial twisted portion of two to three whorls; biserial portion of four chambers; sutures fairly distinct, depressed; wall rather finely arenaceous, grains averaging about 0.015 mm., with a moderate amount of cement; aperture a deep notch at the inner margin of the ultimate chamber, extending well up onto the terminal face.

Length of holotype (fig. 4): 0.52 mm.; maximum width 0.18 mm.

Length of paratype (fig. 5): 0.43 mm.; maximum width 0.17 mm.

Holotype locality: Imperial Oil Limited Spirit River Structure Test A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 876 feet, 22 feet below the base of the Pouce Coupe sand equivalent in the Kaskapau formation.

Paratype locality: G45-5 in Lsd. 13, Sec. 10, Tp. 81, Rge. 13, W. 6th Meridian on Doe creek, Alberta, Canada, from Kaskapau shales, at a footage of 85 below the base of the Pouce Coupe sand.

Holotype and paratype: Univ. of Alberta Pal. Type Coll.

Horizon: This pre-Pouce Coupe form does not occur above the top of the zone bearing its name. At Spirit River, it occurs fairly commonly over an interval, 140 to 185 feet above the base of the Kaskapau formation, with maximum development apparently occurring at a footage of 150 above the Dunvegan formation. Several specimens are found at the Dunvegan locality of C47-9 in samples taken at footages of 125 and 135 (top of the sampled section) above the base of the Kaskapau. At the Doe Creek locality of G45-5, maximum development appears to occur at a footage of 175 above the base of the Kaskapau, with no positive identifications being recorded from higher levels.

Comparison: This species is similar to *Gaudryina hectori* Nauss from the Lloydminster shale of eastern Alberta, in that it is approximately the same size, has identical sutures, and the same general type of wall structure. However, *Gaudryina irenensis* has a stouter triserial portion, and does not become biserial until rather late in its development, as opposed to the relatively long biserial stage in *Gaudryina hectori*. *G. irenensis* has less cement than *G. hectori*, thus not appearing as smoothly finished as the latter.

GAUDRYINA SPIRITENSIS Stelck and Wall, n. sp.

Plate 2, figures 9, 10; Plate 3, figures 8, 9, 10, 11, 12

Gaudryina spiritensis (*nomen nudum*), 1954, Research Council of Alberta Report No. 68, p. 13.

Test small, twisted; early triserial portion of about three whorls, later biserial portion of two whorls; sutures fairly distinct, depressed; wall finely arenaceous, the largest grains about 0.01 mm., with a considerable amount of cement, giving a rather smooth exterior finish, particularly noticeable in surface specimens; aperture a notch at the inner margin of the ultimate chamber, extending well up onto the terminal face.

Length of holotype (Plate 2, fig. 9): 0.31 mm.; maximum width 0.14 mm.

Length of paratype: (Plate 2, fig. 10): 0.24 mm.; maximum width 0.12 mm.

Length of hypotype (Plate 3, figs. 8, 9): 0.22 mm.; maximum width 0.1 mm.

Length of hypotype (Plate 3, figs. 10, 11, 12): 0.22 mm.; maximum width 0.12 mm.; thickness 0.06 mm.

Holotype locality: Imperial Oil Limited Spirit River No. 1 Well in Lsd. 12, Sec. 20, Tp. 78, Rge. 6, W. 6th Meridian, Alberta, Canada, at a depth of 1018 feet, 91 feet above the base of the Kaskapau formation.

Paratype locality: G45-5 in Lsd. 13, Sec. 10, Tp. 81, Rge. 13, W. 6th Meridian on Doe creek, Alberta, Canada, from Kaskapau shales, at a footage of 115 below the base of the Pouce Coupe sand.

Hypotype (Plate 3, figs. 8, 9) locality: S47-4, geographically identical with G45-5, from Kaskapau shales, 97 feet below the base of the Pouce Coupe sand.

Hypotype (Plate 3, figs. 10, 11, 12) locality: As above, at a footage of 186 below the base of the Pouce Coupe sand.

Holotype and paratype: Univ. of Alberta Pal. Type Coll.

Hypotypes: Stanford Univ. Pal. Type Coll.

Horizon: This species does not occur above the top of the *Gaudryina irenensis* zone, and thus can be listed as a pre-Pouce Coupe guide fossil. At Spirit River, about equal numbers of specimens were recovered at footages of 90 and 137 above the base of the Kaskapau formation. Several specimens were found at the Dunvegan locality of C47-9 at a footage of 125 above the base. At the Doe creek localities of G45-5 and S47-4, maximum development occurs at an approximate footage of 140 above the base of the Kaskapau.

Genus GÜMBELITRIA Cushman, 1933

GÜMBELITRIA CRETACEA SPIRITENSIS

Stelck and Wall, n. var.

Plate 2, figure 11

Gümbelitra cretacea var. *spiritensis* (*nomen nudum*), 1954, Research Council of Alberta Report No. 68, p. 11.

Test gradually tapering, twisted about one-third of the distance from the apertural end, where the chamber arrangement changes from three to two to a whorl; chambers, eighteen in triserial portion, three to four in biserial portion, expanding rather rapidly, and inflated, with those in biserial portion much larger and more inflated than the earlier chambers; sutures distinct, depressed; wall calcareous, finely perforate; aperture a large semi-circular opening at the inner margin of the ultimate chamber.

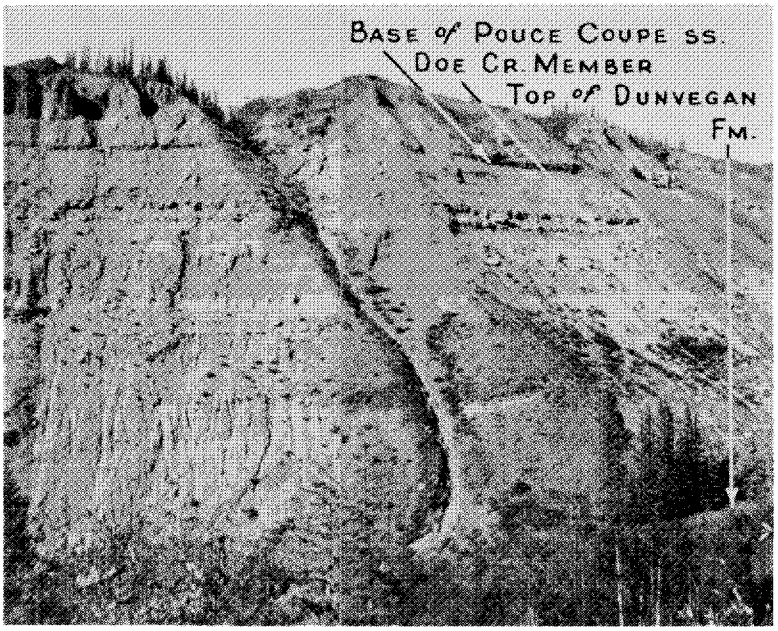
Length of holotype: 0.28 mm.; maximum width 0.12 mm.

Holotype locality: Imperial Oil Limited Spirit River Structure Test A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 782 feet, 60 feet above the top of the Pouce Coupe sand equivalent in the Kaskapau formation.

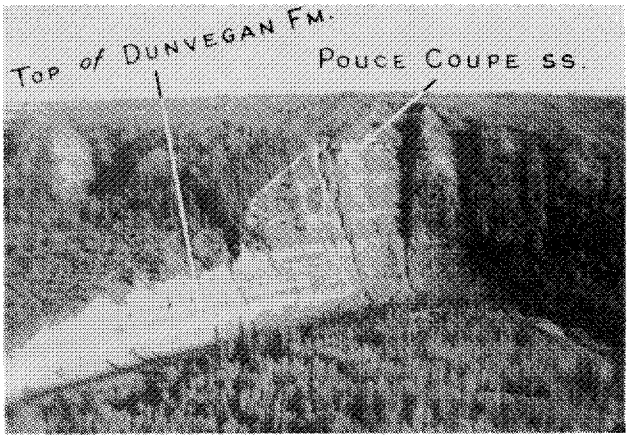
Holotype: Univ. of Alberta Pal. Type Coll.

Range: This rather rare form is restricted for the most part to the *Ammobaculites pacalis* zone of the central Kaskapau formation, with one isolated occurrence being recorded in the *Ammobaculites gravenori* zone of the lower Kaskapau. It has not been recognized outside of the Spirit River area.

FIG. 6



(a) Outcrop of lower Kaskapau shales, Doe creek, Alberta. Locality S47-4, Lsd. 13, Sec. 10, Tp. 81, Rge. 13, W. 6th Mer.



(b) Outcrop of lower Kaskapau shales, Pouce Coupe river, Alberta; Lsd. 2, Sec. 15, Tp. 80, Rge. 13, W. 6th Mer.

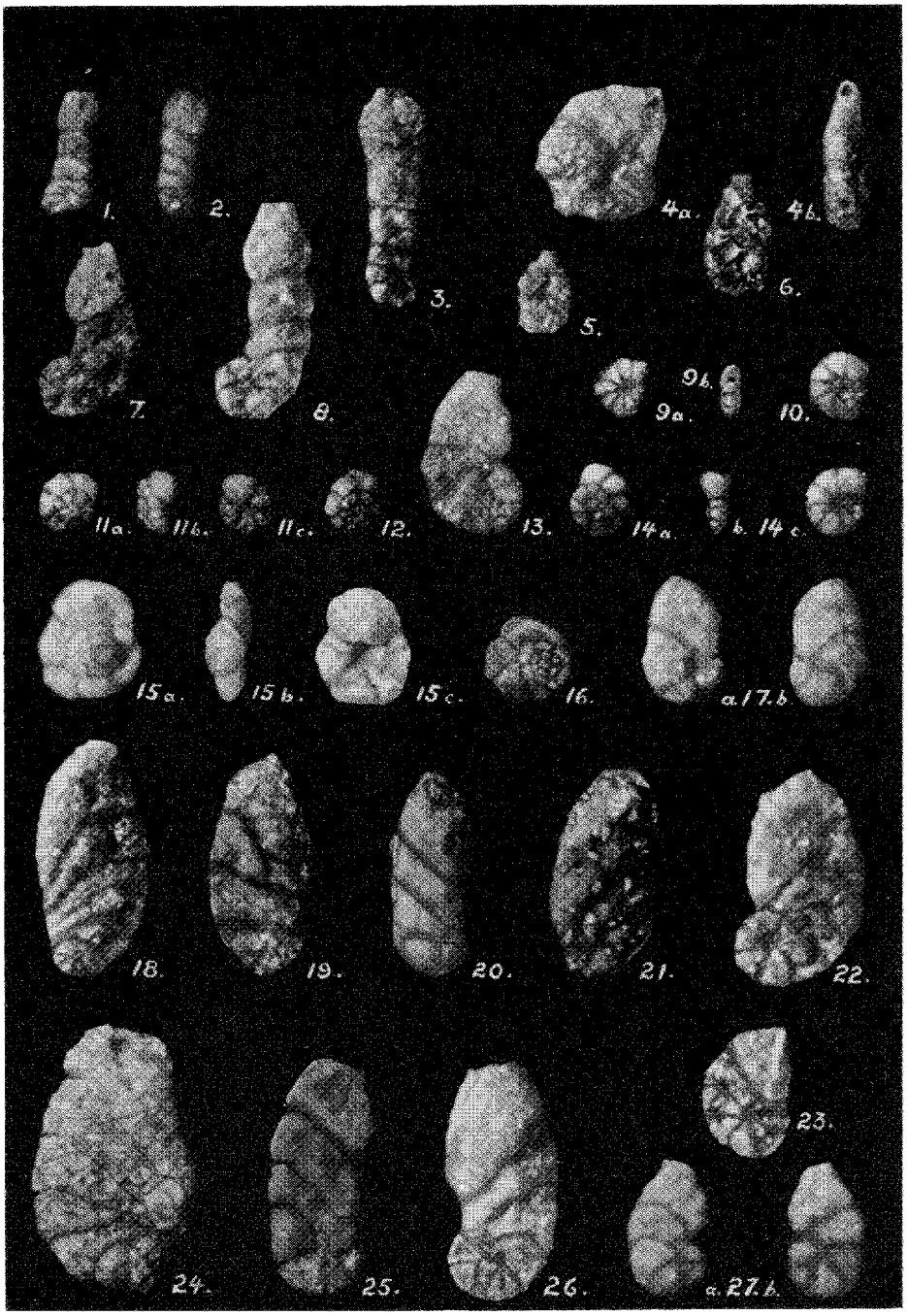


Plate 1—Lower Kaskapau Foraminifera.

Explanation, p. 76.

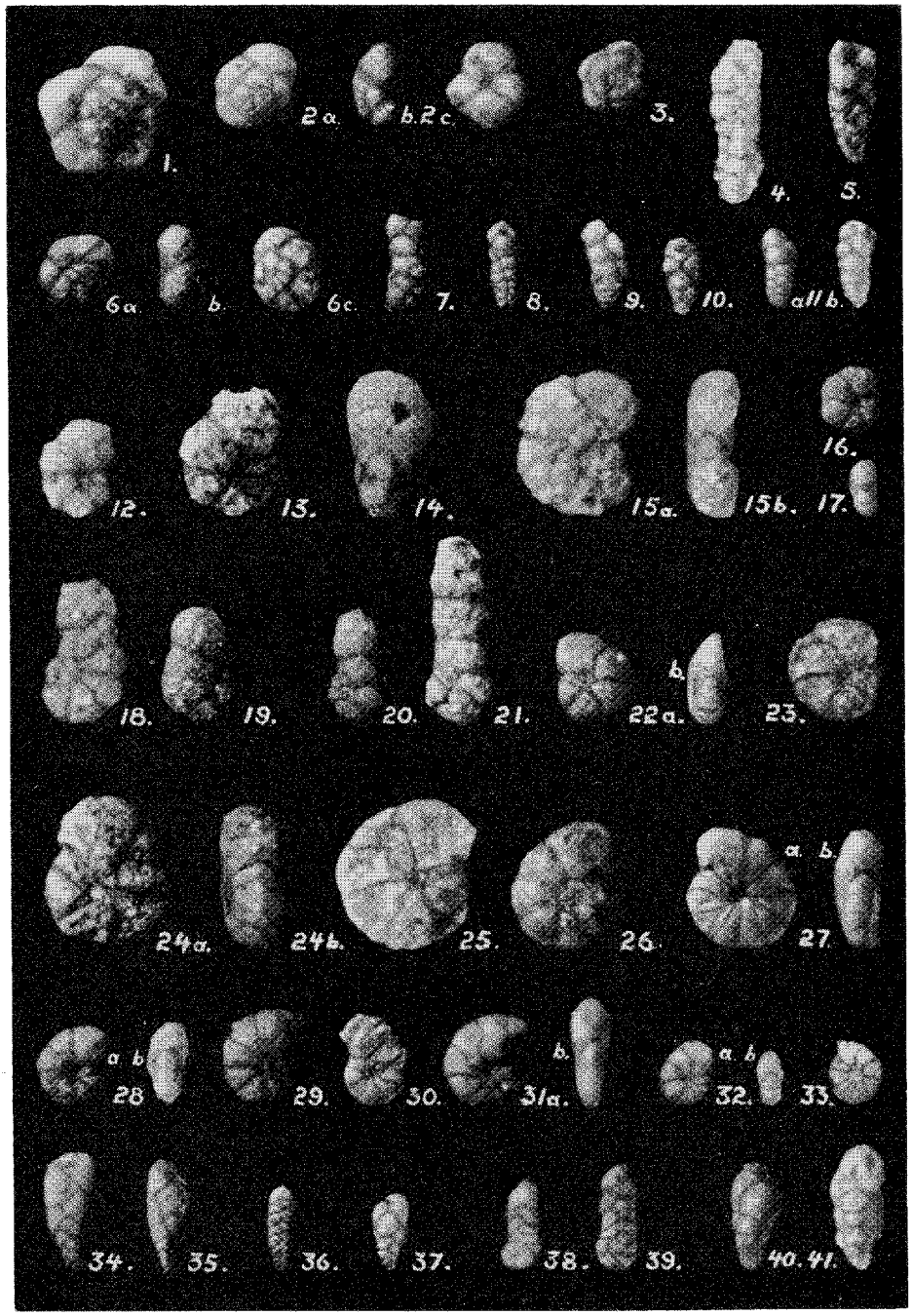


Plate 2—Lower and central Kaskapau Foraminifera.

Explanation, p. 77.

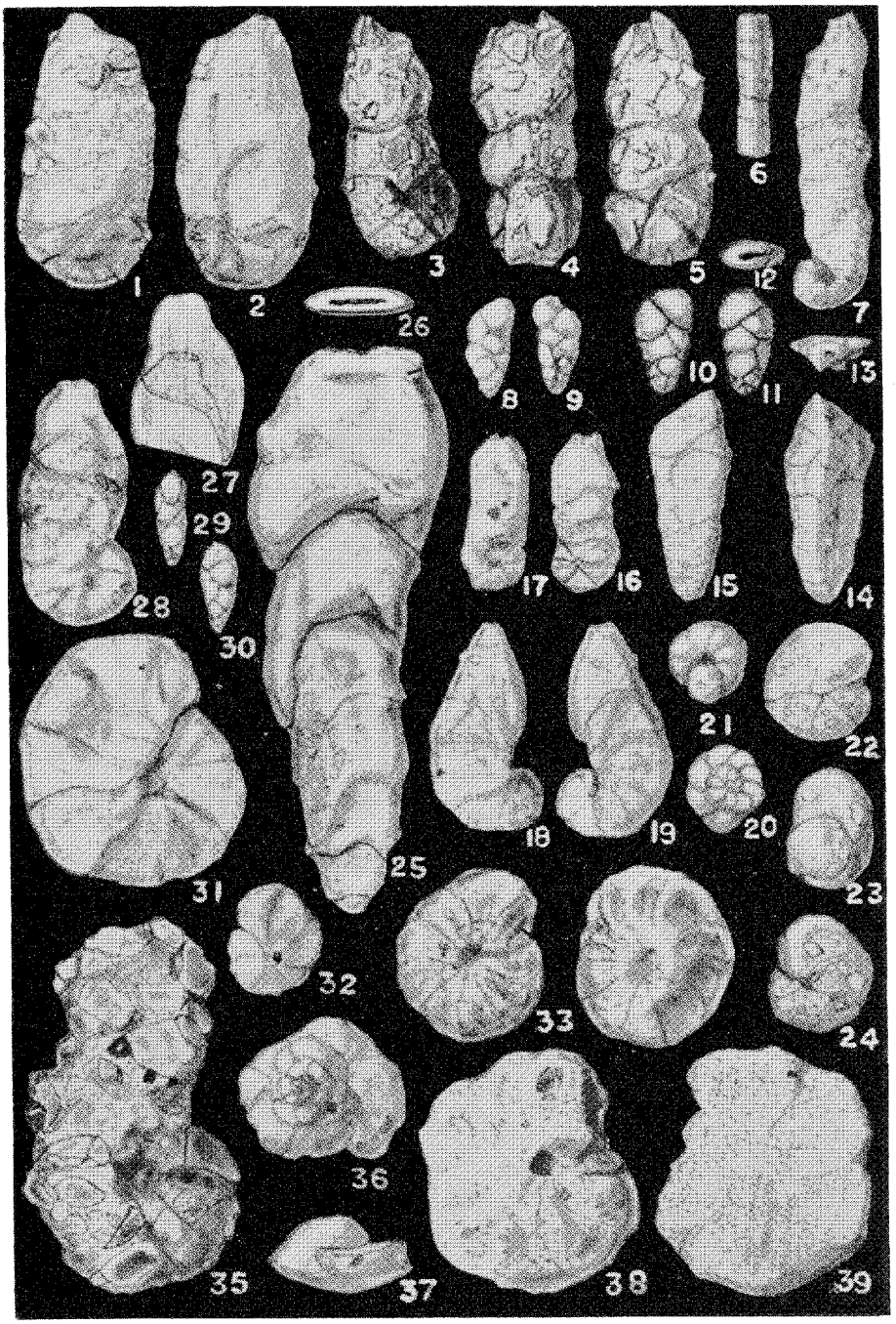


Plate 3—Lower and central Kaskapau Foraminifera.

Explanation, p. 78.

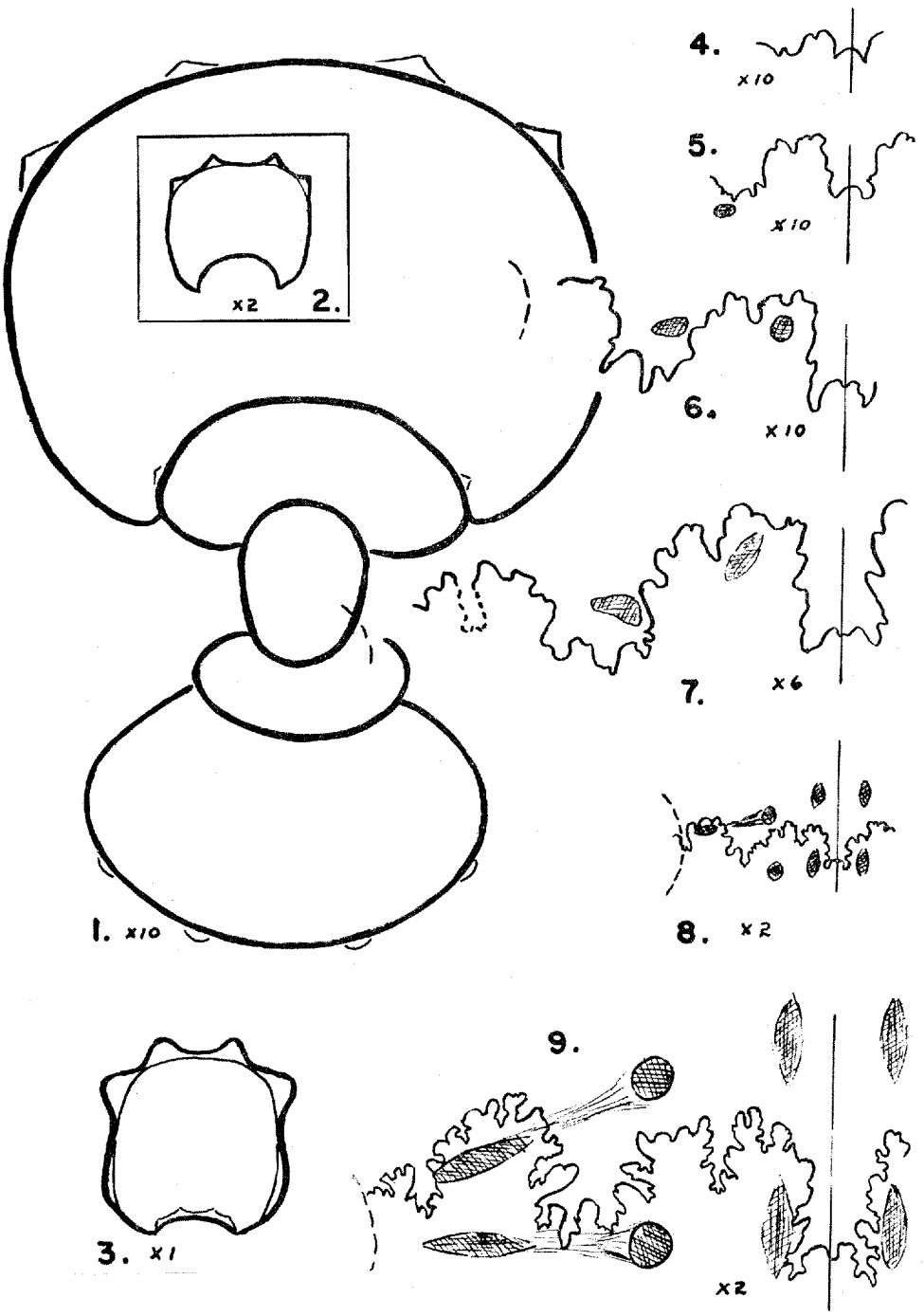


Plate 4—*Dunveganoceras poucecoupense* Warren and Stelck.

Explanation, p. 79.

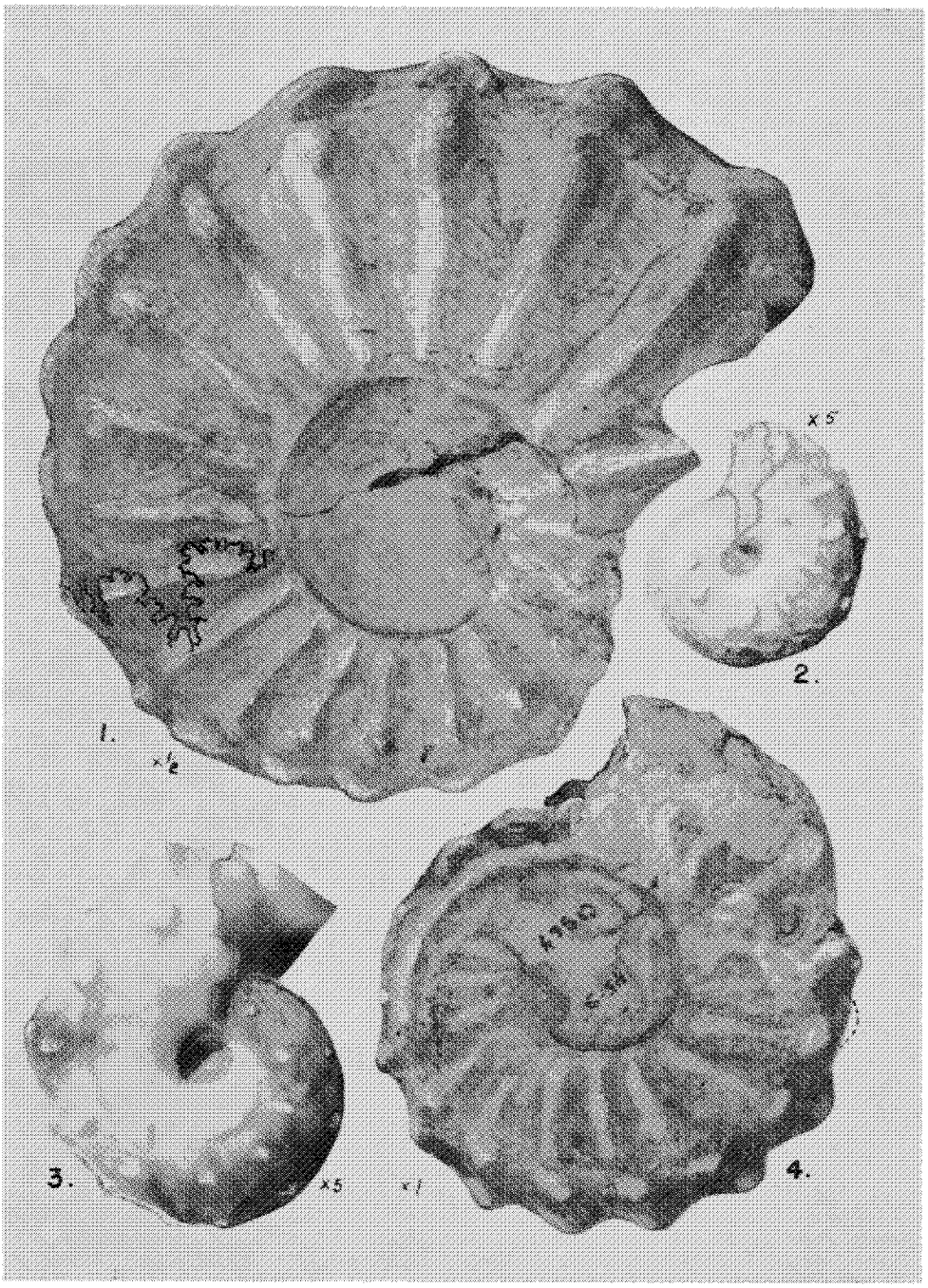


Plate 5—*Dunveganoceras* from Alberta.

Explanation, p. 80.

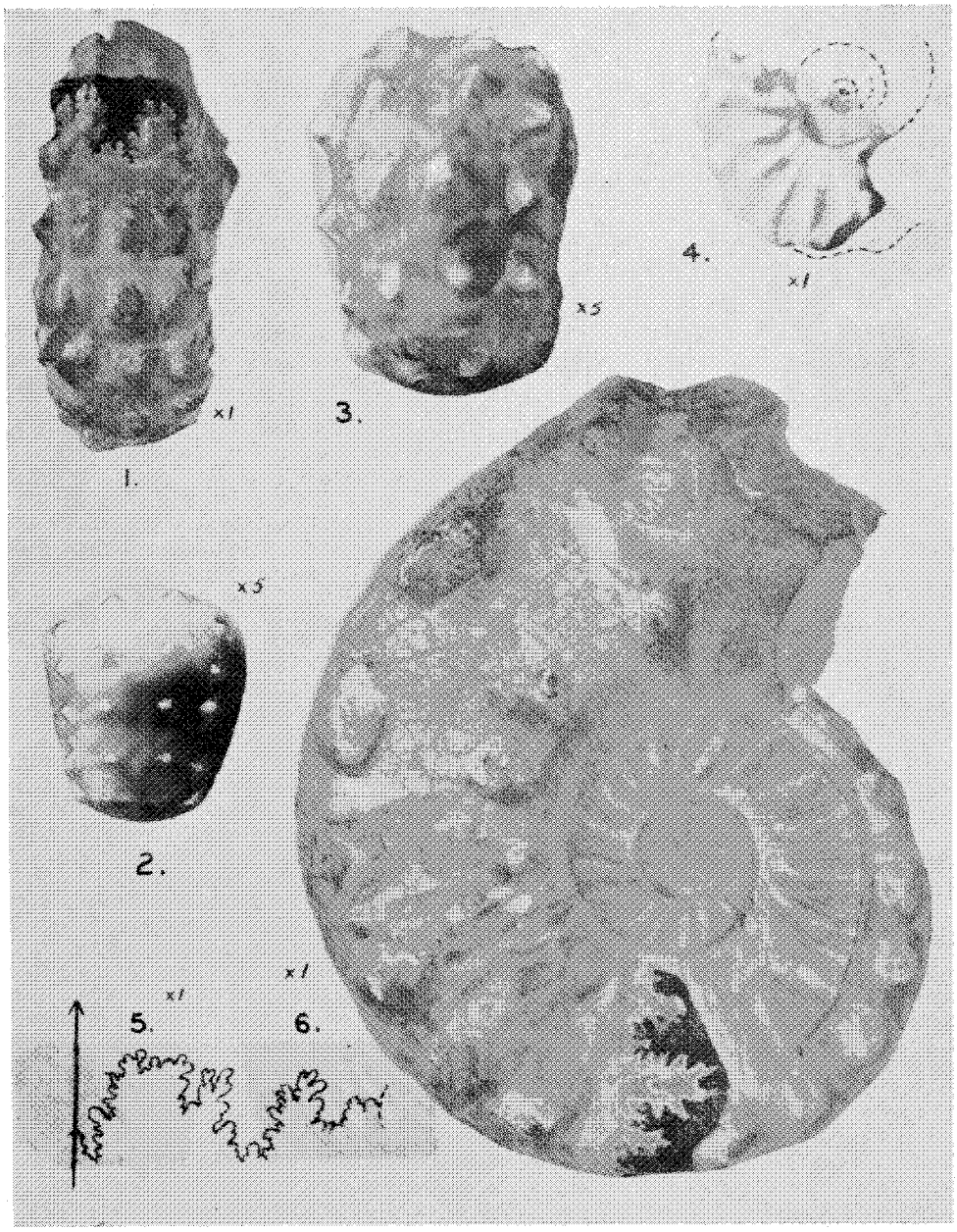


Plate 6—*Dunveganoceras* and *Acanthoceras*.

Explanation, p. 80.

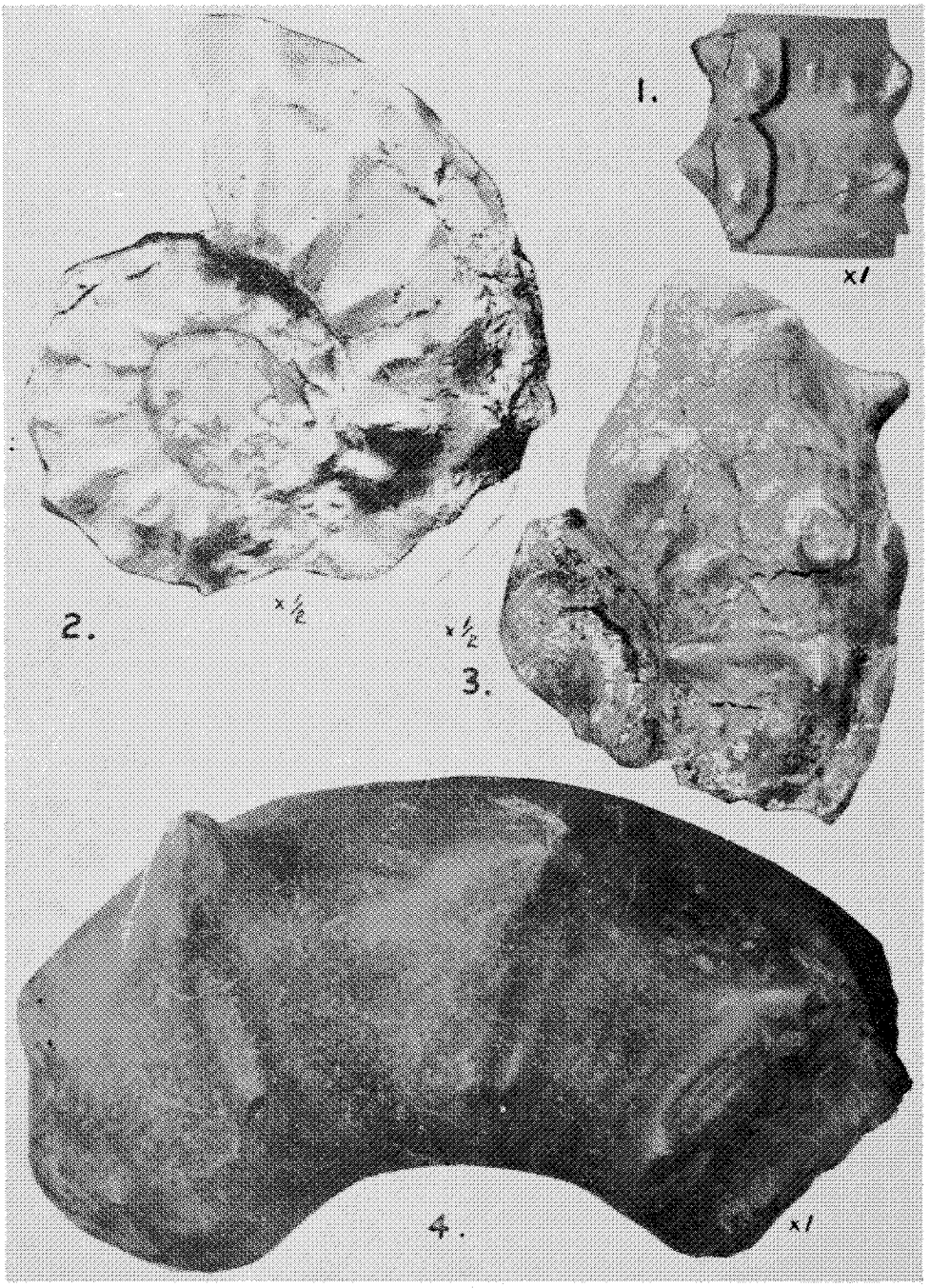


Plate 7—*Dunveganoceras* and *Acanthoceras*.

Explanation, p. 80.

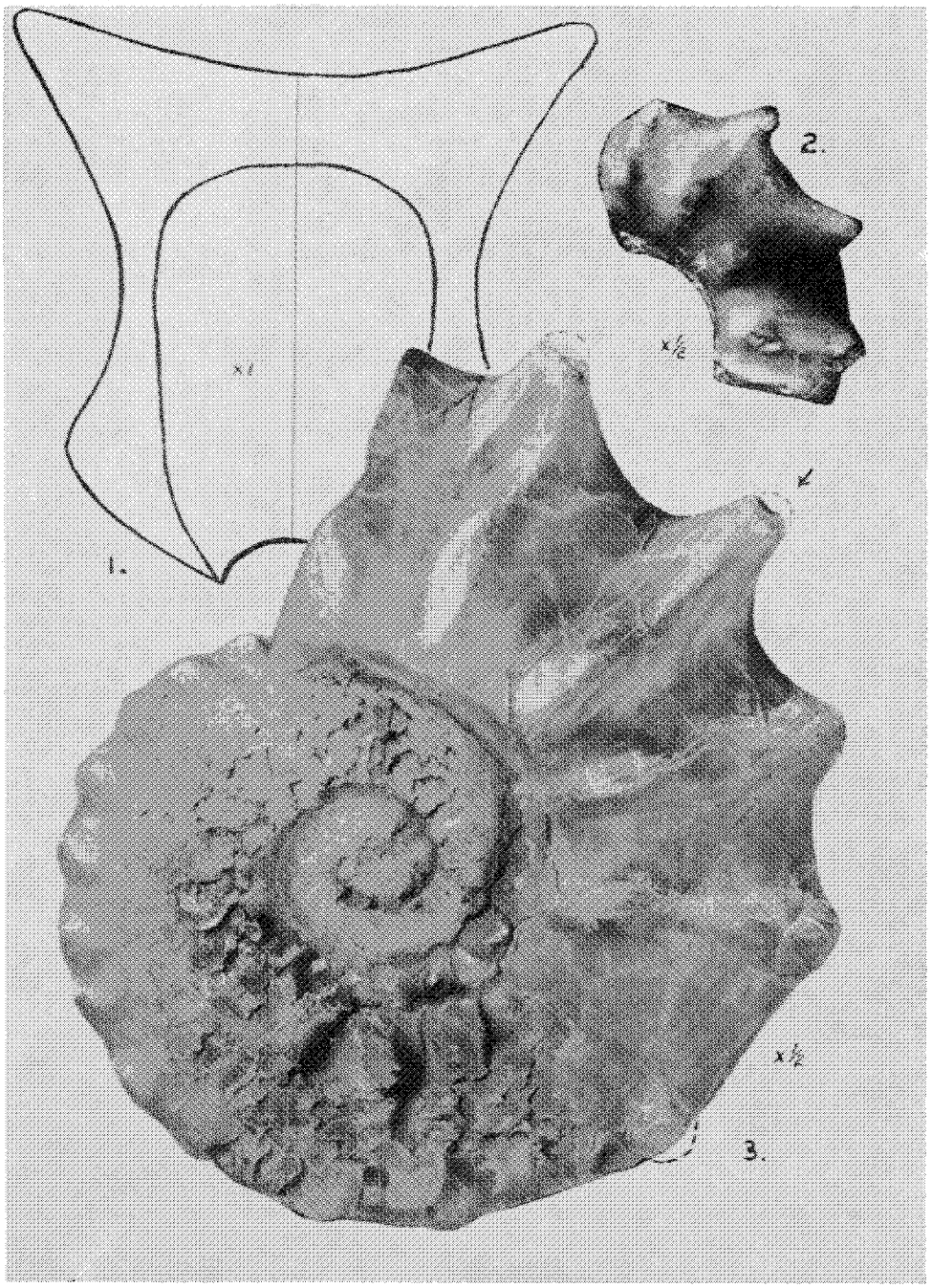


Plate 8—*Acanthoceras* from Alberta.

Explanation, p. 80.

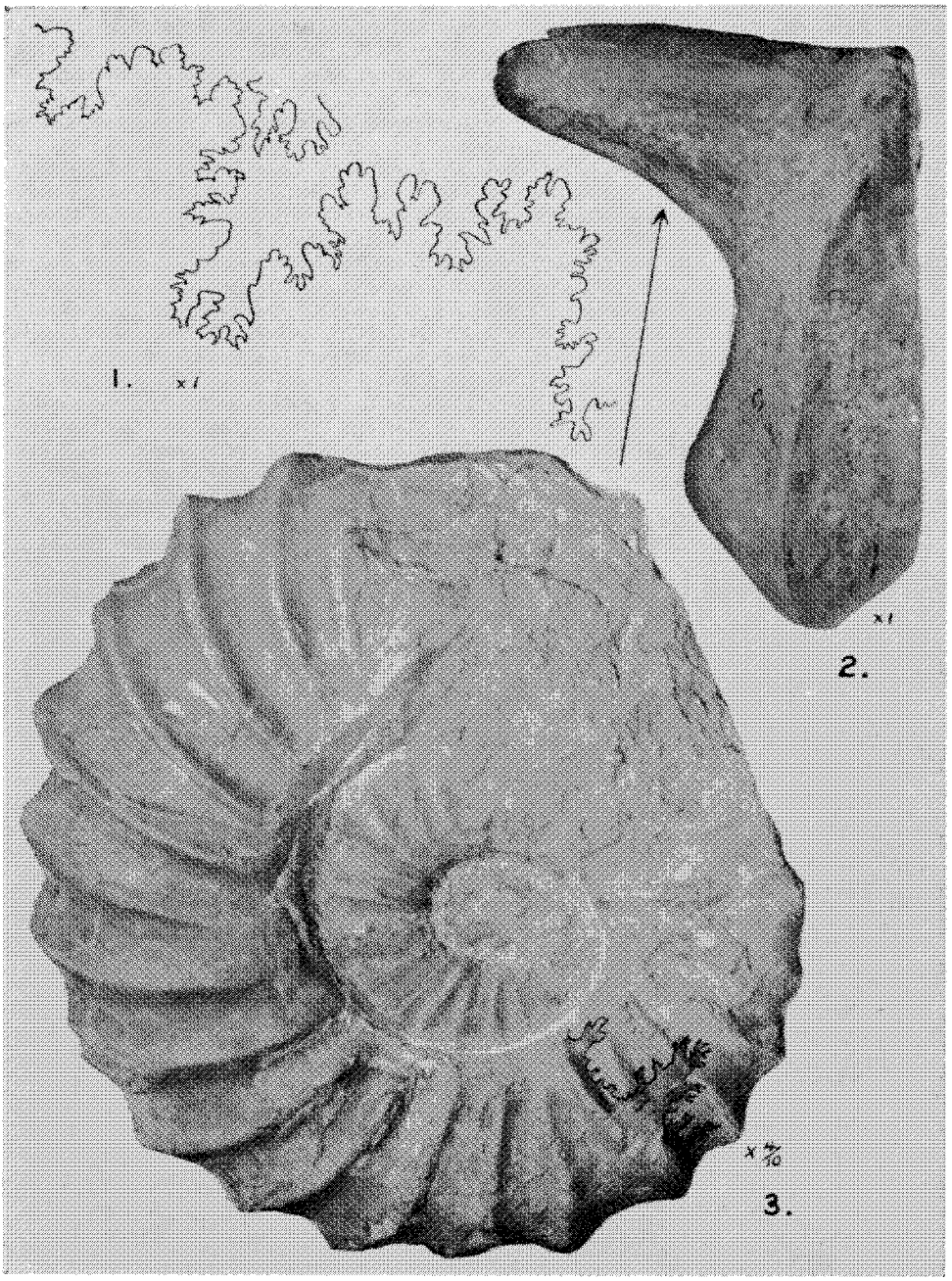


Plate 9—*Dunveganoceras* and *Acanthoceras*.

Explanation, p. 80.

Remarks: Possibly this subspecies should be referred to the genus *Neobulimina*, but tentatively the authors have decided to classify it under *Gümbelitria* because of its large, semi-circular aperture and again, because biseriality is not developed until a very late stage. This biserial portion serves to distinguish this subspecies from *G. cretacea* s.s. and *G. cretacea albertensis* Stelck and Wall.

Genus HAPLOPHRAGMOIDES Cushman, 1910

HAPLOPHRAGMOIDES COLLYRA BAHANI

Stelck and Wall, n. var.

Plate 2, figures 30, 31

Haplophragmoides collyra var. *bahani* (*nomen nudum*), 1954, Research Council of Alberta Report No. 68, p. 10.

Test compressed, rather scaphitoid in outline, venter broadly rounded; test planispirally coiled, evolute, with umbilicus exposing preceding whorl; chambers, gradually enlarging, eight in ultimate whorl, six in penultimate whorl; sutures distinct, slightly depressed, early ones curved, sigmoidal in some specimens, last four sigmoidal; wall very finely arenaceous (grain size never greater than 0.01 mm.), with much cement giving a smooth, yellow-orange, exterior finish; aperture not definitely observed, believed to be a low opening at the base and to one side of the terminal face, extending part way toward the umbilicus.

Length of holotype (fig. 30): 0.3 mm.; diameter 0.22 mm.

Length of paratype (fig. 31): 0.37 mm.; diameter 0.31 mm.; thickness 0.11 mm.

Holotype locality: G45-5 in Lsd. 13, Sec. 10, Tp. 81, Rge. 13, W. 6th Meridian, on Doe creek, Alberta, Canada, from Kaskapau shales, at a footage of 85 below the base of the Pouce Coupe sand.

Paratype locality: As above, at a footage of 110 below the base of the Pouce Coupe sand.

Holotype and paratype: Univ. of Alberta Pal. Type Coll.

Horizon: At the Doe Creek localities of G45-5 and S47-4, this variety is restricted to the pre-Pouce Coupe beds, with the acme occurring at the former locality at a footage of 180 above the base of the Kaskapau formation, that is, on the borderline between the *Ammobaculites gravenori* and *Gaudryina irenensis* zones. Several specimens are noted at Spirit River from the *A. gravenori* zone, but no positive identification has been made above it. At the Dunvegan locality of C47-9, a couple of specimens are observed in the *A. gravenori* zone at a footage of 95 above the base of the Kaskapau.

Comparison: This variety differs from *Haplophragmoides collyra* Nauss in possessing curved to sigmoidal sutures as opposed to the straight and radial ones in the latter. The chambers of the varietal form are not inflated as in the species *s.s.*, giving a compressed appearance to the former.

This variety differs from *H. collyra bullocki* Stelck and Wall, n. var. in having a more finely arenaceous wall than the latter, which, if fossilized without deformation, lacks the development of sigmoidal sutures. Compression sometimes tends to produce a sigmoidal development of the sutures in *H. collyra bullocki* and confusion may thus arise in differentiating between these two varieties, especially if pyritization has obscured the fundamental difference in wall structure.

Name: After W. G. Bahan, Geologist, Sun Oil Company, Dawson Creek, B.C.

HAPLOPHRAGMOIDES COLLYRA BULLOCKI

Stelck and Wall, n. var.

Plate 2, figures 24, 25, 26; Plate 3, figures 31, 32, 38, 39

Test of fair size, exhibiting considerable variation in preservation, usually partly flattened, often partially pyritized, periphery rounded; test planispiral, partly evolute with umbilicus exposing four chambers of penultimate whorl; chambers very gradually enlarging, somewhat inflated, seven in ultimate whorl, first three and last four in groups of approximately equal size; sutures not very distinct, slightly depressed, slightly curved; wall arenaceous, grains averaging about 0.03 mm., with the occasional grain up to 0.05 mm. and larger, amount of cement not great; aperture, a triangular opening at the base of the ultimate chamber, situated at a point about one-third of the distance from the equatorial plane to the umbilical region.

Diameter of holotype (Plate 2, fig. 24): 0.43 mm.; thickness 0.18 mm.

Diameter of paratype (Plate 2, fig. 25): 0.35 mm.; thickness 0.08 mm.

Diameter of paratype (Plate 2, fig. 26): 0.35 mm.; thickness 0.13 mm.

Diameter of hyptoype (Plate 3, fig. 31): 0.5 mm.; thickness 0.15 mm.; diameter of umbilicus 0.05 mm.

Diameter of immature form (Plate 3, fig. 32): 0.2 mm.

Diameter of hypotype (Plate 3, figs. 38, 39): 0.47 mm.

Holotype (fig. 24) locality: Imperial Oil Limited Spirit River Structure Test A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 850 feet, 8 feet below the top of the Pouce Coupe sand equivalent in the Kaskapau formation.

Paratype (fig. 25) locality: As above, at a depth of 758 feet, 5 feet above the top of the Howard Creek sand.

Paratype (fig. 26) locality: As above, at a depth of 754 feet, 9 feet above the top of the Howard Creek sand.

Locality of hypotypes (Plate 3, figs. 31, 32): S47-4 in Lsd. 13, Sec. 10, Tp. 81, Rge. 13, W. 6th Meridian, on Doe creek, Alberta,

Canada, from Kaskapau shales, 196 feet below the base of the Pouce Coupe sand.

Hypotype (Plate 3, figs. 38, 39) locality: S47-28 in Sec. 13, Tp. 80, Rge. 5, W. 6th Meridian, one and one-half miles west of the ferry crossing at Dunvegan, Alberta, Canada, from Kaskapau shales, 9 feet below the Howard Creek sand equivalent.

Holotype and paratypes: Univ. of Alberta Pal. Type Coll.

Hypotypes: Stanford Univ. Pal. Type Coll.

Horizon: This variety occurs commonly in the three lower microfaunal zones of the Kaskapau formation, being recovered from the Spirit River and Dunvegan sections in all three zones, and at the Doe Creek section from the lower two zones. The preservation varies considerably in this form, making it a difficult one to identify, and consequently reducing its value in correlation work.

Comparison: This variety differs from *Haplophragmoides collyra* Nauss in having much coarser quartz grains in its wall structure. The chambers of the varietal form, although somewhat inflated, do not have the globular appearance as exhibited by Nauss' holotype.

A comparison of this new variety with *H. collyra bahani* has been outlined in the preceding description.

Name: After D. Bruce Bullock, consulting geologist, Calgary.

HAPLOPHRAGMOIDES CRICKMAYI Stelck and Wall, n. sp.

Plate 2, figures 16, 17, 22, 23; Plate 3, figures 22, 23, 24

Haplophragmoides crickmayi (*nomen nudum*). 1954; Research Council of Alberta Report No. 68, pp. 10, 12, 13.

Test small to medium, generally found in a pyritized or partially pyritized state, somewhat compressed, periphery narrowly rounded, polygonal in outline, test planispiral, rather tightly coiled, nearly involute, with only small portions of last three chambers of penultimate whorl visible; chambers, five in ultimate whorl, last four of approximately equal size, initial one considerably smaller; sutures distinct, flush, curved, last two slightly sigmoidal and slightly limbate; wall rather finely arenaceous, moderate amount of cement, outcrop specimens smoothly finished; aperture, a low wide slit at the base of the terminal face.

Two immature forms (Plate 2, figs. 16, 17) show a moderate umbilical development.

A variant form (Plate 3, figs. 22, 23, 24) differs from the species *s.s.* in being inflated with a rounded periphery and completely involute.

Diameter of holotype (Plate 2, fig. 22): 0.24 mm.; thickness 0.11 mm.

Diameter of paratype (Plate 2, fig. 23): 0.29 mm.

Diameter of immature form (Plate 2, fig. 16): 0.18 mm.

Diameter of immature form (Plate 2, fig. 17): 0.14 mm.; thickness 0.06 mm.

Diameter of variant form (Plate 3, figs. 22, 23, 24): 0.23 mm.; thickness 0.18 mm.

Holotype locality: Imperial Oil Limited Spirit River Structure Test A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 902.5 feet, 152.5 feet above the projected base of the Kaskapau formation.

Paratype locality: As above, at a depth of 898 feet, 157 feet above the projected base of the Kaskapau.

Locality of immature form (Plate 2, fig. 16): Imperial Oil Limited Spirit River No. 1 Well in Lsd. 12, Sec. 20, Tp. 78, Rge. 6, W. 6th Meridian, Alberta, Canada, at a depth of 1018 feet, 91 feet above the base of the Kaskapau formation.

Locality of immature form (Plate 2, fig. 17): Imperial Oil Limited Spirit River Structure Test A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 834 feet, 8 feet above the top of the Pouce Coupe sand equivalent in the Kaskapau formation.

Locality of variant form (Plate 3, figs. 22, 23, 24): S47-28 in Sec. 13, Tp. 80, Rge. 5, W. 6th Meridian, one and one-half miles west of the ferry crossing at Dunvegan, Alberta, Canada, from Kaskapau shales, 9 feet below the Howard Creek sand equivalent.

Holotype, paratype, and immature forms: Univ. of Alberta Pal. Type Coll.

Variant form: Stanford Univ. Pal. Type Coll.

Horizon: This species occurs characteristically in the *Gaudryina irenensis* zone of the lower Kaskapau formation. At Spirit River it is found commonly in the interval 139 to 195 feet above the base of the Kaskapau, reaching its acme at a footage of 179 above the base, that is, 22 feet below the base of the Pouce Coupe sand equivalent, and not often occurring above this horizon. At the Doe Creek localities of G45-5 and S47-4, maximum development occurs at a footage of 250 above the base of the Kaskapau or 20 feet below the base of the Pouce Coupe sand. A concentration of specimens was recovered at the Dunvegan locality of C47-9, from a footage of 115 above the base of the Kaskapau.

Comparison: Flattened forms of *Haplophragmoides crickmayi* bear a resemblance to specimens of *Haplophragmoides hendersonense* Stelck and Wall. This latter species is generally larger in size, has at least one additional chamber in the ultimate whorl, and its sutures are radial, as compared to the curved and sigmoidal development in those of *H. crickmayi.*

The variant form of *H. crickmayi* is similar to *H. kirki* Wickenden in that both forms are small, involute, and have five chambers. In peripheral view, however, it may be observed that the earlier

chambers of *H. kirki* are less inflated than those in *H. crickmayi* variant.

Name: After Dr. Colin H. Crickmay, staff paleontologist, Imperial Oil Limited, Calgary.

HAPLOPHRAGMOIDES EOCALCULA Stelck and Wall, n. sp.

Plate 2, figure 15

Haplophragmoides eocalcula (*nomen nudum*), 1954, Research Council of Alberta Report No. 68, pp. 11, 13.

Test somewhat compressed, periphery broadly rounded; planispiral, not completely involute with portion of penultimate whorl barely visible, slight umbilical development; chambers obscure, about six in ultimate whorl; sutures very faint, depressed, straight; wall coarsely arenaceous, grains averaging between 0.04 and 0.05 mm., with individual grains projecting from the finer cementing matrix by at least half of their thickness; aperture, a low slit at the base of the ultimate chamber, not often visible.

Diameter of holotype: 0.38 mm.; thickness 0.11 mm.

Holotype locality: Imperial Oil Limited Spirit River Structure Test A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 740 feet, 23 feet above the top of the Howard Creek sand in the Kaskapau formation.

Holotype: Univ. of Alberta Pal. Type Coll.

Horizon: This species occurs characteristically in the *Ammobaculites pacalis* zone of the lower central part of the Kaskapau formation in association with *A. albertensis*. At Spirit River, only a few specimens were found below the Pouce Coupe sand equivalent, in the top beds of the *Gaudryina irenensis* zone. At the Dunvegan locality of S47-27, several specimens were recovered in a sample taken 2 feet above the Howard Creek sand equivalent.

Comparison: This species is very similar to *Ammobaculites albertensis* Stelck and Wall, the only major difference between the two forms being the position of the aperture which is, of course, terminal in *Ammobaculites*. In addition, it is often quite apparent from the outline of the last chamber in *A. albertensis* that the form is tending to develop an uncoiled uniserial portion. It would seem that *H. eocalcula* is the ancestral form of *A. albertensis*.

H. eocalcula seems to be rather closely related to *H. rugosa* Cushman and Waters from the Upper Cretaceous Navarro formation of Texas. However, *H. eocalcula* is a much more compressed form and lacks the prominent umbilicus of the Texas species. Furthermore, the quartz grains in the Canadian form are not so neatly arranged, and there is considerably more cementing material holding them together than there is in the Texas species, which appears to have very little cement.

Again, *H. eocalcula* is quite similar to *H. calcula* Cushman and Waters from the Navarro formation and earlier beds of Texas, but

the latter form seems to have much more cementing material, and it is of a finer nature, than the Alberta species.

HAPLOPHRAGMOIDES NEOLINKI Stelck and Wall, n. sp.

Plate 2, figures 28, 29

Test slightly compressed, somewhat scaphitoid in outline, small to medium in size, usually found as a pyrite replacement, periphery rounded; test planispiral, involute or nearly so, umbilicate; chambers of approximately equal size, seven and one-half to eight and one-half visible in ultimate whorl; sutures fairly distinct, slightly depressed, slightly curved, almost radial; wall arenaceous, grains averaging about 0.015 mm., held together by a moderate amount of cement; aperture, a low wide slit at the base of the terminal face.

Diameter of holotype (fig. 28): 0.22 mm.; thickness 0.09 mm.

Diameter of paratype (fig. 29): 0.25 mm.

Holotype locality: Imperial Oil Limited Spirit River Structure Test A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 838 feet, 4 feet above the top of the Pouce Coupe sand equivalent in the Kaskapau formation.

Paratype locality: As above, at a depth of 750 feet, 13 feet above the top of the Howard Creek sand in the Kaskapau formation.

Holotype and paratype: Univ. of Alberta Pal. Type Coll.

Horizon: At Spirit River, this species is confined to the *Ammobaculites pacalis* zone of the lower central part of the Kaskapau formation, reaching its acme at a footage of 4 above the top of the Pouce Coupe sand equivalent. Two isolated occurrences were recorded at the Dunvegan localities of C47-9 and S47-27 from footages of 77 above the base of the Kaskapau and 2 above the top of the Howard Creek sand equivalent, respectively. It has not been observed in the Pouce Coupe area.

Comparison: This species is similar to *Haplophragmoides linki* Nauss in being involute, umbilicate, and in having the same type of wall structure and radial sutures. However, *H. linki* has inflated globular chambers and a rounded outline, as opposed to the somewhat compressed chambers and the more angular appearance of *H. neolinki*. Furthermore, *H. linki* appears to be considerably thicker than this species.

H. neolinki is quite similar to *Haplophragmoides glabra* Cushman and Waters from the Upper Cretaceous Navarro formation of Texas. However, the sutures of the latter form are definitely curved, as opposed to the almost radial sutures of *H. neolinki*. Again, the holotype of *H. glabra* has one and one-half to two additional chambers.

HAPLOPHRAGMOIDES PACALIS Stelck and Wall, n. sp.

Plate 1, figures 9, 10

Haplophragmoides pacalis (*nomen nudum*), 1954, Research Council of Alberta Report No. 68, p. 10.

Test minute, usually found as a pyrite replacement, periphery rounded; test planispirally coiled, evolute, with umbilicus exposing preceding whorl; chambers, of approximately equal size, nine visible in ultimate whorl, six in penultimate whorl; sutures distinct, flush, somewhat thickened, first four in ultimate whorl curved, last four straight; wall very finely arenaceous, with much cement giving a smooth finish to external surface; aperture, a low arch at the base of the terminal face.

Diameter of holotype (fig. 9): 0.14 mm.; thickness 0.06 mm.

Diameter of paratype (fig. 10): 0.16 mm.

Holotype locality: Imperial Oil Limited Spirit River Structure Test A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 958 feet, 97 feet above the projected base of the Kaskapau formation.

Paratype locality: G45-5 in Lsd. 13, Sec. 10, Tp. 81, Rge. 13, W. 6th Meridian, on Doe creek, Alberta, Canada, from Kaskapau shales, at a footage of 110 below the base of the Pouce Coupe sand.

Holotype and paratype: Univ. of Alberta Pal. Type Coll.

Horizon: At Spirit River, this species is restricted to the pre-Pouce Coupe beds, attaining its acme in the *Ammobaculites gravenori* zone at a footage of 98 above the base of the Kaskapau formation, and not commonly occurring above the zone. This form is also confined to the pre-Pouce Coupe beds at the Doe Creek localities of G45-5 and S47-4, with the most forms being recovered at the former locality from a footage of 155 above the base of the Kaskapau.

HAPLOPHRAGMOIDES cf. H. PACALIS Stelck and Wall

Plate 2, figures 32, 33

Test minute, usually found as a pyrite replacement, periphery rounded; test planispirally coiled, evolute, with umbilicus exposing preceding whorl; chambers, of approximately equal size, seven to seven and one-half visible in ultimate whorl, five or six in penultimate whorl; sutures distinct, flush, slightly curved; wall very finely arenaceous, with much cement, giving a smooth external finish; aperture semilunar at the base and slightly to one side of the terminal face, extending part way to the umbilical region.

Diameter of specimen (fig. 32): 0.11 mm.; thickness 0.06 mm.

Diameter of specimen (fig. 33): 0.12 mm.

Locality of specimen (fig. 32): Imperial Oil Limited Spirit River No. 1 Well in Lsd. 12, Sec. 20, Tp. 78, Rge. 6, W. 6th Meridian, Alberta, Canada, at a depth of 1011 feet, 98 feet above the base of the Kaskapau formation.

Locality of specimen (fig. 33): G45-5 in Lsd. 13, Sec. 10, Tp. 81, Rge. 13, W. 6th Meridian, on Doe creek, Alberta, Canada, from Kaskapau shales, at a footage of 85 below the base of the Pouce Coupe sand.

Specimens: Univ. of Alberta Pal. Type Coll.

Horizon: *Haplophragmoides* cf. *H. pacalis* occurs in the lower and lower central part of the Kaskapau formation, not being found above the *Ammobaculites pacalis* zone. At Spirit River, most of the recorded occurrences are from beds below the Pouce Coupe sand equivalent. A few specimens are found in the pre-Pouce Coupe beds at the Doe Creek localities of G45-5 and S47-4, while one specimen was recovered at a footage of 15 above the top of the Pouce Coupe sand at the Pouce Coupe River locality of G45-19. A questionable occurrence was recorded at the Dunvegan locality of C47-9 from a footage of 95 above the base of the Kaskapau.

Comparison: This form is very closely related to *Haplophragmoides pacalis* s.s., the only major point of difference between the two being the presence of one and one-half to two additional chambers in the ultimate whorl of *H. pacalis* s.s.

HAPLOPHRAGMOIDES SPIRITENSE Stelck and Wall

Plate 2, figure 27; Plate 3, figures 33, 34

Haplophragmoides spiritense Stelck and Wall, 1954, Research Council of Alberta Report No. 68, p. 28, pl. 2, figs. 7, 8, 9.

Diameter of paratype (Plate 2, fig. 27): 0.38 mm.; thickness 0.09 mm.

Diameter of hypotype (Plate 3, figs. 33, 34): 0.35 mm.

Paratype locality: Imperial Oil Limited Spirit River Structure Test A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 760 feet, 3 feet above the top of the Howard Creek sand in the Kaskapau formation.

Hypotype locality: S47-27 in Sec. 13, Tp. 80, Rge. 5, W. 6th Meridian, one and one-half miles west of the ferry crossing at Dunvegan, Alberta, Canada, from Kaskapau shales, 2 feet above the top of the Howard Creek sand equivalent.

Paratype: Univ. of Alberta Pal. Type Coll.

Hypotype: Stanford Univ. Pal. Type Coll.

Genus PROTEONINA Williamson, 1858

PROTEONINA cf. P. ALEXANDERI Loeblich and Tappan

Plate 1, figures 5, 6

Proteonina alexanderi Loeblich and Tappan, 1950, Univ. of Kansas Paleontological Contrib., Protozoa, Article 3, p. 5, pl. 1, figs. 1-2.

Test flattened, a single chamber, roughly bottle shaped, with central area much depressed (through crushing); neck prominent,

but much thinner than main part of test; maximum diameter occurring about midway between base of neck and opposite end of test; wall coarsely arenaceous, of grains up to 0.1 mm., held in place by a small amount of cement; aperture terminal, an elliptical slit, occupying nearly all of the area at the end of the neck.

Length of specimen (fig. 5): 0.3 mm.; maximum diameter 0.18 mm.; length of neck 0.04 mm.

Length of specimen (fig. 6): 0.42 mm.; maximum diameter 0.22 mm.; length of neck 0.09 mm.

Locality of specimen (fig. 5): Imperial Oil Limited Spirit River No. 1 Well in Lsd. 12, Sec. 20, Tp. 78, Rge. 6, W. 6th Meridian, Alberta, Canada, at a depth of 1036 feet, 73 feet above the base of the Kaskapau formation.

Locality of specimen (fig. 6): As above, at a depth of 1034 feet, 75 feet above the base of the Kaskapau.

Specimens: Univ. of Alberta Pal. Type Coll.

Horizon: At Spirit River, this species reaches its acme in the *Ammobaculites gravenori* zone of the basal Kaskapau, at a footage of 75 above the base of the formation, and rarely, if ever, occurs above the zone. It has not been positively identified outside of the Spirit River area.

Comparison: This form seems to be very close to *P. alexanderi* Loeblich and Tappan from the Lower Cretaceous Kiowa shale of Kansas, but has a more prominent neck and apparently a less orderly arrangement of the quartz grains. Both forms are coarsely arenaceous, however, and seem to be essentially similar in general appearance.

Genus REOPHAX Montfort, 1808

REOPHAX sp.

Plate 3, figures 25, 26

Test large, elongate, tapering, somewhat compressed, uniserial, chambers increasing in size throughout; seven chambers make up the test; wall arenaceous, of small rounded grains to 0.02 mm. in much cement, test tends to become flattened in preservation; sutures distinct, depressed, irregularly oblique; aperture terminal, narrowly elliptical, large, simple.

Length of figured specimen: 1.23 mm.; maximum width 0.43 mm.

Locality of figured specimen: S47-4 in Lsd. 13, Sec. 10, Tp. 81, Rge. 13, W. 6th Meridian, on Doe creek, Alberta, Canada, from basal Kaskapau shales, 196 feet below the Pouce Coupe sandstone member.

Figured specimen: Stanford Univ. Pal. Type Coll.

Horizon: Recognized only at the above locality and level.

Remarks: This species with its large aperture and fine wall is somewhat like *Reophax clavulinus* (Reuss) Cushman but has much more irregular chambers than the latter species.

Genus SPIROPLECTAMMINA Cushman, 1927

SPIROPLECTAMMINA PHAULOIDES Stelck and Wall, n. sp.

Plate 2, figures 38, 39

Spiroplectammina phauloides (nomen nudum), 1954, Research Council of Alberta Report No. 68, pp. 11, 12, 13.

Test somewhat compressed, generally found as a pyritized or partially pyritized replacement, early portion of six chambers, planispiral, comprising one-quarter to one-third of length of test, becoming biserial while still spiral; later portion biserial, of eight interlocking chambers; sutures distinct, slightly depressed, radial in coiled portion, almost at right angles to the axis of the test in biserial portion, except for the final two which are noticeably oblique; wall finely arenaceous, considerable amount of cement, giving a smooth finish to the exterior; aperture simple, terminal, at the distal end of the ultimate chamber.

Length of holotype (fig. 39): 0.34 mm.; width of coiled portion 0.15 mm.; length of coiled portion 0.1 mm.

Length of paratype (fig. 38): 0.3 mm.; width of coiled portion 0.13 mm.; length of coiled portion 0.1 mm.

Holotype locality: Imperial Oil Limited Spirit River Structure Test A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 838 feet, 4 feet above the top of the Pouce Coupe sand equivalent in the Kaskapau formation.

Paratype locality: G45-19 in Lsd. 8, Sec. 4, Tp. 80, Rge. 13, W. 6th Meridian, on the east bank of the Pouce Coupe river, Alberta, Canada, in a sample taken from 0 to 5 feet above the Pouce Coupe sand in the Kaskapau formation.

Holotype and paratype: Univ. of Alberta Pal. Type Coll.

Horizon: At Spirit River, the acme of this species occurs at a footage of 4 above the Pouce Coupe sand equivalent, with some specimens being recorded in the upper beds of the underlying *Gaudryina irenensis* zone of the lower Kaskapau formation. Maximum development occurs at the Pouce Coupe river locality of G45-19 directly above the Pouce Coupe sand, with no specimens being found outside of the 15 feet of section above this bed.

Remarks: It is with some doubt that this species, with its terminal aperture, is referred to the genus *Spiroplectammina* which has its aperture at the base of the last chamber. Possibly, it might be more accurately classified under the genus *Ammobaculoides* which possesses a terminal aperture, but also has a definite uniserial portion which, in turn, is lacking in this species. This form can probably be regarded as an intermediate stage between the two genera. The name refers to its similarity to *Ammobaculoides phaulus* Loeblich and Tappan, 1950, from the Kiowa shale of Kansas.

Genus TEXTULARIA Defrance, 1824

TEXTULARIA GRAVENORI Stelck and Wall, n. sp.

Plate 2, figure 36

Textularia gravenori (*nomen nudum*), 1954, Research Council of Alberta Report No. 68, p. 11.

Test minute, tapering, compressed, earliest portion of test sometimes slightly twisted, found only as a pyrite replacement and very fragile; chambers, twenty in biserial arrangement, first three pairs very small and barely visible, last seven pairs slightly larger and of approximately equal size; sutures fairly distinct, depressed; wall finely arenaceous with considerable amount of cement; aperture thought to be a notch at the base of the ultimate chamber.

Length of holotype: 0.22 mm.; maximum width 0.06 mm.

Holotype locality: Imperial Oil Limited Spirit River Structure Test A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 747.5 feet, 15.5 feet above the top of the Howard Creek sand in the Kaskapau formation.

Holotype: Univ. of Alberta Pal. Type Coll.

Horizon: This tiny form has not been recognized outside of the Spirit River area, where it occurs over a short interval from 7 to 15.5 feet above the top of the Howard Creek sand in the *Ammobaculites pacalis* zone of the lower central part of the Kaskapau formation.

TEXTULARIA ROLLAENSIS Stelck and Wall

Plate 2, figures 34, 35

Textularia rollaensis Stelck and Wall, 1954, Research Council of Alberta Report No. 68, p. 30, pl. 1, fig. 17.

Length of holotype (fig. 34): 0.41 mm.; maximum width 0.18 mm.

Length of paratype (fig. 35): 0.39 mm.; maximum width 0.15 mm.

Holotype locality: G45-5 in Lsd. 13, Sec. 10, Tp. 81, Rge. 13, W. 6th Meridian, on Doe creek, Alberta, Canada, from Kaskapau shales, at a footage of 220 below the base of the Pouce Coupe sand.

Paratype locality: Imperial Oil Limited Spirit River Structure Test A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 896 feet, 159 feet above the projected base of the Kaskapau formation.

Holotype and paratype: Univ. of Alberta Pal. Type Coll.

Genus TRITAXIA Reuss, 1860

TRITAXIA PYRAMIDATA DIMINUTA Stelck and Wall, n. var.

Plate 3, figures 13, 14, 15

Test triangular in cross-section, tapering, slightly compressed; triserial, consists of seven convolutions of three chambers each; chambers angular retaining three flattened sides to the test, test tapers slowly toward posterior by decrease in chamber size in that direction, tapers sharply to anterior end to accommodate terminal centrally located aperture; chambers indistinct; sutures indistinct in part; wall arenaceous with considerable amount of cement as an external covering to the fine sandy cement underneath; aperture terminal, simple, elliptical.

Length of holotype: 0.48 mm.; maximum width 0.2 mm.

Holotype locality: S47-4 in Lsd. 13, Sec. 10, Tp. 81, Rge. 13, W. 6th Meridian, on Doe creek, Alberta, Canada, from basal Kaskapau shales, 140 feet below base of Pouce Coupe sandstone member.

Holotype: Stanford Univ. Pal. Type Coll.

Horizon: Recognized only at the above locality and level.

Remarks: The chamber arrangement in this form is like that of *Tritaxia pyramidata* Reuss from the "Middle Cretaceous" of Europe to which we are assigning it as a variety. The Canadian form is more pointed on the apertural end, more compressed, and has less well-defined sutures than the European species.

Genus TROCHAMMINA Parker and Jones, 1859

TROCHAMMINA RUTHERFORDI Stelck and Wall, n. sp.

Plate 1, figures 11, 12, 14, 15, 16; Plate 3, figures 20, 21, 36, 37

Trochammina rutherfordi (nomen nudum), 1954, Research Council of Alberta Report No. 68, pp. 10, 13.

TROCHAMMINA RUTHERFORDI *sensu stricto*

Plate 1, figures 11, 12

Test small, periphery rounded; test trochoid, with a low spire, of three whorls with six and one-half chambers in ultimate whorl, seven and one-half chambers in penultimate whorl, and about five in primary whorl; ventral side of test rather umbilicate; sutures distinct, depressed, slightly curved, nearly radial on dorsal side, radial on ventral side; wall generally finely arenaceous, but with a rare grain as large as 0.03 mm., considerable amount of cement giving a smooth exterior finish to most specimens, more noticeable in outcrop forms; aperture, a low opening at the base of the ultimate chamber on the ventral side, lying about midway between the periphery and the umbilicus.

Diameter of holotype (Plate 1, fig. 11): 0.2 mm.; thickness 0.11 mm.

Diameter of paratype (Plate 1, fig. 12): 0.2 mm.

Holotype locality: Imperial Oil Limited Spirit River Structure Test A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 956 feet, 99 feet above the projected base of the Kaskapau formation.

Paratype locality: G45-5 in Lsd. 13, Sec. 10, Tp. 81, Rge. 13, W. 6th Meridian, on Doe creek, Alberta, Canada, from Kaskapau shales, at a footage of 105 below the base of the Pouce Coupe sand.

Horizon: This species *s.s.* is confined to the pre-Pouce Coupe beds at all localities. At Spirit River, it occurs commonly over the interval extending from the base of the Kaskapau formation to a footage of 105 above it, and less commonly in the overlying beds of the *Gaudryina irenensis* zone to a point 170 feet above the Kaskapau base. It is present at the Pouce Coupe River locality of G45-18 and at the Doe Creek localities of G45-5 and S47-4 over an interval, extending from the Dunvegan-Kaskapau contact upwards to within 55 feet of the base of the Pouce Coupe sand. At the Dunvegan locality of C47-9, a concentration of specimens was recovered in a sample taken at a footage of 95 above the base of the Kaskapau.

Name: After the late Dr. Ralph L. Rutherford, Professor of Geology, University of Alberta.

TROCHAMMINA RUTHERFORDI Variety 1

Plate 1, figure 14; Plate 3, figures 20, 21

Test small, periphery broadly rounded; test trochoid with a very low spire, of two and one-half whorls, eight chambers in ultimate whorl, about six in penultimate whorl; chambers gradually enlarging, only those of the last whorl visible on the ventral side, which is umbilicate; sutures distinct, somewhat thickened, depressed, curved on the dorsal side, radial on the umbilical side; wall finely arenaceous, with much cement, giving a smooth finish to the exterior; aperture not definitely recognizable, thought to be a low opening on the ventral side between the periphery and the umbilicus.

Diameter of specimen (Plate 1, fig. 14): 0.15 mm.; thickness 0.04 mm.

Diameter of specimen (Plate 3, figs. 20, 21): 0.17 mm.

Locality of specimens: S47-4 in Lsd. 13, Sec. 10, Tp. 81, Rge. 13, W. 6th Meridian on Doe creek, Alberta, Canada, in the Kaskapau formation, from footages 186 and 172 below the base of the Pouce Coupe sand.

Specimen (Plate 1, fig. 14): Univ. of Alberta Pal. Type Coll.

Specimen (Plate 3, figs. 20, 21): Stanford Univ. Pal. Type Coll.

Horizon: With one exception, this variety is restricted to the pre-Pouce Coupe beds of the Kaskapau formation. At the Doe Creek localities of G45-5 and S47-4, the acme occurs at a footage 82 above the base of the Kaskapau. Variety 1 is not common in the

Spirit River section, where it appears to be confined to the *Ammobaculites gravenori* zone of the basal Kaskapau. The one exception, that is, the occurrence above the Pouce Coupe sand, was noted at the Pouce Coupe River locality of G45-6, in a bed 15 to 20 feet above the Pouce Coupe sand.

Comparison: *T. rutherfordi* variety 1 differs from the species *s.s.* in having thickened, curved dorsal sutures as opposed to the radial or nearly radial sutures of the latter. Furthermore, the chambers in variety 1 are considerably smaller and there are more of them than in the species *s.s.*

TROCHAMMINA RUTHERFORDI Variety 2

Plate 1, figures 15, 16; Plate 3, figures 36, 37

Test of medium size, periphery angular to broadly rounded; test trochoid, with an intermediate-size spire, sombrero-shaped in peripheral view, with first three whorls representing the crown, and final whorl the brim; chambers indistinct, usually distorted, about six in ultimate whorl, six in penultimate whorl, and six in antepenultimate whorl; sutures often indistinct, appearing slightly curved; wall finely arenaceous with much cement giving a smooth exterior finish; aperture not positively observed, assumed to be a low opening on the ventral side between the periphery and umbilicus.

Diameter of specimen (Plate 1, fig. 15): 0.33 mm.; thickness through spire 0.14 mm.

Diameter of specimen (Plate 1, fig. 16): 0.3 mm.

Long diameter of specimen (Plate 3, figs. 36, 37): 0.37 mm.; breadth 0.3 mm.; thickness 0.17 mm.

Locality of specimen (Plate 1, fig. 15): Imperial Oil Limited Spirit River Structure Test A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 892 feet, 163 feet above the projected base of the Kaskapau formation.

Locality of specimen (Plate 1, fig. 16): G45-5 in Lsd. 13, Sec. 10, Tp. 81, Rge. 13, W. 6th Meridian, on Doe creek, Alberta, Canada, from Kaskapau shales, at a footage of 50 below the base of the Pouce Coupe sand.

Locality of specimen (Plate 3, figs. 36, 37): S47-4, geographically identical with the above, from Kaskapau shales, 134 feet below the base of the Pouce Coupe sand.

Specimens (Plate 1, figs. 15, 16): Univ. of Alberta Pal. Type Coll.

Specimen (Plate 3, figs. 36, 37): Stanford Univ. Pal. Type Coll.

Horizon: This variety occurs in close association with *T. rutherfordi* s.s. and is found over approximately the same lower Kaskapau intervals, at the Doe Creek localities of G45-5 and S47-4, and at the Pouce Coupe River locality of G45-19. It is present in the Spirit River section, but was not recovered at the Dunvegan locality of

C47-9. *T. rutherfordi* variety 2 is not nearly so common a form as *T. rutherfordi* s.s.

Comparison: *T. rutherfordi* variety 2 seems very closely related to the species *s.s.* and appears to be descended from it. The varietal form is, however, larger and has a greater spiral development.

TROCHAMMINA WETTERI Stelck and Wall, n. sp.

Plate 2, figures 1, 2, 3, 6

Trochammina wetteri (nomen nudum), 1954, Research Council of Alberta Report No. 68, pp. 10, 11, 13.

Test exhibiting considerable variation in size and method of preservation, often found as a partial pyrite replacement, but non-pyritized, crushed, pentagonal forms also common, periphery lobulate; test trochoid with a low spire (holotype, fig. 2, has the highest spire in any of the specimens found), of four whorls, with five chambers visible in each of the last three whorls; ventral side, with a well-developed umbilicus; chambers enlarging gradually, globular in outline; sutures distinct in all but badly crushed forms, depressed, curved on dorsal side, radial on ventral side; finely arenaceous for the most part, with an occasional grain as large as 0.03 mm. but usually less than half this size, and with a considerable amount of cementing material giving a smooth over-all finish; aperture not observed, assumed to be a low opening on the ventral side between the periphery and umbilicus, probably extending into the latter. Color light brownish-white in non-pyritized forms.

A variant form (fig. 6) differs from the species *s.s.* in having one less whorl of chambers and generally in being smaller.

Diameter of holotype (fig. 2): 0.27 mm.; thickness through spire 0.15 mm.

Diameter of paratype (fig. 1): 0.39 mm.; thickness through spire 0.13 mm.

Diameter of paratype (fig. 3): 0.22 mm.

Diameter of variant (fig. 6): 0.24 mm.; thickness 0.15 mm.

Holotype (fig. 2) locality: Imperial Oil Limited Spirit River Structure Test A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 910 feet, 145 feet above the projected base of the Kaskapau formation.

Paratype (fig. 1) locality: As above, at a depth of 812 feet, 30 feet above the top of the Pouce Coupe sand equivalent in the Kaskapau formation.

Paratype (fig. 3) locality: As above, at a depth of 878 feet, 177 feet above the projected base of the Kaskapau formation.

Variant (fig. 6) locality: As above, at a depth of 812 feet, 30 feet above the top of the Pouce Coupe sand equivalent.

Holotype, paratype and variant: Univ. of Alberta Pal. Type Coll.

Horizon: At Spirit River, this species *s.s.* occurs erratically in a

subzone (bearing its name) of the *Gaudryina irenensis* zone of the lower Kaskapau formation, numerous specimens being found at the base of the subzone and again, 5 feet from its top. It is not commonly found above the Pouce Coupe sand equivalent. A concentration of specimens was recovered at the Dunvegan locality of C47-9 at a footage of 125 above the base of the Kaskapau.

The variant form is confined to the *Ammobaculites pacalis* zone of the lower central part of the Kaskapau, occurring mainly in the interval 215 to 255 feet above the base of the formation.

Comparison: This species seems very close to *Trochammina* Sp. 1 described and figured by Fox from the top 15 feet of the Belle Fourche shale (Cenomanian) at Crook County, Wyoming. Both forms have the same number of chambers in the final whorl, similar curved dorsal and radial ventral sutures, and the same general type of wall structure. The writers hesitate, however, to place these forms in synonomy at the present time since they are uncertain of the comparison of the earlier whorls in the two forms.

Again, this species is similar to *Trochammina albertensis* Wickenden from the Bearpaw shale of southern Alberta in being approximately the same size, in having the same number of whorls and chambers, and in having identical sutures. However, *T. wetteri* lacks the relatively high spiral development of *T. albertensis*, and appears to have coarser grains in its wall structure.

Name: After Raymond E. Wetter, geologist, Amurex Oil Development Company, Calgary.

Genus VERNEUILINOIDES Loeblich and Tappan, 1949

VERNEUILINOIDES PERPLEXUS (Loeblich)

Plate 2, figure 37; Plate 3, figures 29, 30

Verneuilina perplexa Loeblich, 1946, Jour. Paleontology, vol. 20, p. 138, pl. 22, figs. 14-16.

Verneuilinoides perplexa (Loeblich) Loeblich and Tappan, 1949, Jour. Washington Acad. Sci., vol. 39, p. 91.

Verneuilinoides perplexus (Loeblich) Frizzel, 1954, Texas Bureau of Econ. Geol. Rept. of Investigations No. 22, p. 69, pl. 5, fig. 10.

Test small, slender, tapering, subtriangular in cross-section; test triserial, composed of five convolutions of three chambers each; maximum width at penultimate convolution; chambers gradually enlarging in size; sutures distinct, depressed; wall finely arenaceous, grains averaging about 0.015 mm., with much cement giving a smooth finish to the exterior; aperture not positively recognized, but believed to be a broadly arched opening at the inner margin of the ultimate chamber.

Length of specimen (Plate 2, fig. 37): 0.29 mm.; maximum width 0.12 mm.

Length of specimen (Plate 3, figs. 29, 30): 0.12 mm.; maximum width 0.08 mm.

Locality of specimen (Plate 2, fig. 37): G45-5 in Lsd. 13, Sec. 10, Tp. 81, Rge. 13, W. 6th Meridian, on Doe creek, Alberta, Canada, from Kaskapau shales, at a footage of 110 below the base of the Pouce Coupe sand.

Locality of specimen (Plate 3, figs. 29, 30): S47-4, geographically identical with the above, from Kaskapau shales, 134 feet below the base of the Pouce Coupe sand.

Specimen (Plate 2, fig. 37): Univ. of Alberta Pal. Type Coll.

Specimen (Plate 3, figs. 29, 30): Stanford Univ. Pal. Type Coll.

Horizon: This species is restricted to the pre-Pouce Coupe beds in both the Spirit River and Doe Creek sections. At the former locality, maximum development appears to occur at a footage of 105 above the base of the Kaskapau formation, while at the latter locality it seems to be a footage of 145 above the base. Furthermore, at Doe creek, the form apparently does not occur above the *Ammobaculties gravenori* zone.

VERNEUILINOIDES PERPLEXUS GLEDDIEI

Stelck and Wall, n. var.

Plate 2, figures 40, 41

Verneuilinoides perplexa (Loeblich) var. *gleddiei* (*nomen nudum*), 1954, Research Council of Alberta Report No. 68, pp. 10, 13.

Test small to medium in size, tapering, subtriangular in cross-section, often found as a pyrite replacement, and generally considerably flattened by compression; test triserial throughout, composed of five volutions of three chambers each; maximum width near apertural end, chambers increasing rather rapidly in size as added, with final volution comprising at least one-third of the length of the test; sutures distinct, depressed; wall finely arenaceous with much cement, giving a smooth exterior finish; aperture a broadly arched opening at the base of the ultimate chamber.

Length of holotype (fig. 40): 0.38 mm.; maximum width 0.18 mm.

Length of paratype (fig. 41): 0.43 mm.; maximum width 0.18 mm.

Holotype locality: Imperial Oil Limited Spirit River No. 1 Well in Lsd. 12, Sec. 20, Tp. 78, Rge. 6, W. 6th Meridian, Alberta, Canada, at a depth of 1009 feet, 100 feet above the base of the Kaskapau formation.

Paratype locality: Imperial Oil Limited Spirit River Structure Test A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 916 feet, 139 feet above the projected base of the Kaskapau formation.

Holotype and paratype: Univ. of Alberta Pal. Type Coll.

Horizon: This variety is confined to the pre-Pouce Coupe beds at all localities. At Spirit River it occurs fairly commonly over a

150-foot interval, from 45 to 195 feet above the base of the Kaskapau. At the Dunvegan locality of C47-9, a fair number of specimens were recovered over an interval from 115 to 135 feet (top of the sampled section) above the base of the Kaskapau. It occurs in the pre-Pouce Coupe microfaunal zones at the Doe Creek localities of G45-5 and S47-4, but is not as common here as in the Spirit River area.

Comparison: This varietal form differs from *V. perplexus* (Loeblich) in being much more robust and in having larger chambers.

Name: After Joseph Gleddie, geologist, Imperial Oil Limited, Calgary.

APPENDIX

NEW CENOMANIAN AMMONITES FROM ALBERTA

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The more detailed zonation of the Upper Cretaceous Colorado shale in Alberta has brought about a need for further description of the little-known Cenomanian faunas in Canada. The writers describe three species of large ammonites—one from the lower Athabasca river, one from the Peace River country, and one from southern Alberta—to give an appreciation of the wide extent of the Cenomanian seas in Alberta. The relative stratigraphic position of these three new species to those used for zonation of the Colorado shale of Montana (Cobban, 1951, p. 2197) is believed to be as follows, in descending order:

Cenomanian stage	*Dunveganoceras hagei* n. sp. *Dunveganoceras parvum* Cobban *Dunveganoceras albertense* (Warren) *Dunveganoceras conditum* Haas—*D. clowi* n. sp. *Dunveganoceras pondi* Haas *Acanthoceras athabascense* n. sp.

Genus DUNVEGANOCERAS Warren and Stelck, 1940

The discovery of new species of the ammonite *Dunveganoceras* in the Upper Cretaceous Cody shale of Wyoming and correlative horizons (Haas 1949 and 1951, and Cobban 1953) has given this genus of ammonites more than local distribution. Even English occurrences are not unknown at the top of the Cenomanian stage (Wright and Wright, 1951).

Two new species of *Dunveganoceras* from Alberta are described herein and new occurrences within Alberta and British Columbia are reported. Inner whorls of paratypes of *D. poucecoupense* Warren and Stelck are described to augment the knowledge of the genus. Haas (1949, p. 21) has pointed out the similarity of the early whorls of *Mammites* Laube and Bruder to those of *Dunveganoceras,* and our studies of the inner whorls of *Dunveganoceras* seem to support this.

The genus *Dunveganoceras* is common throughout the northern foothills area of Alberta and in the Peace River district of Alberta and British Columbia. The number of specimens present in museums is relatively small as the discs are too cumbersome for the average collector to transport. The collections of the University of Alberta show the following distribution:

Dunveganoceras albertense (Warren)
Doe creek, Alberta
Dunvegan creek, Alberta
Pouce Coupe river, Alberta
Kiskatinaw river, British Columbia
Stetson (Deep) creek, Torrens River drainage, Alberta
Deadhorse Meadows, Kakwa drainage, Alberta
(Plate 7, fig. 2)
Lynx creek, Kakwa drainage, Alberta
Kakwa river, Alberta

Dunveganoceras poucecoupense Warren and Stelck
Drift, Grosmont, Alberta
Pouce Coupe river, Alberta and British Columbia.

Dunveganoceras parvum Cobban
Murray river, above Coldstream mouth, British Columbia
Cowie creek, British Columbia
Cadomin, Alberta

Dunveganoceras conditum Haas
Dunvegan creek, Alberta
Pouce Coupe river, Alberta
Doe creek, Alberta
Kiskatinaw river, British Columbia
Cadomin, Alberta

Dunveganoceras hagei n. sp.
Dunvegan, Alberta
Cowie creek, British Columbia
Blackstone river, Alberta

Dunveganoceras clowi n. sp.
Castle river, Alberta
Luscar creek, Alberta

Dunveganoceras cf. *pondi* Haas
Pouce Coupe river, Alberta

DUNVEGANOCERAS POUCECOUPENSE Warren and Stelck

Plate 4, figs. 1-9; Plate 5, figs 2-4; Plate 6, figs. 1-4

Dunveganoceras poucecoupense Warren and Stelck, 1940, Trans. Roy. Soc. Can., vol. 34, sec. IV, p. 150, plate 2, fig. 1; plate 3, figs. 2, 5.

Description of inner whorls from paratypes: Inner whorls moderately evolute, becoming less involute in outer whorls; deep umbilicus, outer whorls quadrate, ribbed and nodose; inner whorls smooth and reniform in cross-section.

DIMENSIONS OF PARATYPE
(mm.)

	Diam.	$H_{Max.}$	$H_{Min.}$	$W_{Max.}$	$W_{Min.}$	U
Nucleus	2.2	.....	.....	.....	1.5	?
Half whorl orad from nucleus	3.4	1.4	1.0	3.0	3.0	ca. 0.7
One whorl orad from nucleus	4.7	2.1	1.4	4.2	4.2	1.1
One and one-half whorls orad	7.8	3.6	3.0	5.3	5.3	2.0
Two whorls orad	12.2	6.4	5.0	8.4	8.4	2.1
Two and one-half whorls orad	20.0	9.5	7.0	10.0	10.0	3.5
Three and three-quarter whorls orad	65.0	27.0	24.0	27.0	22.0	15.0

$H_{Max.}$=height from dorsal umbilical margin to ventral margin
$H_{Min.}$=height from dorsal margin to ventral margin
$W_{Max.}$=costal width including bullate projection
$W_{Min.}$=intercostal width
U=umbilical width

The nucleus at a diameter of 2.2 mm. is smooth with a broadly rounded unornamented venter. The whorl cross-section at a diameter of 3.4 mm. shows an even more broadly rounded venter and flanks and a reniform outline. At a diameter of 3.4 mm., small latero-ventral tubercles appear on the rounded sides at the position of maximum width of the whorl cross-section, i.e. about one-third of the height from the umbilical margin to the venter. There are nine latero-ventral tubercles on the whorl between diameters 3.4 to 7.8 mm., and by the latter diameter the tubercles have become slightly elongate radially and have moved to a position two-thirds of the height from the umbilical margin to the venter. Tubercles appear on either side of the venter at a diameter of 4 mm., at two-thirds of the distance from the latero-ventral tubercles to the venter. They are slightly elongated transversely.

At diameter 10 mm. the sides begin to flatten and the latero-ventral tubercles develop a quadrate outline in nodal whorl-section; at 10 mm. diameter an incipient split rib develops between the umbilical margin and the latero-ventral tubercle, and an extension of this rib joins the latero-ventral tubercle and the ventral tubercles but does not cross the venter itself.

At a diameter of 18 mm. the lateral rib develops a low radially elongate node at the umbilical shoulder, becomes a single rib and the latero-ventral tubercles establish the maximum width of the whorl-section.

Between the diameters of 18 mm. and 20 mm. there are eight ribs per half-whorl, showing alternation of strength of expression of the latero-umbilical node, and this latter feature dies out at about 45 mm. diameter. By a diameter of 40 mm. the umbilical node has become sufficiently elongate to become merely a sharpening and

strengthening of the rib on the dorsal part of the flank and to provide an extension of the rib into the umbilicus.

By a diameter of 50 mm. the lateral ribs become sunken on the ventral portion of the flank and the latero-ventral tubercles tend to become stout horns. The ventral tubercles become spirally elongate after 20 mm. diameter, and the rib joining them with the latero-ventral tubercles becomes flexed forward at the ventral shoulder with the front end of the ventral tubercle reaching a position radial to the umbilical portion of the next rib orad.

There are nine ribs per half-whorl by 70 mm. Above the diameter of 65 mm. the latero-umbilical tubercle reappears, as a radially elongate remnant of the rib along the side near the umbilical margin. At a diameter of 255 mm. the rib becomes less sunken on the median portion of the side and subordinates the elongate tubercle into the strong lateral rib that dominates the ultimate whorl of the holotype.

The quadrate whorl-section persists from 65 mm. diameter to 120 mm. diameter, with the venter sunken between the two rows of ventral tubercles. Above 120 mm. diameter, the whorl-section becomes sub-quadrate and finally rounded at a diameter of 250 mm.

The suture of the inner whorls has been illustrated for diameters of 1 mm., 4.5 mm., 6 mm., 10 mm., 20 mm. and 65 mm.; throughout these diameters the irregular bifid nature of the lateral lobe is apparent, and the small lobule dividing the external saddle is present for all these diameters.

Paratypes: Univ. of Alberta Geol. Museum No. Ct. 1111, 1112.

Occurrence: The paratypes Ct. 1111, 1112 U. of A. were collected from a glacial boulder at Grosmont, Alberta; paratype Ct. 964 U. of A. from Pouce Coupe river.

Remarks: At comparative diameter of about 70 mm. the suture of *D. poucecoupense* shows a much wider first lateral saddle than *D. pondi* Haas and a much smaller second lateral lobe than the latter. At 30 mm. the sutures are almost the same in the two species insofar as they may be compared.

The inner whorls of *D. poucecoupense* at 65 mm. diameter show a greater number of ribs (19 per whorl) than *D. albertense* (14 per whorl) (see Plate 7, fig. 2). The umbilical nodes are much stronger at this diameter in *D. albertense*.

DUNVEGANOCERAS CLOWI Warren and Stelck, n. sp.

Plate 9, figs. 1 and 3

Description: Shell large, evolute, moderately involute in inner whorls, latumbilicate; outer whorls ribbed, inner whorls ribbed and nodose; costal whorl-section trapezoidal to slightly depressed at the venter.

Dimensions of holotype:

Maximum diameter 347 mm., estimated minimum diameter 280 mm.;

Umbilicus—maximum diameter 132 mm., minimum diameter 95 mm.;

At beginning of living chamber—height of shell 129 mm., est. width 64 mm.;

Living chamber as preserved—about one-third of the ultimate whorl.

The intercostal whorl-section develops from ovate and slightly flattened on the venter at the beginning of the ultimate whorl to rounded elliptical on the venter at the end of the living chamber. The flanks appear flattened on the penultimate whorl but are gently convex on the ultimate whorl. In costal-section, the trapezoidal outline persists for the entire ultimate volution.

Ribs on the living chamber are stout, arising from undulations of the umbilical margin, becoming defined at the umbilical shoulder and are developed as strong high primary ribs on the sides. The ribs are directed forward from the umbilical shoulder, becoming slightly arcuate in lateral expression. At the ventral shoulder the ribs present a marked angularity as they cross the venter at right angles. An incipient horn develops at the ventral shoulder as approximately a right angle is formed by the junction of the lateral and ventral expressions of the ribs.

In the septate portion of the ultimate whorl, the blunt horns, pointing outward and slightly forward, are developed on the ventral shoulder, and the ribs do not cross the venter (except for the last three previous to the living chamber where the ribs continue across the venter) but sink rather deeply into the median zone between the horns.

In the early portion of the penultimate whorl the ribs show alternately strong and weak expression near the umbilical shoulder. There are 23 ribs on the outer whorl and 12 ribs on the latter half of the penultimate whorl.

The external suture is well shown one-quarter of a volution posterior to the ultimate septum (corresponding to 240 mm. diameter). The siphonal lobe is 40 mm. deep, about 22 mm. (est.) wide at its broadest point, and ends in two main points that diverge at an angle of 60° and both points are trifid. The median knob separating the main points of the siphonal lobe extends one-quarter of the depth of the lobe in height and is broadly trapezoidal in shape. The external saddle is very broad (44 mm.), covering the outer two-fifths of the whorl height. The main lobule dividing it is about one-third as deep as the first lateral lobe, and is trifid with four points on the central prong. Two subsidiary trifid lobules irregularly bisect the two sub-divisions of the external saddle. The first lateral lobe is moderately narrow and about 25 mm. wide to 35 mm. deep, asymmetrically bifid with the outer three pronged terminal

points stronger than the inner. The first lateral saddle is slightly wider than the lateral lobe, and the first auxiliary lobe appears at the umbilical shoulder and is about equal in size to the lobule dividing the external saddle. The first lateral saddle and auxiliary lobe are developed on the side, orad of the rib that marks the most anterior development of the external saddle.

The earlier sutures are only partly visible on the holotype.

Holotype: Univ. of Alberta Geol. Museum No. Ct. 1116.

Occurrence: The holotype occurs on Castle river, Lsd. 7, Sec. 25, Tp. 6, Rge. 3, W. 5th Meridian, from beds at the base of the Blackstone (Lower Alberta) formation. Another specimen represented by a portion of the living chamber was also located on the Castle river. Another example of the species, of 300 mm. diameter, comes from the "barren zone" of the Blackstone formation on Luscar creek, Alberta, and shows the same development of the conch as the holotype at the same diameter.

Remarks: This species is very close to *Dunveganoceras conditum* Haas but may be distinguished from Haas' species by the curvature of the ribs on the ultimate whorl. The horizon of *D. clowi* is assumed to be very close to that of *D.* cf. *conditum* where found at Luscar, Alberta.

This species varies from *Dunveganoceras albertense* (Warren) by possessing a greater number of ribs (23) on the ultimate whorl than the genotype (18 ribs); the ribs are directed more strongly forward in *D. clowi*, and the angulation of the ventral shoulder and flatness of the venter in costal-section are still pronunced on the end of the living chamber. The ribs on the anterior half of the penultimate whorl of *D. clowi* are much less pronounced, more numerous, and lack both the strong nodal development on the umbilical shoulder and the latero-ventral tubercles of *D. albertense*. This latter subdued development is similar to that found in *Mantelliceras* sp. indet. figured by Haas (1949, plate 4, fig. 3). The development of the angulation of the ventral shoulder in the costal whorl-section is very similar to that found in *D. pondi* Haas, but the greater number of ribs per whorl in *D. clowi* readily differentiates these two species. *D. poucecoupense* Warren and Stelck is readily differentiated by its more rounded costal whorl-section in the living chamber and in having straighter and fewer ribs per volution than *D. clowi*.

The assignment of the species to the genus *Dunveganoceras* rather than to *Mantelliceras* is based on the greater similarity of the suture to that of *D. pondi* (at 130 mm.) and the sunken mid-ventral section of the ribs on the septate portion of the shell.

Name: The species is named for W. H. A. Clow, Geologist, Amurex Oil Development Company, Calgary, formerly Geologist, Research Council of Alberta, who found the holotype.

DUNVEGANOCERAS HAGEI Warren and Stelck, n. sp.

Plate 5, fig. 1

Description: Shell large, moderately involute, latumbilicate, whorls ribbed and nodose, whorl-section trapezoidal, usually depressed at the venter; except for the last six ribs, latero-umbilical nodes, latero-ventral nodes and a row of nodes on each side of the venter are present on the ribs.

Dimensions of holotype:

Maximum diameter 260 mm., minimum diameter 195 mm.;

Umbilicus—max. diam. 90 mm., min. diam. 63 mm.;

At max. diam.—Height of shell 110 mm., estimated width 80 mm.;

At beginning of living chamber—Height of shell 80 mm., width 62 mm.;

At beginning of ultimate whorl—Height of shell 48 mm., width 30 mm.;

Living chamber at least one-half of the ultimate volution;

Estimated one-third of apertural end of living chamber broken off in holotype.

The intercostal whorl-section is ovate, slightly flattened on the venter on all parts of the ultimate whorl. In costal-section the last rib preserved on the specimen shows a trapezoidal outline with the ventral region slightly depressed. In all previous costal-sections this ventral depression is exaggerated, horns develop on each side of the venter and on the latero-ventral shoulder, and an outward swelling near the umbilical shoulder gives the sections a very irregular outline based on a trapezoid design.

Ribs on the living chamber are stout, arising from undulations of the umbilical margin, becoming well-defined at the umbilical shoulder, and are developed as strong, radially-directed ribs slightly concave apicad with a swelling at the ventral shoulder. Longitudinally developed, outward-pointing tubercles are developed on the venter on each side of the median portion, and where the ribs cross the venter at the latter half of the living chamber the median ventral portion is sunken between the two elongated tubercles. On the posterior half of the living chamber the ribs do not cross the venter, and these elongated tubercles are elongate orad from the costae giving the costae an appearance of flexing sharply forward at the ventral shoulder.

In the septate portion of the outer whorl the ribs are slightly disposed forward from the umbilical margin and terminate in a bullate latero-ventral tubercle at two-thirds whorl-height from the umbilical margin. The elongate tubercles on each side of the venter are laterally compressed and rounded longitudinally, giving the periphery a crenulated appearance.

In the anterior portion of the penultimate whorl the latero-ventral tubercles become radially elongate again.

There are 18 ribs on the outer volution of the holotype, with 10 ribs per half-whorl on the septate portion of the ultimate whorl.

The external suture is not well displayed but is shown on the flanks at a diameter of about 180 mm. The suture third back from the living chamber is as follows: The siphonal lobe is an estimated 25 mm. deep, about 15 mm. wide at its broadest part, and ends in two main points. The external saddle is very broad (30 mm.), covering the outer two-fifths of the whorl height. The main lobule dividing it is about half as deep as the first lateral lobe, and is trifid. A subsidiary adventitious lobule irregularly divides the ventral subdivision of the external saddle. The latero-ventral bullate tubercle occupies the dorsal subdivision of the external saddle.

The first lateral lobe is moderately narrow, about 20 mm. wide by 28 mm. deep, and is asymmetrically bifid with the inner terminal point heavier than the outer. The first lateral saddle is about the same width as the first lateral lobe, and the first auxiliary lobe appears at the umbilical shoulder and is about equal in width but a little shallower than the lobule dividing the external saddle.

The external saddle and lateral saddles are contained by the same intercostal area, with the points of the main lobes crossing the posterior rib.

Holotype: Univ. of Alberta Geol. Museum No. Ct. 1113.

Occurrence: The holotype occurs on Dunvegan creek, Alberta, Tp. 79, Rge. 5, W. 6th Meridian, from the lower part of the Kaskapau (Lower Smoky) shales. Another specimen (U. of A. Ct. 845), consisting of a flattened half-whorl of diameter 180 mm., was obtained from the basal Blackstone (Lower Alberta) shale on the Blackstone river in the foothills of central Alberta. A further specimen was collected from Cowie creek, British Columbia, about 130 feet above the Pouce Coupe sandstone member of the Kaskapau formation. A specimen that might well be considered a variety of the new species is figured by Haas (1949, plate 15, figs. 1-3) as *Dunveganoceras* sp. indet. from the Cody formation near Greybull, Wyoming.

Remarks: This species varies from the genotype *D. albertense* (Warren) in its smaller size, in the greater involution of the whorls, and in the retention of a flattened or impressed venter in the trapezoidal costal whorl-section. The number of costae in the ultimate volution is the same as in *D. albertense* (Warren), *D. poucecoupense* Warren and Stelck, and *D. pondi* Haas.

The new species has much the same ventral development as *D. pondi* Haas but the whorl-section is much higher and less quadrate in outline in *D. hagei.*

The late ventral development is similar to that of *D. clowi* n. sp., but the greater number of ribs and the reduction of the latero-ventral tubercles on *D. clowi* clearly distinguishes it from *D. hagei.*

The new species is most closely affiliated with *Dunveganoceras* sp. indet. figured by Haas (1949, plate 15, figs. 1-3). Haas' figured

specimen differs from the holotype of *D. hagei* in having a weaker expression of the ribs at equivalent diameter. However, the flattened specimen of *D. hagei* from the Blackstone river shows weakness of ribs similar to *Dunveganoceras* sp. indet. Haas at the same diameter. The Greybull specimen is much smaller than either of the Canadian specimens and may be an immature individual of *D. hagei*. The only characteristic peculiar to the Greybull specimen is the median line of incipient ventral tubercles that is not determinable on the concealed inner whorls of *D. hagei*. If this feature is later found to be present on the inner whorls of *D. hagei*, the writers would consider the Greybull *Dunveganoceras* sp. indet. conspecific with *D. hagei*.

Name: This species is named for C. O. Hage, geological consultant, Calgary, who collected the holotype.

Genus ACANTHOCERAS Neumayr, 1875

ACANTHOCERAS ATHABASCENSE Warren and Stelck, n. sp.

Plate 6, figs. 5, 6; Plate 7, figs. 1, 3, 4; Plate 8, figs. 1-3; Plate 9, fig. 2

Acanthoceras woolgari Mantell. Whiteaves, J. F., 1892, Notes on the Ammonites of the Cretaceous Rocks of the District of Athabasca, etc. Trans. Roy. Soc. Can., vol. 10, sec. IV, p. 119, no figure.

Description: Shell large, evolute, latumbilicate, the outer whorls less strongly embracing than the inner; ribbed and nodose; whorl-section subquadrate.

Dimensions of holotype:

Maximum diameter 250 mm., minimum diameter 205 mm.;

Umbilicus—max. diam. 88 mm., min. diam. 68 mm.;

At beginning of living chamber—Height of shell 67 mm., width 44 mm.;

Living chamber, half a whorl preserved.

The inner whorls have an interrupted keel (as shown in a paratype—Plate 7, fig. 1), which disappears at the beginning of the last volution (diameter 94 mm.). Weak ribs are present on the inner whorls with three rows of nodes on each side—one row on umbilical shoulder and two rows on ventral shoulder. The row of transverse nodes on the umbilical shoulder comes into prominence on the penultimate whorl and the nodes become dominant features on the living chamber. They are inclined to alternate in size, this feature becoming less pronounced on the living chamber. The two rows of nodes on the ventral border are elongate up to a diameter of 120 mm., after which the lateral nodes become more prominent and bullate while the ventral row becomes absorbed in the base of the bullae of the lateral row and disappears as a separate entity at about a quarter of a whorl back of the base of the living chamber. At the front of the living chamber the bullae become laterally extended horns, attaining an expression of as much as 50 mm. on some fragments collected.

On the inner whorls the keel expression corresponds to the position of the ribs, the furrow between the ribs crossing the venter but not the rib itself. For nearly a whorl the venter is completely smooth, but on the outer part of the living chamber a broad rib connects the bullae or horns across the venter. On the inner whorls the ribs are flexed slightly forward on the ventral shoulder. On the living chamber the ribs flatten; sometimes the medial portion of the ribs has an elliptical depression, producing an ill-defined double rib between the nodes.

One paratype, with shell preserved, shows the ornament of the shell to consist of fine transverse growth lines, paralleling the ribs, with about 7 lines between ribs. On the ultimate whorl the number of ribs is 18; on the penultimate whorl the number is 21.

The external suture (at a diameter of 90 mm.) shows a ventral lobe 16 mm. in depth and 14 mm. wide, ending in two subparallel trifid points separated by a small median knob about one-quarter the depth of the ventral lobe.

The external saddle is broad (18 mm.) and is unequally divided by a trifid lobule with the outer subdivision over twice the width of the inner division. The first lateral lobe is quite open (10 mm. wide by 12 mm. deep), and is bifid with the inner prong slightly heavier than the outer. The first lateral saddle is 6 mm. wide. The second lateral lobe appears at the umbilical shoulder, is bifid, 6 mm. wide and tapering, and is about equal in length to the lobule dividing the external saddle.

Types: Univ. of Alberta Geol. Museum, holotype Ct. 1041; paratypes Ct. 1042, Ct. 1043, Ct. 1114; hypotypes Ct. 769, Ct. 1044.

Horizon and locality: Lower beds of the Labiche shale near the "fish scale" horizon. Specimens Ct. 769 and Ct. 1043 were found in glacial drift. Other specimens were found loose at the base of exposure, Sec. 8, Tp. 80, Rge. 17, W. 4th Meridian, Alberta. The horizon is known to be within 40 feet of the "fish scale" beds in the Labiche shale.

Discussion: This species compares very favorably with *Euomphaloceras euomphalum* (Sharpe) = (*Acanthoceras cunningtoni* Sharpe) in general morphology, but differs in having a greater number of ribs and a different keel expression on the inner whorls. *A. cenomanse* (D'Archiac) differs from the Canadian species in expression of the ribs, which are more immature at the same stage of growth in the European species. The Canadian species does not compare favorably with any of the Texas species of *Acanthoceras* known to the writers.

BIBLIOGRAPHY

Bergquist, Harlan R. (1944): Cretaceous of the Mesabi Iron Range, Minnesota. Jour. Paleo., Vol. 18, No. 1, pp. 1-30.

Bolin, E. J. (1954): Some Foraminifera, Radiolaria and Ostracoda from the Cretaceous of Minnesota. Abstract only, Jour. Paleo., Vol. 28, No. 4, p. 512.

Crickmay, C. H. (1944): Pouce Coupe - Peace River. Geol. Surv. Canada, Prelim. Map 44-31.

Cushman, J. A. (1946): Upper Cretaceous Foraminifera of the Gulf Coastal Region of the United States and Adjacent Areas. U.S. Geol. Surv. Prof. Paper 206.

Cobban, W. A. (1951): Colorado Shale of Central and Northwestern Montana and Equivalent Rocks of Black Hills. Amer. Assoc. Petrol. Geol. Bull., Vol. 35, No. 10, pp. 2170-2198.

Cobban, W. A., and Reeside, J. B., Jr. (1952): Frontier Formation, Wyoming and Adjacent Areas. Amer. Assoc. Petrol. Geol. Bull., Vol. 36, No. 10, pp. 1913-1961.

Cobban, W. A. (1953): Cenomanian Ammonite Fauna from the Mosby Sandstone of Central Montana. U.S. Geol. Surv. Prof. Paper 243-D, pp. 45-55.

Dawson, G. M. (1881): On the Geology of the Region between the 54th and 56th Parallel from the Pacific Coast to Edmonton, in Report on an Exploration from Port Simpson on the Pacific to Edmonton on the Saskatchewan and the Peace River Country. Geol. Surv. Canada, Rept. of Progress for 1879-80, Pt. B, pp. 99-136.

Fox, S. K., Jr. (1954): Cretaceous Foraminifera from the Greenhorn, Carlile and Cody Formations, South Dakota, Wyoming. U.S. Geol. Surv. Prof. Paper 254-E.

Frizzell, D. L. (1954): Handbook of Cretaceous Foraminifera of Texas. Texas Bureau of Economic Geology, Rept. of Investigations No. 22.

Gleddie, J. (1949): Upper Cretaceous in Western Peace River Plains, Alberta. Amer. Assoc. Petrol. Geol. Bull., Vol. 33, No. 4, pp. 511-532.

Gleddie, J. (1954): Upper Cretaceous in Western Peace River Plains, Alberta. Symposium: Ralph Leslie Rutherford Memorial Volume, "Western Canada Sedimentary Basin", Amer. Assoc. Petrol. Geol., Tulsa, Appendix pp. 486-509.

Haas, Otto (1949): Acanthoceratid Ammonoidea from near Greybull, Wyoming. Amer. Mus. Nat. Hist. Bull., Vol. 93, Article 1, pp. 1-39.

Haas, Otto (1951): Supplementary Notes on the Ammonoid Genus *Dunveganoceras*. Amer. Mus. Novitates No. 1490, pp. 1-21.

Hofker, Jan (1953): Arenaceous Tests in Foraminifera—Chalk or Silica? The Micropaleontologist, Vol. VII, No. 3, pp. 65-66.

Höglund, Hans (1947): Foraminifera in the Gullmar Fjord and the Skagerak. Inaugural Dissertation, Uppsala, Appelbergs Boktryckeri, A-B. Reprinted from Zoologiska Bidrag Fran Uppsala, Band 26, 327 pages.

Loeblich, A. R. (1946): Foraminifera from the Type Pepper Shale of Texas. Jour. Paleo., Vol. 20, No. 2, pp. 130-139.

McLearn, F. H. (1918): Peace River Section, Alberta. Geol. Surv. Canada, Summ. Rept. 1917, Pt. C, pp. 14-21.

McLearn, F. H. (1919): Cretaceous Lower Smoky River, Alberta. Geol. Surv. Canada, Summ. Rept. 1918, Pt. C, pp. 1-7.

McLearn, F. H. (1926): New Species from the Coloradoan of Lower Smoky and Lower Peace Rivers, Alberta. Geol. Surv. Canada, Museum Bull. 42, pp. 117-126.

McLearn, F. H. (1943): Trends in Some Canadian Cretaceous Species of *Inoceramus*. Canadian Field Naturalist, Vol. 57, pp. 36-46.

McLearn, F. H. (1945): The Upper Cretaceous Dunvegan Formation of Northwestern Alberta and Northeastern British Columbia. Geol. Surv. Canada, Paper 45-27.

McLearn, F. H., and Kindle, E. D. (1950): Geology of Northeastern British Columbia. Geol. Surv. Canada, Mem. 259.

Muller, S. W., and Schenck, H. G. (1943): Standard of Cretaceous System. Amer. Assoc. Petrol. Geol. Bull., Vol. 27, No. 3, pp. 262-278.

Nauss, A. W. (1945): Cretaceous Stratigraphy of Vermilion Area, Alberta, Canada. Amer. Assoc. Petrol. Geol. Bull., Vol. 29, No. 11, pp. 1605-1629.

Nauss, A. W. (1947): Cretaceous microfossils of the Vermilion Area, Alberta. Jour. Paleo., Vol. 21, No. 4, pp. 329-343.

Russell, L. S. (1943): Sexsmith-Bison Lake Map Area. Geol. Surv. Canada, Prelim. Map.

Rutherford, R. L. (1930): Geology and Water Resources in Parts of the Peace River and Grande Prairie Districts, Alberta. Sci. and Ind. Res. Council of Alberta, Report No. 21, pp. 1-68.

Slama, D. C. (1954): Arenaceous Tests in Foraminifera—an Experiment. The Micropaleontologist, Vol. VIII, No. 1, p. 33-34.

Spieker, E. M. (1921): The Geology and Oil Resources of the Foothills South of Peace River in Northeastern British Columbia. Dept. of Lands, British Columbia, Report of Oil Surveys in the Peace River District, 1920, pp. K11-K27.

Stelck, C. R. (1950): Cenomanian-Albian Foraminifera of Western Canada. Doctorate of Philosophy Thesis, Stanford University. Abstract in Stanford Univ. Bull., 8th Series, No. 67, pp. 335-336, 1951.

Stelck, C. R., and Wall, J. H. (1954): Kaskapau Foraminifera from Peace River Area of Western Canada. Research Council of Alberta Report No. 68.

Stephenson, Lloyd W. (1952): Larger Invertebrate Fossils of the Woodbine Formation (Cenomanian) of Texas. U.S. Geol. Surv. Prof. Paper 242.

Wall, J. H. (1951): Cenomanian-Turonian Foraminifera from Kaskapau Formation, Peace River Area, Western Canada. Master of Science Thesis, University of Alberta, Edmonton.

Warren, P. S., and Rutherford R. L. (1928): Fossil Zones in the Colorado Shale of Alberta. Amer. Jour. Sci., Vol. 16, pp. 129-136.

Warren, P. S. (1930): Description of New Species of Fossils from Parts of the Peace River and Grande Prairie Districts, Alberta. Sci. and Ind. Res. Council of Alberta Report No. 21, Appendix.

Warren, P. S., and Stelck, C. R. (1940): Cenomanian and Turonian Faunas in the Pouce Coupe District, Alberta and British Columbia. Trans. Roy. Soc. Canada, Vol. 34, Sec. IV, pp. 143-152.

Webb, J. B., and Hertlein, L. G. (1934): Zones in Alberta shale in the Foothills of Southwestern Alberta. Amer. Assoc. Petrol. Geol. Bull., Vol. 18, No. 11, pp. 1387-1416.

Wickenden, R. T. D. (1945): Mesozoic Stratigraphy of the Eastern Plains, Manitoba and Saskatchewan. Geol. Surv. Canada, Mem. 239.

Wright, C. W., and Wright, E. V. (1951): A Survey of the Fossil Cephalopoda of the Chalk of Great Britain. Monograph, Paleontographical Society, London.

Young, Keith (1951): Foraminifera and Stratigraphy of the Frontier Formation (Upper Cretaceous), Southern Montana. Jour. Paleo., Vol. 25, No. 1, pp. 35-68.

EXPLANATION OF PLATE 1

Lower Part of Kaskapau Formation

Magnification x40 except for figs. 9, 10, 14, which are x60.

Figs. 1-3: *Ammobaculites gravenori* Stelck and Wall, n.sp.; 1, holotype, from Spirit River, Alberta; 2, paratype, from Doe creek, Alberta; 3, paratype, from Spirit River, Alberta (p. 30)

Fig. 4: *Ammobaculites spiritensis* Stelck and Wall, n.sp.; holotype, from Doe creek, Alberta—a, b, side and peripheral views (p. 33)

Figs. 5, 6: *Proteonina* cf. *alexanderi* Loeblich and Tappan, from Spirit River, Alberta (p. 52)

Figs. 7, 8: *Ammobaculites obliquus* Loeblich and Tappan, from Spirit River, Alberta (p. 32)

Figs. 9, 10: *Haplophragmoides pacalis* Stelck and Wall, n.sp.; 9, holotype, from Spirit River, Alberta—a, b, side and peripheral views; 10, paratype, from Doe creek, Alberta (p. 51)

Figs. 11, 12, 14, 15, 16: *Trochammina rutherfordi* Stelck and Wall, n.sp.; 11, holotype, from Spirit River, Alberta—a, view of spire, b, peripheral view, c, umbilical view; 12, paratype, from Doe creek, Alberta; 14, variety 1, from Doe creek, Alberta; 15, variety 2, from Spirit River, Alberta; 16, variety 2, from Doe creek, Alberta (p. 56)

Figs. 13, 27: *Ammomarginulina lorangerae* Stelck and Wall, n.sp.; 13, holotype, from Spirit River, Alberta; 27, variant, from Doe creek, Alberta—a, b, opposite sides (p. 34)

Figs. 17, 20: *Flabellammina irenensis* Stelck and Wall, n.sp., from Doe creek, Alberta; 17, immature form—a, b, opposite sides; 20, holotype (p. 38)

Figs. 18, 19, 21: *Flabellammina webbi* Stelck and Wall, n.sp.; 18, holotype, from Spirit River, Alberta; 19, paratype, from Spirit River, Alberta; 21, variant, from Doe creek, Alberta (p. 41)

Figs. 22, 23: *Flabellammina kaskapauensis* Stelck and Wall, n.sp., from Spirit River, Alberta; 22, holotype; 23, paratype (p. 39)

Fig. 24: *Flabellammina* cf. *hendersonensis* Stelck and Wall, from Dunvegan, Alberta (p. 37)

Figs. 25, 26: *Flabellammina warreni* Stelck and Wall, n.sp.; 25, holotype, from Spirit River, Alberta; 26, paratype, from Doe creek, Alberta (p. 40)

EXPLANATION OF PLATE 2

Lower and Central Parts of the Kaskapau Formation

Magnification x40 approx. except for figs. 32, 33, 36, which are x60.

Figs. 1, 2, 3, 6: *Trochammina wetteri* Stelck and Wall, n.sp., from Spirit River, Alberta; 1, 3, paratypes; 2, holoytpe—a, dorsal view, b, peripheral view, c, ventral view; 6, variant—a, ventral view, b, peripheral view, c, dorsal view ..... (p. 59)

Figs. 4, 5: *Gaudryina irenensis* Stelck and Wall, n.sp.; 4, holotype, from Spirit River, Alberta; 5, paratype, from Doe creek, Alberta ..... (p. 42)

Fig. 7: *Dorothia kaskapauensis* Stelck and Wall, n.sp.; holotype, from Spirit River, Alberta ..... (p. 36)

Fig. 8: *Dorothia kaskapauensis* var. *gracilis* Stelck and Wall, n.sp., n.var.; variety holotype, from Spirit River, Alberta ..... (p. 37)

Figs. 9, 10: *Gaudryina spiritensis* Stelck and Wall, n.sp.; 9, holotype, from Spirit River, Alberta; 10, paratype, from Doe creek, Alberta ..... (p. 43)

Fig. 11: *Gümbelitria cretacea* Cushman var. *spiritensis* Stelck and Wall, n.var.; variety holotype, from Spirit River, Alberta—a, side view, b, view showing aperture ..... (p. 44)

Figs. 12, 13, 14, 18, 19: *Ammobaculites albertensis* Stelck and Wall; 12, paratype, from Pouce Coupe river, Alberta; 13, 14, 18, 19, from Spirit River, Alberta; 18, holotype; 14, large variant in peripheral view showing aperture; 13, 19, paratypes ..... (p. 29)

Fig. 15: *Haplophragmoides eocalcula* Stelck and Wall, n.sp., holotype, from Spirit River, Alberta—a, side view, b, peripheral view ..... (p. 49)

Figs. 16, 17, 22, 23: *Haplophragmoides crickmayi* Stelck and Wall, n.sp., from Spirit River, Alberta; 16, 17, immature forms; 22, holotype—a, side view, b, peripheral view; 23, paratype ..... (p. 47)

Figs. 20, 21: *Ammobaculites pacalis* Stelck and Wall; 20, paratype, from Henderson creek, Alberta; 21, holotype, from Spirit River, Alberta ..... (p. 33)

Figs. 24-26: *Haplophragmoides collyra* Nauss var. *bullocki* Stelck and Wall, n.var., from Spirit River, Alberta; 24, variety holotype—a, side view, b, peripheral view; 25, 26, paratypes ..... (p. 46)

Fig. 27: *Hapophragmoides spiritense* Stelck and Wall, paratype, from Spirit River, Alberta—a, side view, b, peripheral view ..... (p. 52)

Figs. 28, 29: *Haplophragmoides neolinki* Stelck and Wall, n.sp., from Spirit River, Alberta; 28, holotype—a, side view, b, peripheral view; 29, paratype ..... (p. 50)

Figs. 30, 31: *Haplophragmoides collyra* Nauss var. *bahani* Stelck and Wall, n.var., from Doe creek, Alberta; 30, holotype; 31, paratype—a, side view, b, peripheral view ..... (p. 45)

Figs. 32, 33: *Haplophragmoides* cf. *pacalis* Stelck and Wall; 32, from Spirit River, Alberta—a, side view, b, peripheral view; 33, from Doe creek, Alberta ..... (p. 51)

Figs. 34, 35: *Textularia rollaensis* Stelck and Wall; 34, holotype, from Doe creek, Alberta; 35, paratype, from Spirit River, Alberta ..... (p. 55)

Fig. 36: *Textularia gravenori* Stelck and Wall, n.sp., holotype, from Spirit River, Alberta ..... (p. 55)

Fig. 37: *Verneuilinoides perplexus* (Loeblich), from Doe creek, Alberta ..... (p. 60)

Figs. 38, 39: *Spiroplectammina phauloides* Stelck and Wall, n.sp.; 38, paratype, from Pouce Coupe river, Alberta; 39, holotype, from Spirit River, Alberta ..... (p. 54)

Figs. 40, 41: *Verneuilinoides perplexus* (Loeblich) var. *gleddiei* Stelck and Wall, n.var., from Spirit River, Alberta; 40, variety holotype; 41, paratype ..... (p. 61)

EXPLANATION OF PLATE 3

Lower and Central Parts of Kaskapau Formation

Magnification approximately x65.

Figs. 1, 2: *Flabellammina irenensis* Stelck and Wall, n.sp., hypotype, from Doe creek, Alberta; 1, 2, opposite sides ..... (p. 38)

Figs. 3-5: *Ammobaculites pacalis* Stelck and Wall, hypotype, from near mouth of Hines river, Alberta; 3, 5, side views, 4, peripheral view ..... (p. 33)

Fig. 6: *Bathysiphon* sp., from Doe creek, Alberta ..... (p. 36)

Fig. 7: *Ammobaculites gravenori* Stelck and Wall, n.sp., hypotype, from Doe creek, Alberta ..... (p. 30)

Figs. 8-12: *Gaudryina spiritensis* Stelck and Wall, n.sp., hypotypes, from Doe creek, Alberta; 8, 9, views of opposite sides of a hypotype; 10, 11, 12, views of opposite sides and apertural view of another hypotype ..... (p. 43)

Figs. 13-15: *Tritaxia pyramidata* Reuss var. *diminuta* Stelck and Wall, n.var., from Doe creek, Alberta; 13, 14, 15, variety holotype; 13, apertural view; 14, 15, views of opposite sides ..... (p. 56)

Figs. 16, 17: *Ammobaculites* cf. *gravenori* Stelck and Wall, from Doe creek, Alberta; views of opposite sides ..... (p. 31)

Figs. 18, 19: *Ammobaculites obliquus* Loeblich and Tappan, from Doe creek, Alberta; views of opposite sides ..... (p. 32)

Figs. 20, 21, 36, 37: *Trochammina rutherfordi* Stelck and Wall, n.sp., from Doe creek, Alberta; 20, 21, variety 1—20 is view of spire, 21, umbilical view; 36, 37, variety 2—36 is view of spire; 37, peripheral view ..... (p. 56)

Figs. 22-24: *Haplophragmoides crickmayi* Stelck and Wall, n.sp., variant from near mouth of Hines river, Alberta; 22, 24, views of opposite sides; 23, peripheral view ..... (p. 47)

Figs. 25, 26: *Reophax* sp., from Doe creek, Alberta; 25, side view; 26, apertural view ..... (p. 53)

Figs. 27, 28: *Ammomarginulina* cf. *lorangerae* Stelck and Wall, from Doe creek, Alberta; 27, sketch of ultimate and penultimate chambers showing embracing relationship; 28, side view ..... (p. 35)

Figs. 29, 30: *Verneuilinoides perplexus* (Loeblich), from Doe creek, Alberta; views of opposite sides ..... (p. 60)

Figs. 31, 32, 38, 39: *Haplophragmoides collyra* Nauss var. *bullocki* Stelck and Wall, n.var.; 31, hypotype from Doe creek, Alberta; 32, immature form from Doe creek, Alberta; 38, 39, opposite sides of a flattened hypotype from near mouth of Hines river, Alberta ..... (p. 46)

Figs. 33, 34: *Haplophragmoides spiritense* Stelck and Wall, hypotype, from near mouth of Hines river, Alberta; views of opposite sides ..... (p. 52)

Fig. 35: *Ammobaculites albertensis* Stelck and Wall var. *hinesensis* Stelck and Wall, n. var., from near mouth of Hines river, Alberta; variety holotype ..... (p. 30)

EXPLANATION OF PLATE 4

Figs. 1-9: *Dunveganoceras poucecoupense* Warren and Stelck, inner whorls; 1, cross-section of nucleus (x10) showing reniform conch-section at diameter of 12.2 mm., specimen Ct. 1111, U. of A.; 2, whorl-section (x2) at diameter 20 mm., Ct. 1111, U. of A.; 3, whorl-section (x1) at diameter 65 mm., Ct. 1111, U. of A.; 4, suture line (x10) at diameter 1 mm., Ct. 1111, U. of A.; 5, suture line (x10) at diameter 4 mm., Ct. 1112, U. of A.; 6, suture line (x10) at diameter 6 mm., Ct. 1112, U. of A.; 7, suture line (x6) at diameter 10 mm., Ct. 1112, U. of A.; 8, suture line (x2) at diameter 20 mm., Ct. 1111, U. of A.; 9, suture line (x2) at diameter 65 mm., Ct. 1111, U. of A. ..... (p. 64)

EXPLANATION OF PLATE 5

Fig. 1: *Dunveganoceras hagei* Warren and Stelck, n.sp., holotype (x½), Ct. 1113, U. of A. (p. 69)

Figs. 2-4: *Dunveganoceras poucecoupense* Warren and Stelck, inner whorls; 2, (x5) at diameter 7 mm., Ct. 1112, U. of A.; 3, (x5) at diameter 11 mm., Ct. 1112, U. of A.; 4, (x1) at diameter 85 mm., Ct. 964, U. of A. (p. 64)

EXPLANATION OF PLATE 6

Figs. 1-4: *Dunveganoceras poucecoupense* Warren and Stelck, inner whorls; 1, ventral view (x1), Ct. 1111, U. of A.; 2, ventral view (x5) of region where latero-ventral tubercles start, diameter 7 mm., Ct. 1112, U. of A.; 3, ventral view (x5) at diameter 11 mm., Ct. 1112, U. of A.; 4, side view (x1), Ct. 1111, U. of A. (p. 64)

Figs. 5, 6: *Acanthoceras athabascense* Warren and Stelck, n.sp., paratype; side view, Ct. 1043, U. of A., and suture of same at diameter 80 mm. (p. 71)

EXPLANATION OF PLATE 7

Figs. 1, 3, 4: *Acanthoceras athabascense* Warren and Stelck, n.sp.; 1, paratype (x1), Ct. 1042, U. of A., part of venter showing the median row of tubercles; 3, paratype (x½), Ct. 1114, U. of A.; 4, hypotype (x1), Ct. 769, U. of A. (p. 71)

Fig. 2: *Dunveganoceras albertense* (Warren) (x½), Ct. 1115, U. of A., camerate portion from Kakwa river area, Alberta, introduced to show density of ribs in the earlier whorls of the genotype species (p. 66)

EXPLANATION OF PLATE 8

Figs. 1-3: *Acanthoceras athabascense* Warren and Stelck, n.sp.; 1, cross-section of holotype (x1) restored; 2, hypotype (x½) oblique side view of Ct. 769, U. of A. (same specimen as Pl. 7, fig. 4); 3, holotype (x½), Ct. 1041, U. of A., cross-section of fig. 1 taken at arrow (p. 71)

EXPLANATION OF PLATE 9

Figs. 1, 3: *Dunveganoceras clowi* Warren and Stelck, n.sp.; 1, mirror image of suture line of holotype (x1), Ct. 1116, U. of A.; 3, holotype (x½), Ct. 1116, U. of A. (p. 66)

Fig. 2: *Acanthoceras athabascense* Warren and Stelck, n.sp. (x1), Ct. 1044, U. of A., fragment showing the development of the ventro-lateral horn (p. 71)

ERRATA IN REPORT NO. 68

P. 10, line 13: For *F. webbi* read *F. webbi* var.

P. 10, line 43: For *T. rutherfordi* var. read *T. rutherfordi.*

P. 11, line 11, right hand column only: For *H. hendersonense* read *H. neolinki.*

P. 11, line 19: For *T. wetteri* read *T. wetteri* var.

P. 12, line 8: For *H. spiritense* var. read *H. howardense.*

P. 13, line 8: For *T. rutherfordi* var. read *T. rutherfordi.*

P. 13, line 20: For *H. crickmayi* var. read *H. crickmayi.*

P. 32, line 17: H. E. Thalmann of Stanford University has pointed out (pers. comm.) that the name *Tritaxia spiritensis elongata* Stelck and Wall is preoccupied. It is a homonym of *Tritaxia elongata* Halkyard, 1919, Mem. Proc. Manchester Lit. Phil. Soc., Vol. LXII (1917), Manchester, 1919, p. 45, pl. 3, fig. 9. The writers have substituted the name *Tritaxia spiritensis prolongata* Stelck and Wall, Thalmann 1955, "New Names for Foraminiferal Homonyms III", Contr. Cushman Found. Foram. Research, Vol. VI, part 2, No. 133, p. 82.

P. 32, line 41: For *T. kistatinawensis* read *T. kiskatinawensis.*

Figure 2: For *Ammomarginulina obliquus* read *Ammobaculites obliquus.*

Figure 2: Scale of diagram should be 1″=70′.

Figure 3: Scale of diagram should be 1″=70′.