ARCHIVES
AGS
Report
68
1954

PROVINCE OF ALBERTA

Research Council of Alberta Report No. 68

University of Alberta, Edmonton, Alberta

Kaskapau Foraminifera from Peace River Area of Western Canada

by

C. R. Stelck and J. H. Wall

EDMONTON:
PRINTED BY A. SHNITKA, QUEEN'S PRINTER
1954

Price $1.50

Alberta Geological Survey Library
0 1640 3001 9743

PROVINCE OF ALBERTA
Research Council of Alberta Report No. 68
University of Alberta, Edmonton, Alberta

Kaskapau Foraminifera
from
Peace River Area of Western Canada

by

C. R. STELCK
University of Alberta
Department of Geology

and

J. H. WALL
University of Missouri
(formerly with Imperial Oil Exploration)

RECEIVED
JAN 31 2005
Alberta Geological Survey Library

EDMONTON:
PRINTED BY A. SHNITKA, QUEEN'S PRINTER
1954

TABLE OF CONTENTS

NOTE: Certain *nomina nuda* introduced on page 10 et seq. are described in the next report of this series.

LIST OF ILLUSTRATIONS

FOREWORD

The Research Council of Alberta publishes the following report as an original aid to the problems of dating the potentially oil- and gas-bearing strata of the Cretaceous sequence of Alberta. The increasing importance of Cretaceous oil and gas to the economy of Alberta accelerates the necessity for micropaleontological data to be made generally available to the Alberta oil industry.

These studies originated through field collections made by the writers in 1947, under assignment from J. B. Webb, then manager for exploration for Imperial Oil Limited, Calgary. Research carried out at Stanford University and later at the University of Alberta by the senior author resulted in a Stanford University Doctoral dissertation on the Foraminifera of these collections. Financial assistance toward this project was obtained through an Imperial Oil Graduate Fellowship and the Eric Knight Jordan Fellowship held while in attendance at Stanford University.

The junior author continued research on Upper Cretaceous foraminiferal correlations for Imperial Oil Limited in Calgary, completing one of his studies as a Master of Science thesis for the University of Alberta in 1951.

Technical assistance has been 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. Field collections studied included those of the writers and some made by J. Y. Smith and J. Gleddie of Imperial Oil Limited, Calgary.

ABSTRACT

Twenty-six species and subspecies of Foraminifera, of which 23 are new, are figured and described from the central part of the Upper Cretaceous Kaskapau formation from the Peace River area of Alberta and British Columbia. Microfaunal zones are introduced for the transition beds from the Cenomanian stage to the Turonian stage as represented by the sand and shale members of the lower and central parts of the Kaskapau formation. Lower Turonian portions of the Kaskapau formation are correlated with the second white specks zone of the Colorado and Lloydminster shale of Alberta, with the Favel formation of Manitoba, with the Greenhorn limestone of the western plains of the United States, and with portions of the Eagle Ford formation of Texas. The foraminiferal assemblages indicate deep neritic to bathyal conditions of deposition in early Turonian time in the Peace River area.

Kaskapau Foraminifera from Peace River Area of Western Canada

INTRODUCTION

The Peace River area of western Canada has a Lower Cretaceous marine succession of strata of boreal affinities. The contained boreal microfauna is distinct from the partly correlative Comanchean faunas of the Gulf of Mexico. Gulf of Mexico faunas did not appear in western Canada until the Lower Turanian stage of the Upper Cretaceous. The Lower Turonian microfauna serves, then, as a common datum for North American strata and this microfauna is found in the Peace River area in the central part of the Kaskapau formation.

The central Kaskapau microfaunas are of mixed pelagic and benthonic assemblages. The ancestry of the benthonic assemblages is contained, for the most part, in the history of Lower Cretaceous microfaunas peculiar to the boreal floodings. The Gulf Coast floodings introduced the pelagic element. The pelagic element is dominated by the species of *Gümbelina, Gümbelitria,* and *Globigerina.* This latter fauna can be readily dated by the contained megafauna of *Inoceramus labiatus* which places the pelagic fauna, in terms of the European section, in Lower Turonian. The identification of the pre-Turonian beds may be made by the ammonite genus, *Dunveganoceras,* which has been found at the top of the Cenomanian beds in England (Wright and Wright 1951, p. 29). In western Canada, *Dunveganoceras* is found around 200 to 250 feet below the occurrence of *Inoceramus labiatus* and identification of the Cenomanian-Turonian boundary is dependent rather on the spectrum of the microfauna as ammonites are rare at this interval.

The boundary between the Cenomanian and Turonian has been arbitrarily set at the horizon of introduction of the pelagic fauna into the microfaunal assemblages. This earliest Turonian pelagic microfaunal assemblage is outlined and described in this paper.

The pelagic species have already been recorded from the Gulf Coast Foraminifera microfauna by Cushman (1946). The benthonic species are mainly new.

STRATIGRAPHY

An exposition of the strata of the Kaskapau formation is necessary to the proper assignment of microfaunal zones. Inasmuch as the Lower Turonian contact in southern Alberta is, in part, modified by diastems and erosional unconformities, it has been found necessary to go to the Peace River country to obtain a continuous stratigraphic sequence from the zone of *Dunveganoceras* (late Cenomanian) to the zone of *Inoceramus labiatus* (early Turonian). This involves the transition beds from the Dunvegan formation to the Kaskapau formation. In this transition interval lie several stray

sands of marine and brackish origin. The sands already named include the Pouce Coupe sand member and the Doe Creek sand member. In addition, we introduce the term, Howard Creek sand member, for a sand slightly higher in position than the Pouce Coupe member. The Doe Creek and the Pouce Coupe sand members belong to the west side of the Alberta syncline and the latter has been recognized by the senior author as far south as the Cadomin area in the foothills of Alberta. The Howard Creek sand occurs on the east side of the Alberta syncline in the Peace River area and apparently has only local extent. The relationship of these sands to the proposed zonation of the Cenomanian-Turonian stage boundary is figured on Fig. 4. The electrolog of this transition is figured in Figs. 2 and 3.

The stratigraphic position of these sands to other known sands of the Peace River area is given in the following sequence of Upper Cretaceous strata:

Formation	*Member*
Wapiti	Wapiti sandstones
	Basal Wapiti sand
Wapiabi	— shale —
	Chinook sandstone
	— shale —
	"First" speckled shale
	Badheart sandstone
	— shale —
Cardium	Baytree conglomerate
	Cardium sand
Kaskapau	— shale —
	"Sand on Mt. Tuskoola"
	"Second" speckled shale
	Howard Creek sand (new name)
	— shale —
	Pouce Coupe sand
	— shale —
	Doe Creek sand
	— shale —
Dunvegan	Dunvegan formation
Shaftesbury	— shale —
	Fish scale sand (basal Upper Cretaceous)

Inasmuch as the fauna described herein comes from the Kaskapau formation of the above stratigraphic sequence, it is deemed advisable to review the history of the term Kaskapau.

Kaskapau Formation

The formation name "Smoky River" was first used by G. M. Dawson in 1879 for the "upper dark shales" exposed on Smoky River. In 1918 F. H. McLearn subdivided this formation into three members, namely, the "Lower shale", "Bad Heart Sandstone", and "Upper shale". In 1926 McLearn assigned the name "Kaskapau" to

the "Lower shale" member. Gleddie, in 1949 (p. 517), proposed that, where applicable, "the name Smoky River be raised to group rank to include in ascending order the Kaskapau, Cardium, and Wapiabi formations". He erroneously included the Badheart in the Cardium formation.

The writers for convenience use the additional terms, "lower", "central" and "upper parts" of the Kaskapau formation.

The term "upper part" includes that portion of the Kaskapau above the second white specks and below the Cardium sandstone in the Pouce Coupe area.

The "lower part" includes the section between the top of the underlying Dunvegan formation and the top of the Pouce Coupe sandstone.

The "central part" refers to the sediments from the top of the Pouce Coupe sandstone to the top of the Lower (Second) White Speckled Shale horizon. (In the western part of the Peace River area the latter horizon is not known as a field marker but becomes replaced by the base of a correlative sand member that occurs on Tuskoola mountain and caps the lower bench of Wartenbe mountain in British Columbia.)

The "lower" and "central" parts of the Kaskapau formation may be divided into the following microfaunal zones:

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

Shales of the Kaskapau formation underlie most of the Peace River area south of the Pine River - Peace River valleys. In the main, the formation consists of medium to dark grey, marine shales. The "lower part" of the formation, referred to by Gleddie (1949) and others as the "basal transitionary zone", including Doe Creek and Pouce Coupe sandstone members (Warren and Stelck, 1940), consists of brackish to marine shale, silty shale, sandstone, and a little ironstone. Considerable ledge-forming ironstone appears in the uppermost beds of the formation in the Pouce Coupe, Spirit River and Smoky River areas.

Gleddie (1949, p. 521) gives an approximate thickness of 1,550 feet for the Kaskapau formation near Pouce Coupe and 900 feet in the vicinity of Spirit River. More recent subsurface work in the latter area suggests an overall thickness of about 1,100 feet to the base of the Badheart sandstone. In the Smoky River area, J. Y. Smith (Gleddie, ibid.) reports a thickness ranging from 520 to 600 feet.

The most important section studied is at Spirit River, as the entire interval from the Lower (Second) White Speckled Shale to

the Dunvegan was cored at either the Spirit River Structure Test No. A-337-1 or in the Imperial Spirit River No. 1 well. In the latter well, between the depths of 400 and 740 feet, the section of the Kaskapau formation consists of medium to dark grey shale, calcareous white speckled to 700 feet, with a few small silt and sand lenses. Between the depths of 740 and 1,055 feet, the formation consists of medium grey, sandy to silty shale with pyrite tracings, along with several beds of buff and grey fine-grained sandstone, glauconitic and shaly in part. Sandstone beds occur more commonly in the basal 135 feet of the formation at this locality.

The writers introduce the name "Howard Creek sand" for the bed of buff grey, fine- to medium-grained, partly glauconitic, shaly sandstone (calcareous in uppermost 12 inches), which occurs between the depths of 763 and 777 feet in the Imperial Spirit River No. 1 well. This sand outcrops on Howard Creek to the northwest of Spirit River. It has been assumed that the Howard Creek sand might be the correlative of the Pouce Coupe member because it is better developed and more striking in appearance, as reflected on the electrolog, than the sand equivalent of the Pouce Coupe member. However, a bed between the depths of 842 and 854 feet, consisting of buff-grey fine-grained, glauconitic, shaly in part, sandstone is now considered to be the equivalent of the Pouce Coupe sandstone member for reasons discussed later.

The Pouce Coupe sandstone member, at its type locality (mouth of Saskatoon Creek, B.C.), consists of yellow, massive, fine-grained, clean sandstone, approximately 30 feet in thickness. The top of the sand is about 300 feet above the base of the Kaskapau.

The Doe Creek sandstone member, at its type locality (east of the hamlet of Doe River, B.C.), consists of yellow, fine-grained sandstone, argillaceous toward the base, approximately six feet in thickness. The top of the sand is 75 feet below the base of the Pouce Coupe sand member and about 225 feet above the base of the Kaskapau formation.

The sections between the two sand members and between the Doe Creek member and the underlying Dunvegan formation is made up chiefly of silty to sandy shale, with occasional bands of siltstone, sandstone, and ironstone.

An excellent marker known as the "white chalcedonic bed" occurs 145 feet above the Pouce Coupe sand (on Kiskatinaw River near Arras, B.C.), consisting of tuffaceous sandstone with large white chalcedonic nodules. The 50 feet of section sampled above this latter marker is made up chiefly of grey silty shale, while the interval between it and the Pouce Coupe sand consists also of grey silty shale but with considerable interbedded thin sandstone and some ironstone bands and a very high bentonitic content in the shales.

CORRELATION OF THE CENTRAL AND LOWER PARTS OF THE KASKAPAU FORMATION

CENOMANIAN-TURONIAN BOUNDARY

Warren and Stelck (1940, p. 144) place the Cenomanian-Turonian boundary at, or a few feet above, the top of the Pouce Coupe sand which contains the *Dunveganoceras* (Late Cenomanian) fauna. The writers found no foraminifera, other than those of the pelagic microfaunal zone, which could be identified with the forms from outside of the area, and thus are dependent upon the occurrences of the various dated ammonites and pelecypods for age determination and microfaunal units. Accordingly, all of the foraminifera restricted to the lower part of the Kaskapau, that is, between the Pouce Coupe sand and the Dunvegan formation, are, by direct calibration, Upper Cenomanian in age. The microfauna of the pelagic zone is known to be Lower Turonian in age.

The writers suggest that a more refined boundary between the Cenomanian and Turonian should be drawn at the top of the *Ammobaculites pacalis* zone, about 100 feet above the Pouce Coupe sand at Spirit River, Alberta, and 150 feet above it in the Pouce Coupe area. Although there is a pronounced change in microfaunal content in the beds above and below the Pouce Coupe sand, that is, at the base of the *Ammobaculites pacalis* zone, it is not as significant as the break occurring at the top of the zone because, at the latter point, environmental changes are indicated.

It would appear that the sediments from the top of the Dunvegan formation to the top of the *Ammobaculites pacalis* zone (23 feet above the "Howard Creek" sand), were deposited in a near-shore environment, whereas those in the overlying *Haplophragmoides spiritense* zone were deposited in deeper water, still relatively shallow, and within the neritic zone. The writers do not wish to convey the impression that environmental change should, in itself, ordinarily have any bearing on the placing of a time boundary, but the Turonian was an age of rapid world-wide flooding. In this case, the first Lower Turonian megafossils (*Inoceramus labiatus* var.) appear 50 feet above the horizon of change at Spirit River, about 75 feet above at Pouce Coupe, and reflect the completed ecological shift to deeper water. The top of the *Ammobaculites pacalis* zone is the dividing line between the shallow-water Cenomanian and the deep-water Turonian stages.

LOCAL CORRELATIONS

Of the four sections studied, the two at Spirit River and Pouce Coupe are, by far, the most important, since much more data is available concerning them. Consequently, the correlation between these localities is discussed first, after which the sections at Dunvegan Crossing and Kiskatinaw River are correlated with those at Spirit River and Pouce Coupe, respectively. Figure 4 shows the correlation across the area.

Correlation of Pouce Coupe and Spirit River Area Sections

The contribution made by each microfaunal zone to the general correlation is given, followed by a summary of the reasons for the correlation of the Pouce Coupe member.

The *Ammobaculites gravenori* zone has the following forms either restricted to it or their acmes within it and not commonly found above it:

Pouce Coupe	Spirit River
Ammobaculites gravenori	*Ammobaculites gravenori*
Ammobaculites spiritensis	*Ammobaculites obliquus* Loeblich and Tappan
Ammomarginulina lorangerae	*Ammomarginulina lorangerae*
Flabellammina kaskapauensis	*Flabellammina kaskapauensis*
Flabellammina warreni	*Flabellammina warreni*
Ammomarginulina lorangerae var.	*Flabellammina webbi*
Flabellammina irenensis	*Flabellammina* cf. *hendersonensis*
Flabellammina webbi	*Proteonina* cf. *alexanderi* Loeblich and Tappan
Trochammina rutherfordi var. 1	*Trochammina rutherfordi* var. 1
Trochammina rutherfordi var. 2	*Trochammina rutherfordi* var. 2
Trochammina rutherfordi	*Trochammina rutherfordi*
Haplophragmoides collyra var. *bahani*	*Haplophragmoides collyra* Nauss var. *bahani*
Verneuilinoides perplexa (Loeblich)	*Haplophragmoides pacalis*

It will be seen that eight of the above thirteen varieties are common to both areas. In addition, both *Ammobaculites spiritensis* and *Flabellammina webbi var.*, from the Pouce Coupe area, are probably present at Spirit River, but outside of one or two isolated occurrences they cannot be positively identified. *Ammomarginulina lorangerae var.* and *Flabellamina irenensis* are not found at Spirit River either in this zone or in any overlying zone. Finally, *Verneuilinoides perplexa* and *Haplophragmoides pacalis* occur in both areas in the zone, but with the former ranging somewhat higher stratigraphically at Spirit River.

On the evidence presented above, the writers conclude that the lower 180 feet or possibly the lower 160 feet at Pouce Coupe can be correlated with the lower 135 feet of the Kaskapau at Spirit River.

The *Gaudryina irenensis* zone has the following forms either confined to it or their acmes within it and not commonly found outside:

Pouce Coupe	Spirit River
Haplophragmoides crickmayi	*Haplophragmoides crickmayi*
	Trochammina wetteri

In addition, the following group of prominent species, although occurring more or less commonly in the underlying *Ammobaculites gravenori* zone in both areas, is not found above the top of the *Gaudryina irenensis* zone or the Pouce Coupe sand:

Ammobaculites gravenori	*Trochammina rutherfordi var.*
Gaudryina spiritensis	*Verneuilinoides perplexa* (Loeblich) var. *gleddiei*

From the above, it is concluded that the 90 feet of section from the top of the *Ammobaculites gravenori* zone to the base of the Pouce Coupe sand in the Pouce Coupe area correlates with the corresponding 66-foot interval at Spirit River, and that the bed of sand immediately overlying the top of the zone at the latter locality, 201 to 213 feet above the base of the Kaskapau (842 to 854 feet in

drilled section), is the correlative of the Pouce Coupe member at its type locality.

The *Ammobaculites pacalis* zone has the following forms either restricted to it or their acmes within it and not commonly found elsewhere:

Pouce Coupe	Spirit River
Ammobaculites pacalis	*Ammobaculites pacalis*
Ammobaculites albertensis	*Ammobaculites albertensis*
Ammobaculites albertensis var.	*Ammobaculites albertensis* var.
Haplophragmoides eocalcula	*Haplophragmoides eocalcula*
Haplophragmoides hendersonense	*Haplophragmoides hendersonense*
Spiroplectammina phauloides	*Spiroplectammina phauloides*
	Dorothia kaskapauensis
	Dorothia kaskapauensis var. *gracilis*
	Gümbelitria cretacea var. *spiritensis*
	Textularia gravenori
	Trochammina wetteri

It will be seen that nearly half of the above species are common to both areas, and it is desirous to point out that these five forms occur more abundantly than the group not in common. In this latter connection it should be mentiond that *Textularia gravenori* is a very small, pyritized, rare form, not found as yet outside of Spirit River, and that *Gümbelitria cretacea* var. *spiritensis*, a rather rare form also, would probably not be recovered in normal sampling of surface outcrops.

It has been stated previously that the placing of the top of this zone is doubtful in the Pouce Coupe area, because three specimens of *Ammobaculites pacalis* were found in a sample 100 feet higher stratigraphically than the horizon which is presently considered the top (150 feet above the Pouce Coupe sand). However, these occurrences are entirely isolated from the main group of specimens, with none being found in the intervening 100 feet. Furthermore, only one specimen of *Flabellammina hendersonensis* was found at Spirit River, and this at ten feet above the top of the *Ammobaculites pacalis* zone. At Henderson Creek this species does not appear to occur any lower than ten feet above the same horizon. Thus, these occurrences of *Flabellammina hendersonensis* tend to indicate that the level taken for the top of the *Ammobaculites pacalis* zone at Pouce Coupe is equivalent to the one at Spirit River.

From the above evidence the correlation of the 150 feet of sediments immediately above the Pouce Coupe sand in the Pouce Coupe area with the 102 feet of beds above the Pouce Coupe sand equivalent at Spirit River is indicated. The occurrence of identical forms in both the Pouce Coupe and Spirit River areas in beds above the Pouce Coupe sand serves to establish correlation of this member.

The *Haplophragmoides spiritense* zone seems to have its associated sediments thinning out more rapidly in the direction of Spirit River than do the underlying beds, where they are represented by

relatively small fractions of their thicknesses in the former area. The arguments for this are:

(1) In the Pouce Coupe area the first specimens of *Trochammina webbi* are not encountered until one moves upward in the section for 335 feet above the Pouce Coupe sand, whereas in the Spirit River area the base of the *Trochammina webbi* subzone occurs at a footage of 138 above the Pouce Coupe sand equivalent.

(2) In the Pouce Coupe area, *Haplophragmoides spiritense* var. occurs more or less commonly in the beds from the Pouce Coupe sand to the top of the section, whereas at Spirit River this form does not appear at levels higher than about 115 feet above the Pouce Coupe equivalent.

(3) In the Pouce Coupe area, *Flabellammina hendersonensis* occurs more or less commonly in the beds from 160 feet above the Pouce Coupe sand to the top of the section, but at Spirit River the only specimen found was about 110 feet above the Pouce Coupe sand equivalent.

(4) In the Pouce Coupe area, *Flabellammina gleddiei* is one of the most common forms, occurring above the top of the *Ammobaculites pacalis* zone, but at Spirit River this species is missing completely.

(5) *Haplophragmoides spiritense* itself has not been recognized in the Pouce Coupe area, although it occurs abundantly at Spirit River. If it is to be found in the former area, one would expect it above the top of the sampled section.

The *Pelagic microfaunal* zone has not been collected from outcrop in the Pouce Coupe area, nor has its accompanying lithologic marker—the Lower (Second) White Speckled shale—been recognized. The upper central and upper parts of the Kaskapau are unfortunately almost entirely concealed in the area, and until such time as a core hole is drilled in an appropriate location our knowledge regarding detail of these horizons in the western part of the Peace River area is restricted.

The Pouce Coupe sand—The arguments for correlation of the Pouce Coupe member from Pouce Coupe to Spirit River are as follows:

(1) There is a marked difference of microfaunal content of the beds above and below the sand in both areas, shown in discussion of the foraminifera in the principal zones.

(2) The acmes of two foraminiferal species, *Spiropiectammina phauloides* and *Haplophragmoides crickmayi,* occur respectively directly above, and about 20 feet below, the Pouce Coupe sand in both areas.

(3) The correlation of the other prospective sand in the Spirit River area, that is, the Howard Creek sand, with the Pouce Coupe member at its type locality seems extremely unlikely because: (a) there is no break in the microfaunal sequence across the former, and (b) one would have to account for a slight thickening or, at best, no change in thickness of the "lower" part of the Kaskapau across the area, although there is a definite trend of thinning from west to east in all of the other lithological units.

Correlation of Spirit River and Dunvegan Area Sections

The *Ammobaculites gravenori* zone is incompletely known at Dunvegan because of inadequate sample coverage. The following four species, common to both the Dunvegan and Spirit River areas, are either restricted to the zone or attain their maximum development in it and are rarely found above:

Ammobaculites gravenori
Trochammina rutherfordi var.
Flabellammina cf. *hendersonensis*
Flabellammina kaskapauensis

In addition, one or two specimens of *Flabellammina irenensis* were found in the zone at Dunvegan. This form, although not recovered at Spirit River, is confined to this zone in the Pouce Coupe area.

The lower 110 feet of the Kaskapau formation at Dunvegan can probably be correlated with the lower 135 feet at Spirit River.

The *Gaudryina irenensis* zone is only partially known at Dunvegan because of lack of sample coverage, but the following characteristic forms were recorded at both Dunvegan and Spirit River:

Gaudryina spiritensis
Gaudryina irenensis
Haplophragmoides crickmayi var.
Trochammina wetteri
Verneuilinoides perplexa (Loeblich) var. *gleddiei*

The *Ammobaculites pacalis* zone is likewise only partially known at Dunvegan. The following three typical species found at Dunvegan are present also at Spirit River and Pouce Coupe:

Ammobaculites pacalis
Ammobaculites albertensis
Haplophragmoides eocalcula

The Howard Creek sand at the Dunvegan locality—The sandstone bed 180 to 189 feet above the base of the Kaskapau at Dunvegan is correlated with difficulty because of the gaps in the sample coverage curbing the value of the microfaunal evidence. However, it can be correlated with the Howard Creek sand rather than the Pouce Coupe sand at Spirit River for the following reasons:

(1) If the sand were the Pouce Coupe member at Dunvegan, a thickness of at least 79 feet would have to be postulated for the *Gaudryina irenensis* microfaunal zone which, although not unreasonable, appears unlikely because it is only 78 feet thick at Spirit River. Regionally, this zone would be expected to thin considerably in a northeast direction.

(2) A concentration of specimens of *Haplophragmoides crickmayi* 20 feet below the top of the sampled section at Dunvegan indicates that the possible top of the *Gaudryina irenensis* zone and, thus, the position of the Pouce Coupe equivalent, might be expected to occur at about the top of the sampled section. The possibility exists that the Pouce Coupe sand may have pinched out altogether at Dunvegan.

(3) The lack of any specimens of *Spiroplectammina phauloides* above the sandstone bed at Dunvegan indicates correlation with the Howard Creek sand, because this form occurs characteristically directly above the Pouce Coupe sand at Spirit River and Pouce Coupe.

(4) The sparse microfauna recovered from the 16 feet sampled directly below the sandstone bed does not contain any recognizable specimens of *Ammobaculites pacalis* or *Ammobaculites albertensis* (species occurring characteristically in the interval between the Pouce Coupe and Howard Creek sands at Spirit River.) This microfauna with its undiagnostic *Haplophragmoides* and lack of recognizable species of *Ammobaculites,* does not appear unlike the fauna recovered from the beds directly below the Howard Creek sand at Spirit River.

Correlation of the Pouce Coupe - Kiskatinaw River Area Sections

Because of the poor microfossil recovery at the Kiskatinaw River locality the writers were unable to establish a definite microfaunal zoning, and thus could not make any detailed microfaunal correlation across to the Pouce Coupe locality. However, the presence of the "white chalcedonic bed" and the Pouce Coupe sand at this locality assure its general correlation with the Pouce Coupe section. It appears that the interval from the "white chalcedonic bed" to the Pouce Coupe sand is about 50 feet thinner here than at Pouce Coupe. This is in accordance with the occurrence of *Dunveganoceras albertense* from shales below the Pouce Coupe sand, near this locality rather than in the sand itself as in the Pouce Coupe type section.

Regional Correlations

This paper is primarily concerned with a description of Lower Turonian microfaunal suites as found within the Upper Cretaceous Kaskapau formation of the Peace River country. However, it is in the interests of stratigraphers to deal briefly with the lateral extension of correlatives of this horizon, using the additional information derived from megafaunas wherever necessary. The pelagic foraminifera themselves are the only forms found outside the Peace River area that may be determined with a fair degree of certainty. Arenaceous benthonic forms seem to be more local in distribution or may have been somewhat neglected by workers in more distant areas.

The central Kaskapau formation may be assigned a lower or early Turonian age in the standard of the Cretaceous system in Europe. The presence of the ubiquitous *Inoceramus labiatus* Schlotheim in the central part of the Kaskapau shale is sufficient index. This same *Inoceramus* also allows correlations within the limits of the continent of North America.

The widespread seas of the lower Turonian stage extended from the Gulf of Mexico to the Arctic Ocean. In northern Alaska, the *Gümbelina-Globigerina* pelagic microfaunal zone carrying a megafauna of *Scaphites delicatulus, Watinoceras, Borissjakoceras,* and *Inoceramus labiatus* occurs in the Seabee member of the Colville group (Payne, 1951). In the vicinity of Fort Norman in the Mackenzie River drainage of northern Canada a similar suite of *Inoceramus labiatus, Inoceramus* sp., *Borissjakoceras, Watinoceras reesidei* and *Scaphites delicatulus* has been collected by the senior author just west of Bear Rock at the base of the Upper Cretaceous sequence.

Throughout the plains section of central and southern Alberta the zone of *Inoceramus labiatus,* carrying a pelagic microfauna wherever investigated, is commonly referred to by petroleum geologists as the "second or lower white specks". This is a sedimentary marker within the Colorado shale that can be readily determined in sample examination of well-cuttings by the presence of numerous small white calcareous bodies in the shales. These small white specks indicate incipient chalk or limestone deposition and have been shown (Dawson, 1874; Goodman, 1951) to consist of fossil aggregates of calcareous algae, viz: Coccoliths and Rhabdoliths. The junior writer has determined the presence of *Globigerina cretacea* and *Gümbelina globulosa* and *Gümbelitria cretacea* in the Wabamun Lake Well (lsd. 5, sec. 5, tp. 51, rge. 4, w. 5th mer.) for at least 100 feet below the top of the second white specks.

Nauss (1945, p. 1617) has reported the characteristic occurrence of *Globigerina cretacea* and *Gümbelina globulosa* in the central part of the Lloydminster shale of the Alberta-Saskatchewan border area. This microfaunal evidence is supported by the reported (ibid.) presence of *Inoceramus labiatus* 112 miles northeast of Lloydminster at the south end of Green Lake, Saskatchewan, in association with abundant *Globigerina.*

The second white specks of the Colorado shale is a well-known marker over most of southern Alberta and the southern part of Saskatchewan where the limey character of the shales become more pronounced. This limey character is sufficient in Manitoba to warrant a formational name (Favel) for the second white specks zone. The Favel formation of Manitoba has yielded (Wickenden, 1945, p. 33) *Gümbelina globulosa, Gümbelitria cretacea* and *Globigerina cretacea.* In addition, the Keld or lower member of the Favel formation has yielded *Inoceramus labiatus.* The Favel formation of 170 feet maximum thickness is considered to be a direct correlative of the second white speckled shale zone of the Kaskapau formation.

In the foothills of Alberta, the zone of *Inoceramus labiatus* has been recognized by Warren and Rutherford (1928) and by Webb and Hertlein (1934) in the lower part of the Alberta shales within the Blackstone formation. In the Cadomin area of the central foothills *Inoceramus labiatus* occurs about 560 feet above the base of the Blackstone formation, and the white concretionary nodular member shown in Figure 4 near the base of the Turonian stage in the Kaskapau formation is found about 520 feet above the base of the Blackstone formation. In the Bragg Creek area, Alberta, *Inoceramus* cf. *labiatus* occurs within 50 feet of the base of the Alberta shales, and in the Castle River area, Alberta, *Inoceramus labiatus* and *Watinoceras reesidei* occur within a few inches of the underlying volcanic beds (Crowsnest?).

In the United States, Young (1951) has recently reported the occurrence of *Globigerina cretacea* and *Gümbelina globulosa* from the "*Vascoceras* beds" of the central portion of the Frontier formation in southern Montana. As these "*Vascoceras* beds" are described as blue calcareous shale carrying *Inoceramus labiatus,* it appears that they represent the approximate equivalent of the lower white speckled shale zone of the Kaskapau formation of the Peace River

area of Alberta. This same correlation follows down through the Greenhorn limestone of South Dakota, Nebraska and northern Colorado with *Inoceramus labiatus* providing the key index. In southern Colorado, Wyoming and New Mexico, the *Inoceramus labiatus* fauna occurs in the lower part of the Mancos shale.

In the mid-continent region of the United States and southward into Texas the Greenhorn equivalents are found within the Eagle Ford formation, and in the list of Eagle Ford Foraminifera prepared by Helen Jeanne Plummer (Adkins, 1933, p. 438) the following forms were included: *Globigerina cretacea* d'Orbigny, *Gümbelina globulosa* (Ehrenberg), *Haplophragmoides* aff. *calcula* Cushman and Waters, *Trochammina diagonis* (Carsey), *Ventilabrella eggeri* Cushman. The first two species are found in the Kaskapau formation and *Ventilabrella eggeri* is found in the Favel formation in Manitoba (Wickenden, 1945). Forms similar to *Haplophragmoides calcula* and *Trochammina diagonis* are found in the Kaskapau formation in the uppermost Cenomanian and lower Turonian stages.

The record of the lower Turonian flooding of the North American continent is therefore clearly demonstrated from the Arctic Ocean to the Gulf of Mexico. The Pelagic microfaunal zone of the second white speckled shale of the Kaskapau formation may be correlated with the *Watinoceras reesidei - Inoceramus labiatus* faunal zone of the Colorado shale as indicated by Cobban (1951, p. 2197). The underlying *Haplophragmoides spiritense* zone of the Kaskapau formation is then closely equivalent to the *Sciponoceras gracile - Metoicoceras whitei* zone of the Colorado shale (Cobban, ibid.) and marks the base of the Turonian stage as indicated by Cobban. *Metoicoceras whitei* is placed at the base of the Turonian stage by Muller and Schenck (1943) in dealing with the standard of the Cretaceous system.

ECOLOGY

The two microfaunal zones at the base of the Turonian in the Kaskapau formation of northwestern Alberta reveal two ecological assemblages. The shift of ecology is from shallower water to open-sea environment in going from the *Haplophragmoides spiritense* zone to the overlying *Gümbelina-Globigerina* pelagic zone.

The *Haplophragmoides spiritense* zone contains only four recorded microfaunal genera. *Haplophragmoides* makes up 52 per cent of the overall suite, *Trochammina* 22 per cent, *Gümbelitria* 17 per cent and *Tritaxia* 9 per cent. The environment appears neritic but relatively shallow and cool, with depth of water probably in the neighborhood of 100 to 300 feet, but it could be as deep as 600 feet, which would be the equivalent of the depth of the seaward edge of the continental shelf today. The finely arenaceous *Haplophragmoides* and *Trochammina* show marked reduction in coarseness of clastic content from the same genera within underlying zones. Such genera as *Ammobaculites, Dorothia, Gaudryina,* present in the zone immediately preceding, are absent from the *H. spiritense* zone. *Tritaxia* is considered to be a deeper water form by Galloway (1933, p. 218), not occurring in Recent dredgings in water shallower than 155 fathoms. *Inoceramus* of the accompanying megafauna are rela-

tively thin-shelled, a feature of deeper-water forms. The dearth of calcareous foraminiferal forms is assumed to be indicative of cooler water, but this could be in part a phenomenon of lack of preservation.

The *Gümbelina-Globigerina* pelagic zone also carries four genera. *Gümbelitria* makes up 44 per cent of the microfaunal assemblage, *Globigerina* 32 per cent and *Gümbelina* 23 per cent; *Haplophragmoides,* the only other genus, makes up less than one per cent. This assemblage is a little more difficult to assess in the light of the numerous pelagic forms. It is fairly safe to assume that the seaways were fairly well open and to assume a corollary of attendant deeper water than that found in the underlying zone. Although pelagic, and the modern record of *Globigerina* reports greatest abundance in the bathyal zone (600-6,000 feet) of our Recent oceans, it is not unreasonable to assume a fair number of specimens in the deeper parts of the neritic zone, or at least in the shallower parts of the bathyal depths. The occurrence of pelagic forms to the exclusion of nearly all other groups might be interpreted as an indication of unfavorable benthonic conditions for microfaunas within the neritic environment in the manner of an inland type of euxinic basin. The alternative to the latter is an assumption that the pelagic sediments of the Kaskapau sea were depositd in a seaway having water depths of over 1,000 feet. If the ubiquitous *Inoceramus labiatus* was benthonic, then life was not erased from the marls and muds of the bottom of the Second white specks sea. We are, therefore, forced to the conclusion that waters of over 1,000 feet depth existed in the heart of the Peace River area in early Turonian time, even though we would hesitate to apply the term continental slope to an area now so far inland.

Formal Descriptions

Order *Foraminifera*

Genus AMMOBACULITES Cushman, 1910

AMMOBACULITES ALBERTENSIS Stelck and Wall, n.sp.

Plate 1, Figures 21, 22

Test fairly robust, cylindrical in cross-section but usually found considerably flattened due to distortion in fossilization, early portion closely coiled, generally comprising about half of test in mature specimens, with four or five chambers visible; later portion nearly always bent, of two approximately equal chambers, rarely two and one-half to three, in uniserial arrangement; sutures, oblique, depressed, distinct in partially pyritized, cylindrical specimens, fainter in flattened, non-pyritized forms; wall arenaceous, exhibiting considerable variation in size of quartz grains, the average about .03 mm., but with the occasional grain up to .075 mm., amount of cement not great; aperture, terminal, central, simple.

The figured specimens are paratypes. The holotype, on which the above description is based, was recovered from the Imperial Oil Limited Spirit River Structure Test No. A-337-1, 18 feet above the top of the Howard Creek sand, and it will be figured in our next paper.

Length of paratype (Fig. 21): .5 mm., width of coiled portion .2 mm., length of ultimate chamber .2 mm., diameter .15 mm.

Length of paratype (Fig. 22): .46 mm., width of coiled portion .136 mm.

Locality of paratypes: Imperial Oil Limited Surface Division 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, two feet above the Howard Creek sand.

Paratypes: Stanford Univ. Pal. Type Coll.

Horizon: This Upper Cenomanian species is nearly always restricted in range to the *Ammobaculites pacalis* zone.

Comparison: This species seems to be related to *Ammobaculites goodlandensis* Cushman and Alexander from the Lower Cretaceous of Texas, in possessing the same relative rugosity and general outline of the test. However, the Alberta species is much smaller and lacks the indented sutures of the Texas form.

AMMOBACULITES PACALIS Stelck and Wall, n.sp.

Plate 1, Figure 19

Test robust, cylindrical in cross-section, often found as a pyritized or partially pyritized replacement; early portion tightly coiled, comprising one-quarter to one-third of overall length of test, with generally three chambers, occasionally four, visible; later portion of two to three chambers, of approximately equal size, in straight

uniserial arrangement; sutures distinct, depressed, at right angles to long axis of test; wall arenaceous, of variable size quartz grains, generally not larger than .05 mm., but with an occasional one up to .09 mm., embedded in a matrix of much finer material, with a clear cement; aperture terminal, central, simple.

The figured specimen is a paratype. The holotype, on which the above description is based, was recovered from the Imperial Oil Limited Spirit River Structure Test A-337-1, 15.5 feet above the top of the Howard Creek sand, and it will be figured in our next paper.

Length of paratype: .5 mm.; width of coiled portion .21 mm.

Paratype locality: Imperial Oil Limited Surface Division 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, seven feet above the Howard Creek sand.

Paratype: Stanford Univ. Pal. Type Coll.

Horizon: At Spirit River, this species is a distinctive fossil, of the zone bearing its name. *Ammobaculites pacalis* is confined to the late Cenomanian beds at all localities, save Henderson Creek, where there appears to be a very few stragglers in the earliest Turonian.

Comparisons: This species appears similar in size and wall structure to *Ammobaculites alexanderi* Cushman from the Upper Cretaceous Taylor marl of Texas, but is much more robust in the coiled portion than the latter species, and differs from it also in having approximately equal chambers in the later portion, whereas those in the Texas form increase in length as added. *Ammobaculites pacalis* differs from *Ammobaculites albertensis* mainly in having transverse sutures as opposed to the oblique ones of the latter species.

Genus FLABELLAMMINA Cushman, 1928

FLABELLAMMINA BESSBOROENSIS Stelck and Wall, n.sp.

Plate 1, Figure 26

Test much compressed, periphery narrowly rounded, early portion closely coiled, later chambers uncoiled, axis becoming straight; chambers indistinct, coiled portion showing slightly through outer cement layer; three chambers in straight portion triangular, embracing chevrons; sutures indistinct, slightly indented at the margin on straight portion; wall with much cement and small content of very fine arenaceous material completely contained within the cement, giving a smooth finish to the exterior; aperture terminal, simple.

Length of holotype: .65 mm., width .31 mm.

Holotype locality: Imperial Oil Limited Surface Division locality S47-36 in Sec. 15, Tp. 78, Rge. 17, W. 6th Meridian, on Kiskatinaw River, one mile north of Arras, British Columbia, Canada, from Kaskapau shales, 118 feet below a prominent lithological marker, known as the "white chalcedonic bed", below the *Inoceramus labiatus* zone and approximately 20 feet above the Pouce Coupe sand.

Holotype: Stanford Univ. Pal. Type Coll.

Horizon: This rare species is known only at its type locality in beds of probable Cenomanian age above the Pouce Coupe sand.

Comparison: This species is somewhat like *Flabellammina compressa* (Beissel) Alexander and Smith from the Upper Cretaceous Taylor marl of Texas, but has a much finer wall makeup and is smaller.

Name: After the hamlet of Bessborough, British Columbia.

FLABELLAMMINA GLEDDIEI Stelck and Wall, n.sp.

Plate 1, Figure 24, 25; Plate 2, Figure 16

Test compressed, periphery narrowly rounded, early portion not tightly coiled, with about six chambers visible in final volution; later portion of five or six wedge-shaped chambers, penultimate one the largest; sutures indistinct in most specimens, flush, oblique, ultimate one arcuate and extending almost back to coiled portion; wall finely arenaceous, considerable amount of cement, giving a smooth finish to part or all of test; aperture terminal, slightly produced, possibly elliptical.

Length of holotype (Plate 2, Figure 16): .74 mm.; maximum width .38 mm.

Length of paratype (Plate 1, Figure 24: .63 mm.; width .38 mm.

Length of paratype (Plate 1, Figure 25): .7 mm.; width .4 mm.

Holotype locality: Imperial Oil Limited Surface Division locality G45-3 in Lsd. 12, Sec. 15, Tp. 79, Rge. 13, W. 6th Meridian on Henderson Creek, Alberta, Canada, from Kaskapau shales, 145 feet above the "white chalcedonic bed", or approximately 345 feet above the Pouce Coupe sand.

Holotype: Univ. of Alberta Pal. Type Coll.

Locality of paratypes: Imperial Oil Limited Surface Division locality S47-36 in Sec. 15, Tp. 78, Rge. 17, W. 6th Meridian, on Kiskatinaw River, one mile north of Arras, British Columbia, Canada, from Kaskapau shales, 118 feet below the "white chalcedonic bed", below the *Inoceramus labiatus* zone and approximately 20 feet above the Pouce Coupe sand.

Paratypes: Stanford Univ. Pal. Type Coll.

Horizon: This species occurs in the central portion of the Kaskapau at the Kiskatinaw River and Henderson Creek localities. At the latter locality numerous specimens were recovered from the Turonian shales, 140 to 150 feet above the "white chalcedonic bed".

Remarks: The paratypes show more involute coiled portions than does the holotype, but this feature is not regarded as being of sufficient importance to warrant the establishment of another taxonomic unit.

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

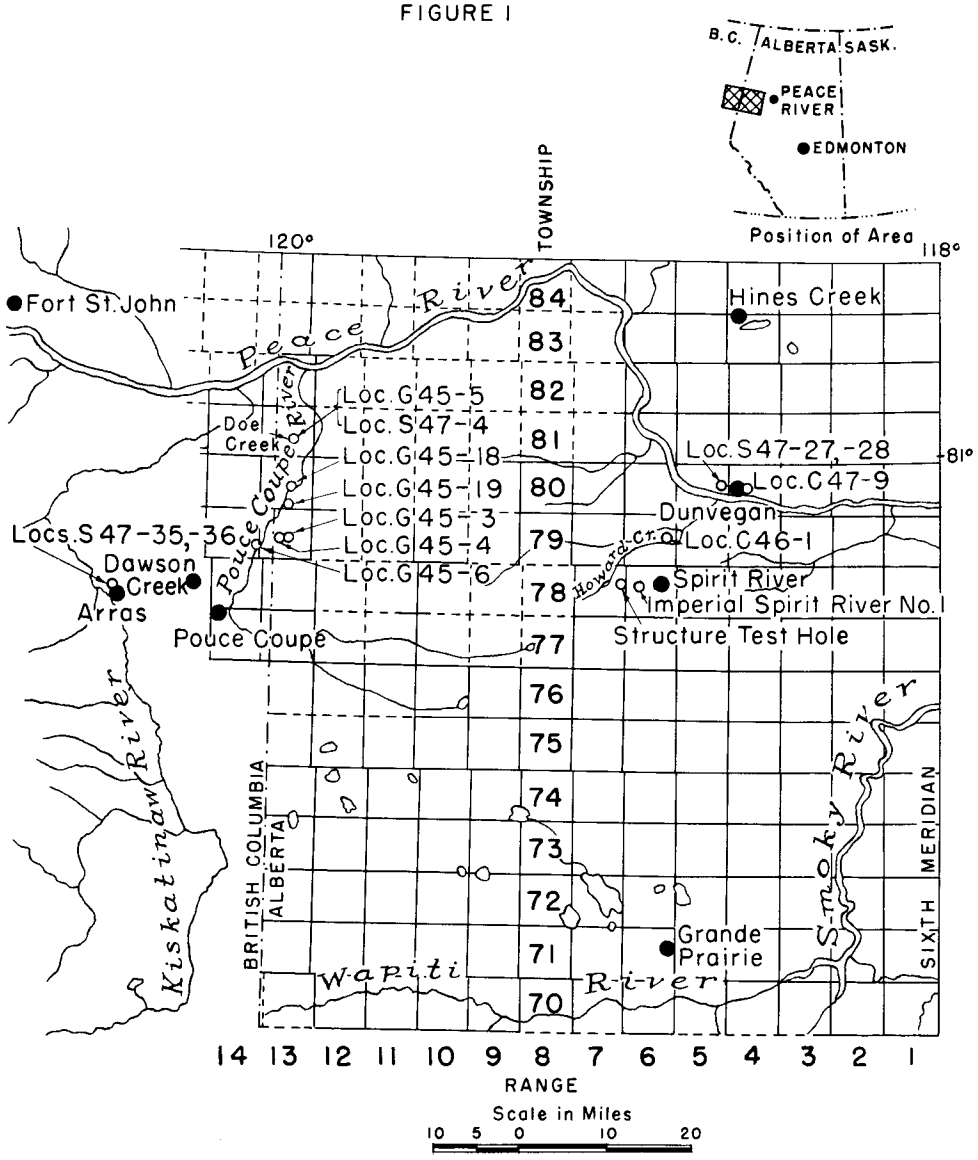
FLABELLAMMINA HENDERSONENSIS Stelck and Wall, n.sp.

Plate 2, Figures 17, 18

Test compressed, periphery rounded, of six external chambers; chambers obscured, first four small, of approximately equal size, last two much larger and comprising about four-fifths of the size of the test; sutures indistinct, obscured by the overlapping margins of

LOCALITIES OF MICROFAUNAL SUITES
IN WESTERN PEACE RIVER AREA

FIGURE 1



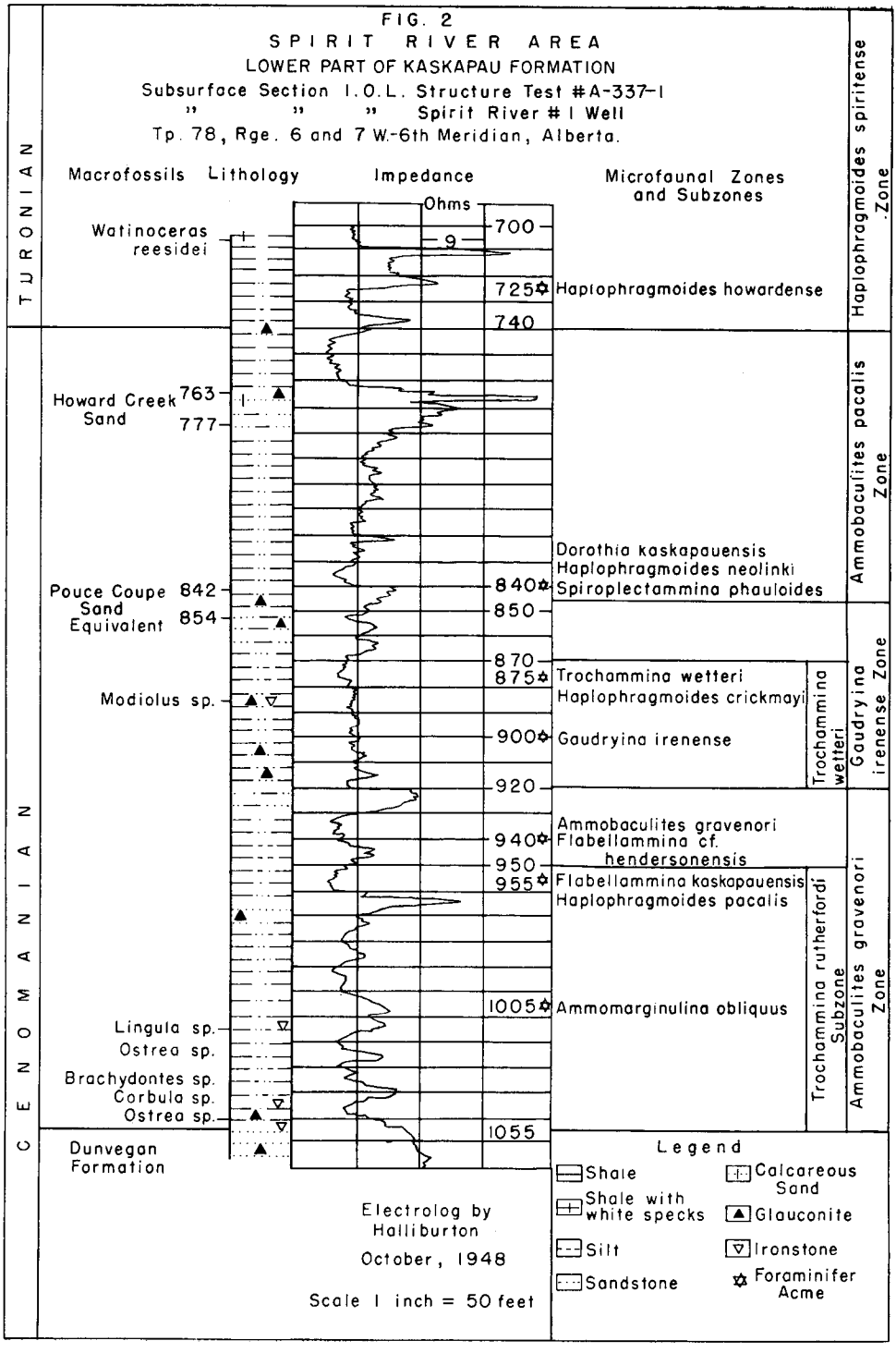


FIG. 2
SPIRIT RIVER AREA
LOWER PART OF KASKAPAU FORMATION
Subsurface Section I.O.L. Structure Test #A-337-I
" " " Spirit River # I Well
Tp. 78, Rge. 6 and 7 W.-6th Meridian, Alberta.
TURONIAN
CENOMANIAN
Macrofossils
Lithology
Impedance
Ohms
Microfaunal Zones and Subzones
Watinoceras reesidei
Howard Creek Sand
763
777
Pouce Coupe Sand Equivalent
842
854
Modiolus sp.
Lingula sp.
Ostrea sp.
Brachydontes sp.
Corbula sp.
Ostrea sp.
Dunvegan Formation
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 irenense
Ammobaculites gravenori
Flabellammina cf. hendersonensis
Flabellammina kaskapauensis
Haplophragmoides pacalis
Ammomarginulina obliquus
Haplophragmoides spiritense Zone
Ammobaculites pacalis Zone
Gaudryina irenense Zone
Trochammina wetteri Subzone
Ammobaculites gravenori Zone
Electrolog by Halliburton
October, 1948
Scale I inch = 50 feet
Legend
Shale
Shale with white specks
Silt
Sandstone
Calcareous Sand
Glauconite
Ironstone
Foraminifer Acme

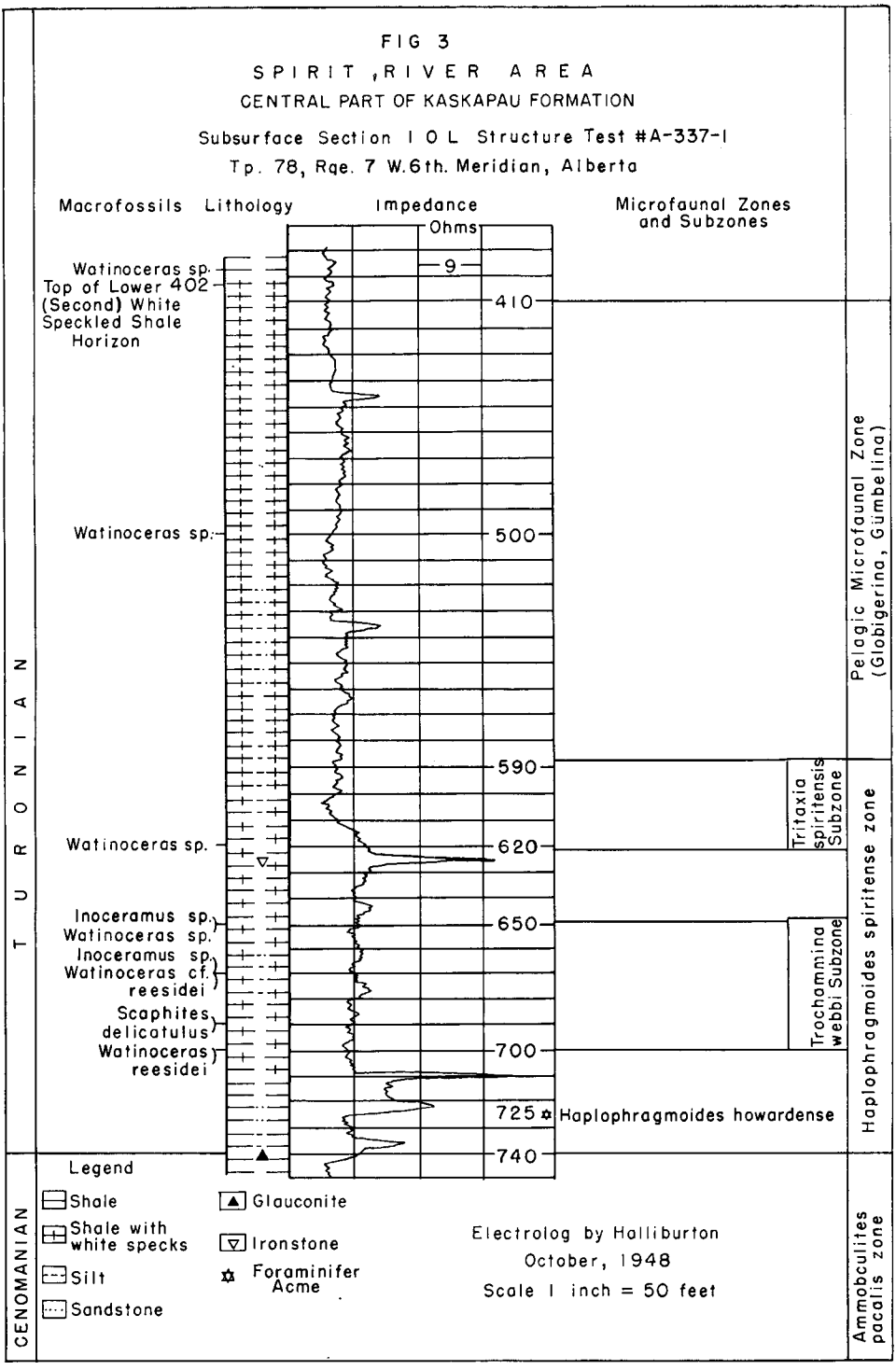
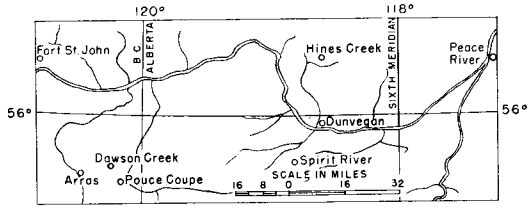


FIG 3
SPIRIT ,RIVER AREA
CENTRAL PART OF KASKAPAU FORMATION
Subsurface Section I O L Structure Test #A-337-I
Tp. 78, Rge. 7 W.6th. Meridian, Alberta
Macrofossils
Lithology
Impedance
Ohms
Microfaunal Zones and Subzones
9
410
500
590
620
650
700
725
740
Watinoceras sp.
Top of Lower (Second) White Speckled Shale Horizon
Watinoceras sp.
Watinoceras sp.
Inoceramus sp.
Watinoceras sp.
Inoceramus sp.
Watinoceras cf. reesidei
Scaphites delicatulus
Watinoceras reesidei
Haplophragmoides howardense
TURONIAN
CENOMANIAN
Pelagic Microfaunal Zone (Globigerina, Gümbelina)
Tritaxia spiritensis Subzone
Trochammina webbi Subzone
Haplophragmoides spiritense zone
Ammobculites pacalis zone
Legend
Shale
Shale with white specks
Silt
Sandstone
Glauconite
Ironstone
Foraminifer Acme
Electrolog by Halliburton
October, 1948
Scale 1 inch = 50 feet

FIG. 4

MAJOR CORRELATION POINTS IN THE CENTRAL AND LOWER PARTS OF THE KASKAPAU FORMATION PEACE RIVER AREA WESTERN CANADA

STELCK AND WALL, 1954.



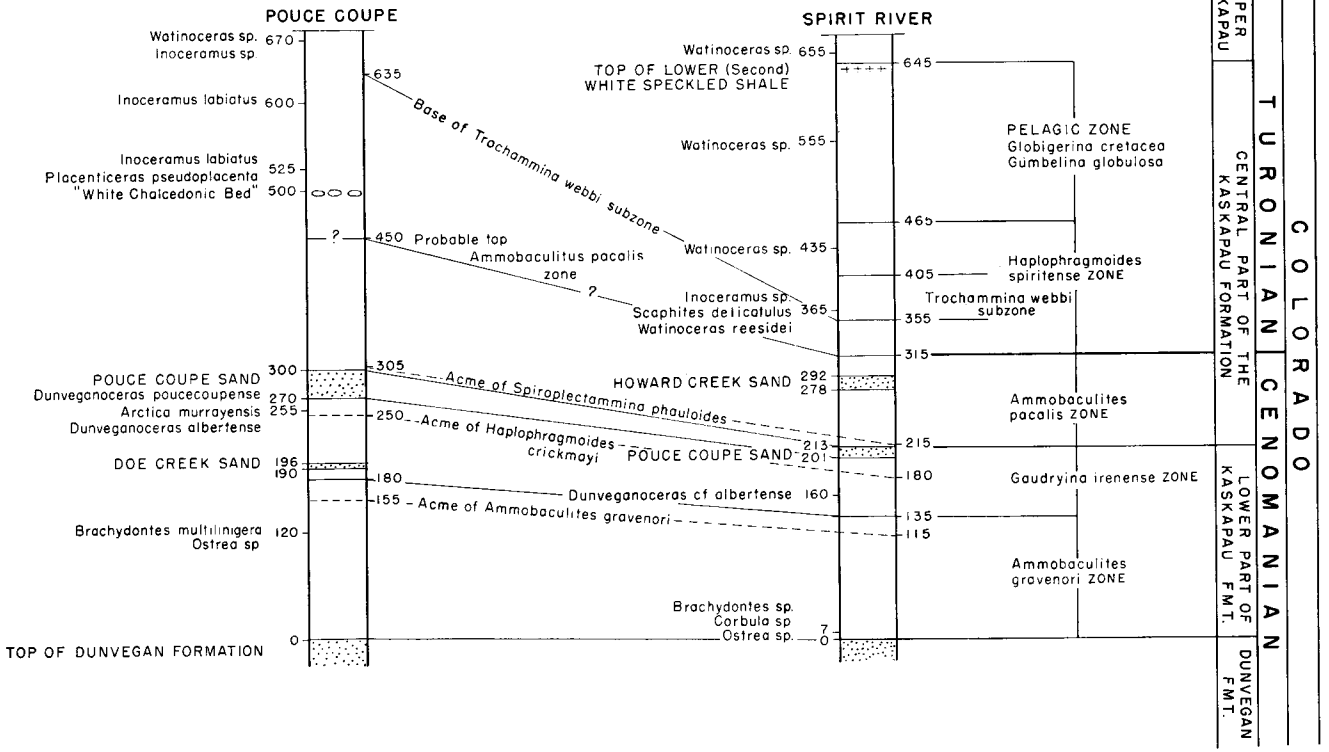
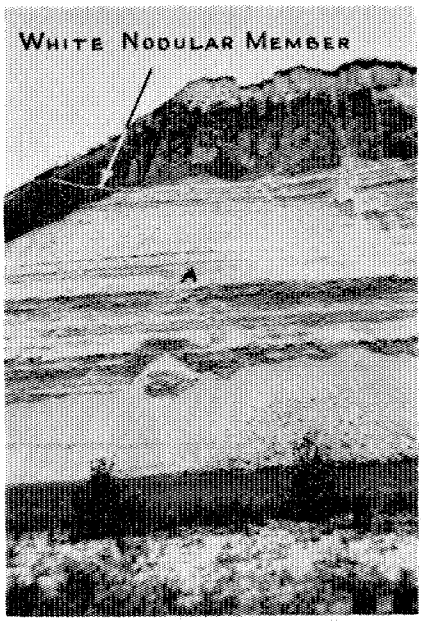
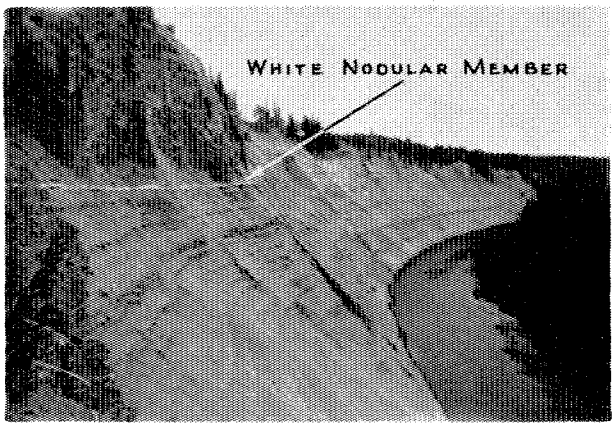


FIG. 5



(a) Outcrop of central Kaskapau shales. Kiskatinaw River, British Columbia, Sec. 15, Tp. 78, Rge. 17, W. 6th Mer. The Cenomanian-Turonian boundary lies at A approximately 50 feet below the white chalcedonic nodular member.



(b) Same outcrop as above looking upstream, locality S–47–36. Approximately 175 feet of section exposed.

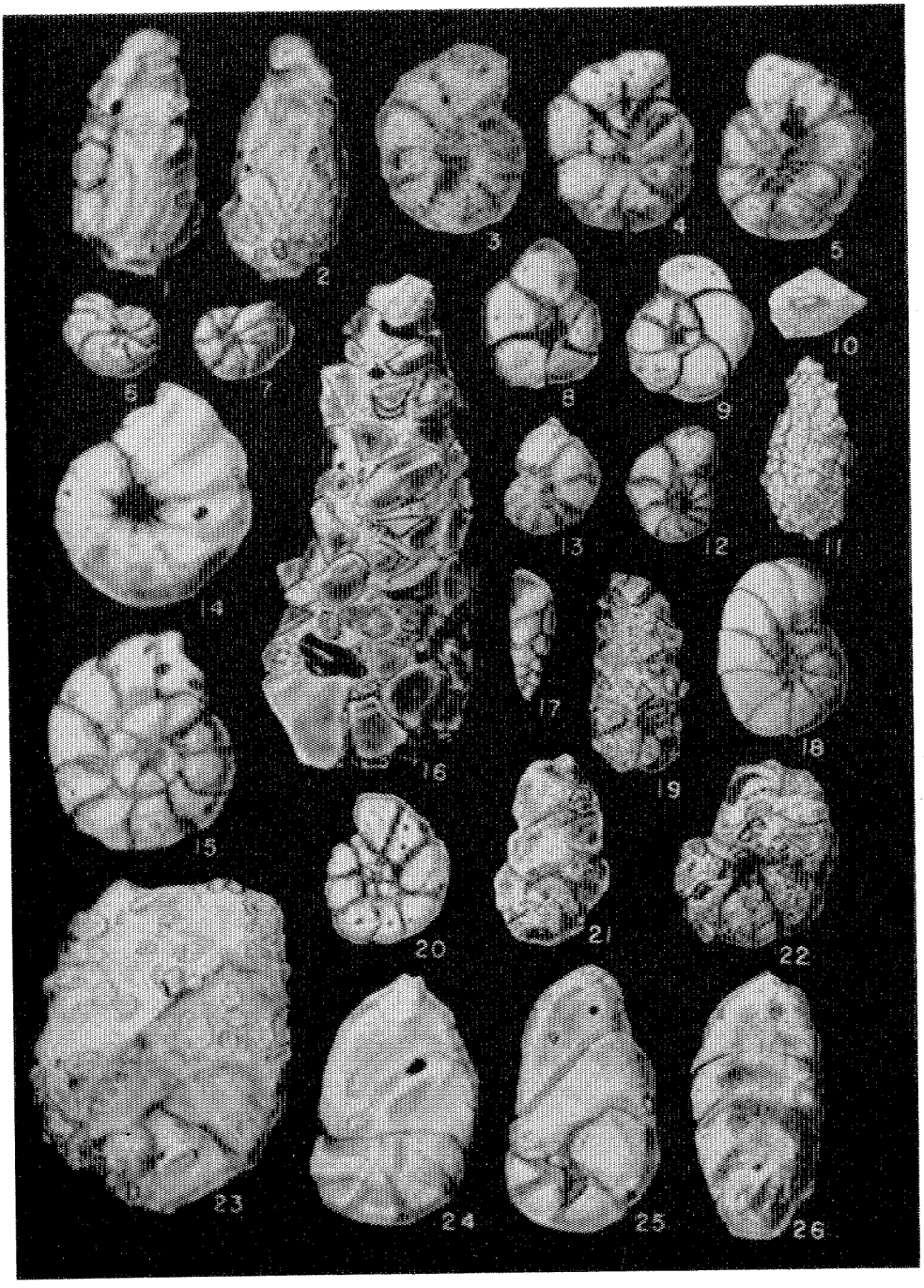


PLATE I—Central Kaskapau Foraminifera.

Explanation, p. 37

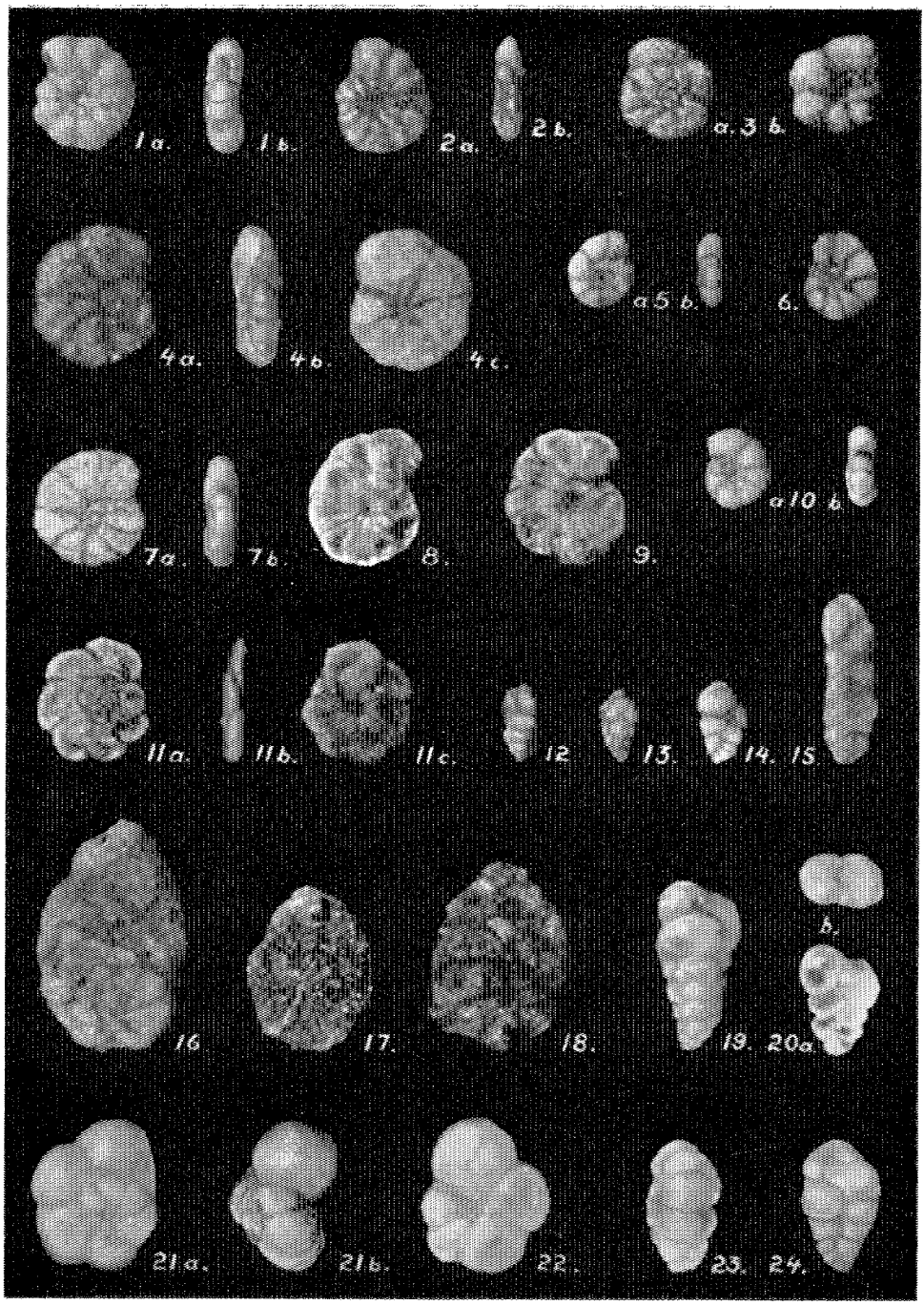


PLATE II—Central Kaskapau Foraminifera.

Explanation, p. 38

the later chambers, arcuate, extending back to the coiled portion; wall arenaceous, with quartz grains averaging .04 mm., occasional grain up to .1 mm., embedded in a fair amount of cement, but surface rather rough and uneven; aperture terminal, slightly produced, possibly elliptical.

Length of holotype (Fig. 17): .67 mm.; maximum width .53 mm.

Length of paratype (Fig. 18): .64 mm.; maximum width .47 mm.

Holotype locality: Imperial Oil Limited Surface Division locality S47-36 in Sec. 15, Tp. 78, Rge. 17, W. 6th Meridian, on the west bank of the Kiskatinaw River, one mile downstream from Arras, British Columbia, Canada, from Kaskapau shales 85 feet below the "white chalcedonic bed", or about 50 feet above the Pouce Coupe sand.

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

Horizon: This Turonian species occurs sporadically in the central part of the Kaskapau formation, above the Pouce Coupe sand, at the Henderson Creek and Kiskatinaw River localities. Only one specimen has been found in the Spirit River section, near the base of the *Haplophragmoides spiritense* zone.

Name: After Henderson Creek, Alberta.

FLABELLAMMINA SUCCEDENS Stelck and Wall, n.sp.

Plate 1, Figure 23

Test compressed, periphery rounded, early portion closely coiled, later chambers straightening but successively overlapping on one edge to the coiled portion; chambers indistinct; four or five rapidly increasing chambers, in coiled portion, visible; ultimate chamber incipiently chevron-shaped; sutures obscure, but intercameral walls give slight indication of position by support of outer wall; wall arenaceous with much cement giving a smooth finish to most of the wall, a few large grains to .1 mm. studding the exterior; aperture terminal, elongate elliptical.

Length of holotype: .8 mm., width .57 mm.

Holotype locality: Imperial Oil Limited Surface Division locality S47-36 in Sec. 15, Tp. 78, Rge. 17, W. 6th Meridian, on Kiskatinaw River, one mile north of Arras, British Columbia, Canada, from Kaskapau shales, 17 feet below the "white chalcedonic bed", below the *Inoceramus labiatus* zone.

Holotype: Stanford Univ. Pal. Type Coll.

Horizon: Outside of its type locality, this rare form has been recorded only at Dunvegan, where a couple of specimens were found directly above the Howard Creek sand.

Genus GLOBIGERINA d'Orbigny, 1826

GLOBIGERINA CRETACEA d'Orbigny, 1826

Plate 2, Figures 21, 22

Globigerina cretacea d'Orbigny, Young 1951, Jour. Paleontology, Vol. 25, No. 1, p. 65, pl. 14, figs. 1-3.

Test rather small, periphery rounded; test rotaloid, consisting of two and one-half whorls, with five chambers in both ultimate and

penultimate volutions, spire low; ventral side of test with a well-developed umbilicus; chambers globular, inflated to various degrees, not too loosely appressed; sutures distinct, depressed; wall calcareous, finely perforate, with surface hispid in many specimens, smoothly polished and hyaline in others; aperture large, opening into the umbilicus.

Diameter of plesiotype (Figure 21): .2 mm.; thickness .12 mm.

Diameter of plesiotype (Figure .22): .21 mm.

Locality of plesiotypes: Imperial Oil Limited Spirit River Structure Test No. A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 515 feet, 113 feet below the top of the Lower (Second) White Speckled Shale horizon of the Kaskapau formation.

Plesiotypes: Univ. of Alberta Pal. Type Coll.

Horizon: In the Spirit River section, this species is restricted to the interval 8 to 188 feet below the top of the Lower Speckled Shale. It has not been recovered elsewhere in the area to date, since this horizon is not exposed in outcrop, and again there has been no other core hole penetrating this portion of the Turonian beds.

Remarks: This pelagic form seems to have world-wide distribution and the name has been used to embrace a "form species". For these reasons, a critical synonomy is omitted as it would entail type specimen research in foreign museums.

Genus GÜMBELINA Egger, 1899

GÜMBELINA GLOBULOSA (Ehrenberg), 1834

Plate 2, Figure 20

Güimbelina globulosa (Ehrenberg), Young, 1951, Jour. Paleontology, vol. 25, No. 1, p. 63, pl. 14, figs. 12,23-26.

For other references, see U.S.G.S. Prof. Paper 206, p. 105.

Test very small, tapering, usually the widest part across the last two chambers, but occasionally across the second last pair of chambers; chambers, twelve in biserial arrangement, expanding rapidly in size, especially in the last three pairs, inflated, globular; sutures distinct, depressed, oblique to the long axis of test; wall calcareous, finely perforate, smooth, occasionally hyaline; aperture a broadly arched opening at the inner margin of the last chamber.

Length of plesiotype: .19 mm.; maximum width .13 mm.

Plesiotype locality: Imperial Oil Limited Spirit River Structure Test No. A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 562 feet, 160 feet below the top of the Lower (Second) White Speckled Shale horizon of the Kaskapau formation.

Plesiotype: Univ. of Alberta Pal. Type Coll.

Horizon: This species occurs in close association with *Globigerina cretacea* over the same interval and, like the latter, it has also not been recovered in the area other than from the Spirit River well section.

Genus GÜMBELITRIA Cushman, 1933

GÜMBELITRIA CRETACEA Cushman, 1933

Plate 2, Figures 23, 24

For references, see U.S.G.S. Prof. Paper 206, p. 103.

Test small, gradually tapering, rounded triangular in cross-section; test triserial, with five whorls of three chambers each; chambers gradually expanding, partly inflated, subglobular; sutures distinct, depressed; wall calcareous, finely perforate, often polished smooth in places and appearing hyaline; aperture a narrowly rounded, prominent, arched opening at the inner margin of the last chamber.

Length of plesiotype (Fig. 23): .22 mm.; maximum width .11 mm.

Length of plesiotype (Fig. 24): .21 mm.; maximum width .13 mm.

Plesiotype (Fig. 23) locality: Imperial Oil Limited Spirit River Structure Test No. A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 562 feet, 160 feet below the top of the Lower (Second) White Speckled Shale horizon of the Kaskapau formation.

Plesiotype (Fig. 24) locality: As above, at a depth of 566 feet.

Plesiotypes: Univ. of Alberta Pal. Type Coll.

Horizon: At Spirit River, this species occurs commonly through the interval 58 to 188 feet below the Lower Speckled Shale in association with *Globigerina cretacea* and *Gümbelina globulosa,* but unlike the latter two, which are not found below this point, it ranges down into Cenomanian beds of the *Ammobaculites pacalis* zone, and occurs very rarely in *Gaudryina irenensis* zone, that is, below the Pouce Coupe sand equivalent.

GÜMBELITRIA CRETACEA ALBERTENSIS

Stelck and Wall, n.var.

Plate 2, Figure 19

Test of medium size, gradually tapering, consisting of eight whorls of three chambers each; chambers rather gradually increasing in size, somewhat inflated, final three the largest and most inflated; sutures distinct, depressed; wall calcareous, finely perforate, often polished smooth in places and appearing hyaline; aperture a wide semi-elliptical opening at the inner margin of the ultimate chamber.

Length of holotype: .31 mm.; maximum width .15 mm.

Holotype locality: Imperial Oil Limited Spirit River Structure Test No. A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 596 feet, 194 feet below the top of the Lower (Second) White Speckled Shale horizon of the Kaskapau formation.

Holotype: Univ. of Alberta Pal. Type Coll.

Horizon: In the Spirit River area, this form occurs in close association with *Gümbelitria cretacea* ss., but is not nearly as common as the latter form. It has not been observed above a point in the section about 150 feet below the top of the Lower Speckled Shale

but, like *G. cretacea* ss., it ranges down into the lower Kaskapau beds.

Comparison: This form is very closely related to *G. cretacea* ss. and seems to be an elongate variety of it, although there is a possibility that it may be the microspheric stage of the latter form.

Genus HAPLOPHRAGMOIDES Cushman 1910

HAPLOPHRAGMOIDES BONANZAENSE Stelck and Wall, n.sp.

Plate 2, Figure 10

Test planispiral, almost involute, with only small portion of preceding whorl visible, periphery rounded; chambers of approximately equal size, very slightly inflated, six and one-half to seven in ultimate whorl; sutures distinct, depressed, all radial save ultimate one, which is slightly curved; wall finely arenaceous with much cement, giving a smooth finish to the exterior; aperture, a low rounded arch opening at the base of the terminal face.

Diameter of holotype: .22 mm.; thickness .09 mm.

Holotype locality: Imperial Oil Limited Surface Division locality G45-3 in Lsd. 12, Sec. 15, Tp. 79, Rge. 13, W. 6th Meridian on Henderson Creek, Alberta, Canada, from Kaskapau shales, 145 feet above the "white chalcedonic bed" or 345 feet above the top of the Pouce Coupe sand.

Holotype: Univ. of Alberta Pal. Type Coll.

Horizon: This Turonian species occurs rather rarely in the central part of the Kaskapau formation, at the Henderson Creek and Kiskatinaw River localities, where it is found above and below the "white chalcedonic bed" respectively.

Comparison: This species is rather similar to *Haplophragmoides howardense* n.sp. in having radial sutures and the same type of arenaceous wall. However, the latter form has at least one and one-half chambers more in its ultimate whorl and is more evolute than *H. bonanzaense*.

Name: After the hamlet of Bonanza, Alberta.

HAPLOPHRAGMOIDES DIVERSITATUM Stelck and Wall, n.sp.

Plate 1, Figures 8, 9; Plate 2, Figure 3

Test planispiral, periphery rounded, somewhat lobulate, with a thin transparent border; test partly evolute on one side, with part of preceding whorl visible, opposite side much more evolute with nearly two complete whorls showing; chambers enlarging rather gradually, last one the largest, six in ultimate whorl, five in penultimate whorl on more evolute side; sutures distinct, depressed, curved; wall very finely arenaceous with much cement giving a smooth exterior finish; aperture, a low arch at the base of the terminal face, placed slightly to the evolute side of the test.

Diameter of holotype (Plate 2, Fig. 3): .32 mm.

Diameter of paratype (Plate 1, Figs. 8, 9): .38 mm.

Holotype and Paratype locality: Imperial Oil Limited Surface Division locality S47-35 in Sec. 15, Tp. 78, Rge. 17, W. 6th Meridian, on the west bank of the Kiskatinaw River, one mile downstream

from Arras, British Columbia, Canada, from Kaskapau shales, six feet above the "white chalcedonic bed", or approximately 150 feet above the top of the Pouce Coupe sand.

Holotype: Univ. of Alberta Pal. Type Coll.

Paratype: Stanford Univ. Pal. Type Coll.

Horizon: The only significant occurrence of this Turonian species is at the Kiskatinaw River locality, where it ranges over a short interval above and below the "white chalcedonic bed".

Remarks: This species with unequal involution is suggestive of *Trochammina* but inasmuch as the aperture is on the more evolute side, it may be left in the genus *Haplophragmoides*.

HAPLOPHRAGMOIDES HENDERSONENSE

Stelck and Wall, n.sp.

Plate 2, Figure 4

Test somewhat compressed, of medium size, periphery rounded; test planispiral, partly evolute on one side with edge of penultimate whorls visible, opposite side involute; chambers, six to seven in ultimate whorl, last five of approximately equal size; sutures fairly distinct, flush, slightly thickened, slightly limbate toward the umbilicus, radial; wall finely arenaceous, with a considerable amount of cement, giving a smooth exterior finish; aperture, a low slit centrally situated at the base of the terminal face.

Diameter of holotype: .41 mm.

Holotype locality: Imperial Oil Limited Surface Division locality G45-4 in Lsd. 3, Sec. 16, Tp. 79, Rge. 13, W. 6th Meridian, on Henderson Creek, Alberta, Canada, from Kaskapau shales, 55 feet below the "white chalcedonic bed" or approximately 145 feet above the top of the Pouce Coupe sand.

Holotype: Univ. of Alberta Pal. Type Coll.

Horizon: This species occurs in the central part of the Kaskapau formation at the Henderson Creek locality, most commonly near the probable top of the *Ammobaculites pacalis* zone, but it also ranges upward into the early Turonian section above the "white chalcedonic bed".

HAPLOPHRAGMOIDES HOWARDENSE Stelck and Wall, n.sp.

Plate 1, Figure 20; Plate 2, Figures 5, 6

Test not large, planispirally coiled, evolute, with umbilicus exposing preceding whorl; periphery rounded, shell compressed in some specimens as shown in paratypes; chambers, all approximately the same size, eight and one-half in ultimate whorl, six and one-half in penultimate whorl; sutures distinct, depressed, radial, somewhat thickened, especially toward the umbilical margins; wall very finely arenaceous, with much cement giving a smooth finish to the exterior; aperture, a low opening at the base of the terminal face. Color pale yellow.

Diameter of holotype (Plate 2, Fig. 5): .23 mm.; thickness .07 mm.

Diameter of paratype (Plate 2, Fig. 6): .25 mm.

Diameter of paratype (Plate 1, Fig. 20): .3 mm.; diameter of umbilicus .08 mm.

Holotype locality: Imperial Oil Limited Surface Division locality G46-1 in northeast ¼, Sec. 14, Tp. 79, Rge. 6, W. 6th Meridian on Howard Creek, Alberta, Canada, from Kaskapau shales, 10 feet above the top of the *Ammobaculites pacalis* zone, or about 30 feet above the Howard Creek sand.

Paratype (Plate 2, Fig. 6) locality: Imperial Oil Limited Surface Division locality G45-3 in Lsd. 12, Sec. 15, Tp. 79, Rge. 13, W. 6th Meridian, on Henderson Creek, Alberta, Canada, from Kaskapau shales, 65 feet above the "white chalcedonic bed" or about 265 feet above the top of the Pouce Coupe sand.

Paratype (Plate 1, Fig. 20) locality: Imperial Oil Limited Surface Division locality S47-36 in Sec. 13, Tp. 78, Rge. 17, W. 6th Meridian, on the west bank of the Kiskatinaw River, one mile downstream from Arras, British Columbia, Canada, from Kaskapau shales, 32 feet below the "white chalcedonic bed", or about 105 feet above the Pouce Coupe sand.

Holotype and Paratype (Plate 2, Figs. 5, 6): Univ. of Alberta Pal. Type Coll.

Paratype (Plate 1, Fig. 20): Stanford Univ. Pal. Type Coll.

Horizon: This species has a widespread occurrence over the area, in the central part of the Kaskapau formation, above the Pouce Coupe sand. In the Howard Creek and Spirit River sections, it occurs mainly in the approximate interval 10 to 25 feet above the base of the *Haplophragmoides spiritense* zone, that is, about 30 to 45 feet above the Howard Creek sand.

Comparison: *H. howardense* is similar to *H. spiritense* in having about the same number of chambers, and in being evolute to about the same degree. However, the former species is considerably smaller and its sutures are radial and depressed, as opposed to the curved and flush sutures of *H. spiritense*. *H. howardense* is also more smoothly finished than is *H. spiritense* and has no quartz grains in its makeup larger than the cementing material, whereas the latter species does have some grains considerably larger than those in the matrix.

Name: After Howard Creek, Alberta.

HAPLOPHRAGMOIDES HOWARDENSE MANIFESTUM

Stelck and Wall, n.var.

Plate 1, Figures 3, 4, 5, 18; Plate 2, Figures 1, 2

Test planispiral, evolute to completely evolute, with umbilicus exposing two and one-half to three and one-half whorls on both sides of test; test often compressed (as shown in paratypes), periphery rounded, somewhat indented; chambers, of approximately equal size, somewhat inflated, subglobular, nine and one-half in ultimate whorl, six and one-half or more in penultimate whorl; sutures distinct, depressed, radial, except for last four in ultimate whorl, which are slightly curved (in some compressed forms, the sutures are

thickened and strongly arcuate, as exhibited by paratype, Plate 2, Fig. 2); wall finely arenaceous, with much cement giving a smooth external finish; aperture, a low slit at the base of the ultimate chamber.

Diameter of holotype (Plate 2, Fig. 1): .31 mm.; thickness .11 mm.

Diameter of paratype (Plate 2, Fig. 2): .31 mm.; thickness .08 mm.

Diameter of paratype (Plate 1, Fig. 3): .35 mm.

Diameter of paratype (Plate 1, Figs. 4, 5): .35 mm.

Maximum diameter of paratype (Plate 1, Fig. 18): .42 mm.; minimum diameter .3 mm.; diameter of umbilicus .05 mm.; height of ultimate chamber .18 mm.

Holotype locality: Imperial Oil Limited Surface Division locality G45-3 in Lsd. 12, Sec. 15, Tp. 79, Rge. 13, W. 6th Meridian, on Henderson Creek, Alberta, Canada, from Kaskapau shales, 90 feet above the "white chalcedonic bed" or about 290 feet above the top of the Pouce Coupe sand.

Paratype (Plate 2, Fig. 2) locality: As above, 80 feet above the "white chalcedonic bed".

Paratype (Plate 1, Fig. 3) locality: Imperial Oil Limited Surface Division locality S47-35, in Sec. 15, Tp. 78, Rge. 17, W. 6th Meridian, on the Kiskatinaw River, one mile north of Arras, British Columbia, Canada, from Kaskapau shales, six feet above the "white chalcedonic bed", at the base of the *Inoceramus labiatus* zone.

Paratype (Plate 1, Figs. 4, 5) locality: Imperial Oil Limited Surface Division locality S47-36, in same geographical position, 50 feet below the "white chalcedonic bed".

Paratype (Plate 1, Fig. 18) locality: As above, 17 feet below the "white chalcedonic bed".

Holotype and Paratype (Plate 2): Univ. of Alberta Pal. Type Coll.

Paratypes (Plate 1): Stanford Univ. Pal. Type Coll.

Horizon: This variety has been recognized only at the Henderson Creek and Kiskatinaw River localities, where it is found in the central part of the Kaskapau formation, both above and below the "white chalcedonic bed".

Comparison: This form seems to stand in varietal relationship to *H. howardense*, differing from the latter mainly in being more evolute and having additional chambers. In addition, the sutures of the specific form do not show any tendency to become curved or arcuate but remain radial.

Remarks: Considerable compression and crushing is often evident in this form, as demonstrated by the paratypes, illustrated on Plate 2, Fig. 2, and especially on Plate 1, Fig. 18. There is a possibility that compression may account for the strongly arcuate nature of the sutures in some of the specimens recovered. It is not thought that this latter feature alone is of enough importance to warrant the establishment of another variety.

The arnaceous wall of the paratype, Plate 1, Fig. 3, has somewhat coarser grains in its makeup than the other paratypes, and its sutures and chambers are indistinct. However, it is very closely related to the varietal form otherwise, and it is not considered necessary to detach it at the present time.

HAPLOPHRAGMOIDES SPIRITENSE Stelck and Wall n.sp.

Plate 2, Figures 7, 8, 9

Test of fair size, usually found in a flattened state as illustrated by paratype (Plate 2, Fig. 9), periphery rounded; test planispiral, partly evolute with umbilicus exposing about six chambers of penultimate whorl; chambers, eight and one-half to nine and one-half in ultimate whorl, very gradually enlarging in size; sutures distinct, except in crushed forms, where their presence is indicated by slight ridges, flush to slightly raised, thickened, curved; wall finely arenaceous, with an occasional grain of .015 mm. size, considerable amount of cement, giving a generally smooth finish to the exterior; aperture, a low triangular opening at the base of the ultimate chamber, slightly to one side of the equatorial region.

Diameter of holotype (Plate 2, Fig. 7): .38 mm.; thickness .09 mm.

Diameter of paratype (Plate 2, Fig. 8): .38 mm.; estimated thickness .025 mm.

Diameter of paratype (Plate 2, Fig. 9): .4 mm.; estimated thickness .025 mm.

Holotype locality: Imperial Oil Limited Spirit River Structure Test No. A-337-1 in Lsd. 16, Sec. 24, Tp. 78, Rge. 7, W. 6th Meridian, Alberta, Canada, at a depth of 664 feet, 99 feet above the Howard Creek sand or 178 feet above the top of the Pouce Coupe sand equivalent in the Kaskapau formation.

Paratype (Plate 2, Fig. 8) locality: As above, at a depth of 658 feet, 184 feet above the top of the Pouce Coupe sand equivalent.

Paratype (Plate 2, Fig. 9) locality: As above, at a depth of 625 feet, 217 feet above the top of the Pouce Coupe sand equivalent.

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

Horizon: This Turonian species is characteristic of the central part of the Kaskapau at Spirit River, where it occurs abundantly in the zone bearing its name, that is, in the 150 feet of section extending from 23 to 173 feet above the top of the Howard Creek sand. It has not been positively recognized outside of the Spirit River area.

Comparison: This species is similar to *Haplophragmoides howardense* in having the same number of chambers and in being evolute to about the same degree. However, this species is considerably larger and its sutures are curved and flush, as opposed to the radial and depressed sutures of *H. howardense*. *H. spiritense* is not as smoothly finished as *H. howardense* and has some quartz grains of considerably larger size than its cementing material, whereas the grain size in *H. howardense* is not distinguishable from the matrix.

Name: After the village of Spirit River, Alberta.

HAPLOPHRAGMOIDES TREMBLAYENSE

Stelck and Wall, n.sp.

Plate 1, Figures 6, 7

Test very small, compressed, planispiral, closely coiled with slight development of an umbilicus, periphery narrowly rounded, chambers distinct with eight chambers in ultimate whorl; sutures distinct, thickened, impressed, curved, assuming sigmoidal pattern often on crushing; test wall thin, mostly cement, small amount of very fine arenaceous material, smooth finish with transparent periphery and clear chamber partitions; aperture a low opening at the base of the terminal face of the ultimate chamber.

Long diameter of holotype .3 mm.; short diameter .18 mm.; diameter of umbilicus .02 mm.

Holotype locality: Imperial Oil Limited Surface Division locality S47-36 in Sec. 15, Tp. 78, Rge. 17, W. 6th Meridian on the Kiskatinaw River, one mile north of Arras, British Columbia, Canada; from Kaskapau shales, 67 feet below the "white chalcedonic bed" or approximately 70 feet above the Pouce Coupe sand.

Holotype: Stanford Univ. Pal. Type Coll.

Horizon: This species has not been recognized outside of its type locality and level.

Comparison: This species is very similar in design to *H. gigas* var. *minor* Nauss, but much smaller, and more thinly walled than the latter. It may well be the immature stage of varieties such as *Haplophragmoides howardense* var. *manifestum.*

Name: After Tremblay Creek, near Arras, British Columbia.

Genus MILIAMMINA Heron-Allen and Earland, 1930

MILIAMMINA BISOBSCURA Stelck and Wall n.sp.

Plate 1, Figure 1

Test sub-elliptical, compressed, ultimate chamber only distinct, earlier chambers obscured, chambers in alternate cyclic arrangement; sutures obscured; walls arenaceous of fairly coarse grains up to .03 mm., covered with finely arenaceous cement that totally obscures earlier chambers and sutures; aperture simple restricted at the end of the last formed chamber, extra smooth cement finish around the apertural end of the last chamber.

Length of holotype .58 mm.; width of holotype .27 mm.

Holotype locality: Imperial Oil Limited Surface Division locality S47-35 in Sec. 15, Tp. 78, Rge. 17, W. 6th Meridian, Kiskatinaw River, one mile north of Arras, British Columbia, Canada, from Kaskapau shales, 12 feet above the "white chalcedonic bed" or from the base of the *I. labiatus* zone of the Lower Turonian.

Holotype: Stanford Univ. Pal. Type Coll.

Horizon: This rare species has not been recognized outside of its type locality and level.

Genus PROTEONINA Williamson, 1858

PROTEONINA ARRASENSIS Stelck and Wall n.sp.

Plate 1, Figures 10, 11

Test a single elongate rounded chamber, rounded at base, tapered to apertural end with maximum diameter about one-quarter of length up from base; wall coarsely arenaceous with no cement visible except at apertural edge, grains making up test, angular, fairly evenly graded, around .06 mm. size; aperture terminal, simple, elliptical; no neck distinguished.

Length of holotype .43 mm.; maximum width .22 mm.

Holotype locality: Imperial Oil Limited Surface Division locality S47-36, in Sec. 15, Tp. 78, Rge. 17, W. 6th Meridian, on the Kiskatinaw River, one mile north of Arras, British Columbia, from Kaskapau shales about 120 feet above the Pouce Coupe sand.

Holotype: Stanford Univ. Pal. Type Coll.

Comparison: Except for the smaller size, this species is very similar to *Proteonina difflugiformis* H. B. Brady as illustrated by J. A. Cushman from the Cretaceous of Texas.

Name: After the hamlet of Arras, British Columbia.

PROTEONINA? EUREKAENSIS Stelck and Wall, n.sp.

Plate 1, Figure 16

Test a large single? chamber, rounded, elongate, rounded at the base and tapered to the apertural end with maximum diameter close to the base; test wall coarsely arenaceous on the exterior with intergranular spaces filled with a finely arenaceous cement; grains on exterior, mainly angular quartz grains, up to .25 mm. in size; aperture not apparent; neck not differentiated.

Length of holotype 1.15 mm.; maximum width .5 mm.

Holotype locality: Imperial Oil Limited Surface Division 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, from Kaskapau shales, two feet above the Howard Creek sand.

Holotype: Stanford Univ. Pal. Type Coll.

Horizon: This rare form has not been positively identified outside of its type locality and level.

Comparison: This large species may be a large variety of *Proteonina arrasensis* but may be distinguished from the latter by the coarser material studding the test and the very large size of the former.

Name: After the Eureka plains farming area, north of Dunvegan, Alberta.

Genus TEXTULARIA Defrance, 1824

TEXTULARIA ROLLAENSIS Stelck and Wall, n.sp.

Plate 1, Figure 17

Test of medium size, often preserved as a pyrite replacement, tapering, compressed, slightly twisted in early portion; chambers, twelve in interlocking biserial arrangement, enlarging rather gradu-

ally, with ultimate chamber the largest, and the last four comprising over half of length of test; sutures distinct, depressed; wall finely arenaceous with much cement, giving a smooth finish to the exterior; aperture, a notch at the inner margin of the ultimate chamber, extending well up onto the terminal face.

The figured specimen is a paratype, which is somewhat smaller in size than the holotype and has ten chambers, as opposed to twelve in the latter. The holotype, on which the above description is based, was recovered at the Imperial Oil Limited Surface Division locality G45-5 on Doe Creek, Alberta, from Kaskapau shales, 220 feet below the base of the Pouce Coupe sand, and it will be figured in our next paper.

Length of paratype .31 mm.; maximum width .11 mm.

Paratype locality: Imperial Oil Limited Surface Division locality S47-36 in Sec. 15, Tp. 78, Rge. 17, W. 6th Meridian, on the Kiskatinaw River, one mile north of Arras, British Columbia, Canada, from Kaskapau shales, 74 feet below the "white chalcedonic bed", or approximately 65 feet above the Pouce Coupe sand.

Paratype: Stanford Univ. Pal. Type Coll.

Horizon: This species is generally indicative of the lower (pre-Pouce Coupe sand) part of the Kaskapau formation, being confined to this portion of the Cenomanian section at the Spirit River and Doe Creek localities. Only two occurrences have been noted in the Kiskatinaw River area, one at the level of the figured paratype and the other at a short distance above the "white chalcedonic bed".

Comparison: *T. rollaensis* is somewhat like *T. pygmaea* Reuss from the Upper Gault but is more twisted than the latter species.

Name: After the hamlet of Rolla, British Columbia.

Genus TRITAXIA Reuss, 1860

TRITAXIA SPIRITENSIS Stelck and Wall, n.sp.

Plate 2, Figures 12, 13, 14

Test subtriangular in cross-section, tapering, compressed; test triserial, consisting of five whorls of three chambers each; chambers gradually enlarging in size; sutures, uusally distinct, depressed; wall finely arenaceous with much cement, giving a rather glistening surface to many specimens; aperture circular, produced at the end of the ultimate chamber. Color usually white, occasionally light brown or brownish-white.

Length of holotype (Fig. 12) .28 mm.; maximum width .12 mm.

Length of paratype (Fig. 13) .26 mm.; maximum width .13 mm.

Length of paratype (Fig. 14) .28 mm.; maximum width .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 664 feet, 99 feet above the Howard Creek sand or 178 feet above the top of the Pouce Coupe sand equivalent of the Kaskapau formation.

Paratype (Figure 13) locality: As above, same depth.

Paratype (Figure 14) locality: As above, at a depth of 630 feet, 212 feet above the top of the Pouce Coupe sand equivalent.

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

Horizon: This species seems to range over most of the lower and central Kaskapau, but it occurs much more commonly in the *Haplophragmoides spiritense* zone of the central Kaskapau than elsewhere. At Spirit River, most of the specimens were found in this zone, with only a relatively few being recovered from beds of the underlying microfaunal zones. At the Henderson Creek and Pouce Coupe River localities, it was observed to occur sporadically in beds of the central Kaskapau, both above and below the "white chalcedonic bed".

Remarks: The triseriality of this species is generally not apparent from an examination of the vast majority of specimens. It is usually compressed in such a manner as to disguise both its triangularity and triseriality, since it appears upon preliminary examination as a flattened, biserial form. Distortion in fossilization in some cases produces rather weird shapes of the test, making positive identification of this species difficult.

TRITAXIA SPIRITENSIS ELONGATA Stelck and Wall, n.var.

Plate 2, Figure 15

Test elongate, compressed, triserial, with about seven whorls of three chambers apiece; chambers gradually enlarging in size, those in last four whorls approximately equal; sutures indistinct, depressed; wall finely arenaceous, with grains no larger than .015 mm., moderate amount of cement; aperture circular, produced, at the end of the last chamber; color light brown or brownish-white.

Length of holotype: .59 mm.; maximum width .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 618 feet, 145 feet above the Howard Creek sand or 224 feet above the top of the Pouce Coupe sand equivalent of the Kaskapau formation.

Holotype: Univ. of Alberta Pal. Type Coll.

Horizon: This form is confined to a 30-foot interval, 143 to 173 feet above the Howard Creek sand, at the top of the *Haplophragmoides spiritense* zone of the central Kaskapau. It has been found only at Spirit River.

Comparison: *T. spiritensis elongata* seems to be an elongate variety of *T. spiritensis*. Its biserial appearance is thought to be due to distortion in fossilization, and the form is considered to have been triserial originally.

Genus TROCHAMMINA Parker and Jones, 1859

TROCHAMMINA KISTATINAWENSIS Stelck and Wall, n.sp.

Plate 1, Figures 12, 13

Test small, periphery sharply rounded; test trochoid of two whorls with flattened spire; ultimate whorl with nine chambers, chambers increase regularly in size, chambers distinct, only seven chambers of ultimate whorl visible on ventral side, as cement material fills both umbilicus and area around the aperture; sutures thickened, slightly arcuate; wall very finely arenaceous with much

cement; aperture assumed to open into umbilicus from inside edge of terminal chamber.

Long diameter of holotype .3 mm.; breadth of holotype .2 mm.

Holotype locality: Imperial Oil Limited Surface Division locality S47-35 in Sec. 15, Tp. 78, Rge. 17, W. 6th Meridian on the Kiskatinaw River, one mile north of Arras, British Columbia, Canada, from Kaskapau shales, six feet above the "white chalcedonic bed", or at the base of the *Inoceramus labiatus* zone.

Holotype: Stanford Univ. Pal. Type Coll.

Horizon: This rare species has not been recognized outside of its type locality and level.

Remarks: It is possible that this form may represent the earlier chambers or be the ancestral stage of *T. latumbilicata.*

Name: After the Kiskatinaw River, British Columbia.

TROCHAMMINA LATUMBILICATA Stelck and Wall, n.sp.

Plate 1, Figures 14, 15

Test medium size, periphery rounded, test trochoid with two distinct whorls and primary obscured whorl or whorls, low rounded spire on dorsal side and deep umbilical depression, chambers distinct in ultimate and penultimate whorls with ten chambers in final whorl and seven in penultimate whorl; sutures distinct and thickened on dorsal side, slightly depressed and indistinct on ventral side; wall very finely arenaceous, grain size .008 mm., with much cement giving a smooth finish to the exterior; aperture not known.

Diameter of holotype .55 mm.; width of umbilicus .1 mm.

Holotype locality: Imperial Oil Limited Surface Division locality S47-36 in Sec. 15, Tp. 78, Rge. 17, W. 6th Meridian on the Kiskatinaw River, one mile north of Arras, British Columbia, Canada, from Kaskapau shales, six feet below the "white chalcedonic bed", just below the base of the *Inoceramus labiatus* zone.

Holotype: Stanford Univ. Pal. Type Coll.

Horizon: No range data is available for this species outside of its type locality and level.

Comparison: The number of chambers in the outer whorl of this species is equal to those of *Trochammina ribstonensis* Wickenden, but this latter species is much smaller, lacks an umbilicus and has oblique sutures.

TROCHAMMINA WEBBI Stelck and Wall, n.sp.

Plate 2, Figure 11

Test of fair size, compressed, flattened, periphery lobulate; test trochoid with a very low spire, of three whorls, six to seven chambers in ultimate whorl, same number in penultimate whorl and about five in primary whorl; ventral side often with a ringlike ridge surrounding the umbilicus, created by compression of the chambers on fossilization; chambers gradually enlarging in size, subglobular in outline, often scalloped on ventral side; sutures rather indistinct, oblique, depressed on dorsal side, radial, and with their location

usually indicated by ridges on the ventral side; wall mostly finely arenaceous but often with flecks of dark mica up to .04 mm. in size scattered over the dorsal side, concentrated for the most part in the region of the spire; amount of cement considerable, giving a fairly smooth finish to the exterior; aperture not recognized, assumed to be a low opening on the ventral side between the periphery and the umbilicus.

Diameter of holotype .38 mm.; thickness .05 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 658 feet, 105 feet above the Howard Creek sand or 184 feet above the top of the Pouce Coupe sand equivalent of the Kaskapau formation.

Holotype: Univ. of Alberta Pal. Type Coll.

Horizon: This species occurs commonly in the *Haplophragmoides spiritense* zone of the central part of the Kaskapau at Spirit River, over a 50-foot interval (*T. webbi* subzone), extending from 63 to 113 feet above the top of the "Howard Creek" sand. At the Henderson Creek locality some specimens were found in the uppermost part of the sampled section in the central Kaskapau, that is, 135 to 150 feet above the "white chalcedonic bed" (approximately 335 to 350 feet above the top of the Pouce Coupe sand).

Comparison: This species does not seem to differ a great deal from *Trochammina diagonis* (Carsey) Cushman and Waters, described originally from the Upper Cretaceous Navarro group of Texas. The Alberta form appears to have an extra whorl of chambers and its sutures are not as distinct as those of the Texas species.

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

BIBLIOGRAPHY

Adkins, W. S. (1933): The Geology of Texas, Vol. I, pt. II. University of Texas Bulletin 3232, pp. 239-518.

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.

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

Dawson, G. M. (1874): Notes on the Occurrence of Foraminifera, Coccoliths, etc., in the Cretaceous Rocks of Manitoba. Canadian Naturalist, 2nd Series, Vol. 7, pp. 252-257.

Galloway, J. J. (1933): A Manual of Foraminifera. James Furman Kemp Memorial Series, Pub. No. 1, Principia Press, Bloomington, Indiana, 483 pp.

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

Goodman, A. J. (1951): White Specks in Colorado Shale. Amer. Assoc. Petrol. Geol. Bull., Vol. 35, No. 11, pp. 2427-2429.

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

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

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.

Payne, T. G. (1951): The Arctic Slope. Oil and Gas Investigations, U.S.G.S. Map O.M.126, Sheets 1, 2, 3.

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.

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., and Stelck, C. R. (1940): Cenomanian and Turonian Faunas in the Pouce Coupe District, Alberta and British Columbia. Roy. Soc. Canada Trans., 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

Central Part of Kaskapau Formation
Magnification about x65.

Fig. 1, 2: *Miliammina bisobscura* Stelck and Wall, n.sp,. holotype, from Kiskatinaw River, B.C.; 1, 2, opposite sides.

Fig. 3, 4, 5: *Haplophragmoides howardense* var. *manifestum* Stelck and Wall, n.var., paratypes, from Kiskatinaw River, B.C.; 4, 5, opposite sides of same specimen.

Fig. 6, 7: *Haplophragmoides tremblayense* Stelck and Wall, n.sp., holotype, from Kiskatinaw River, B.C.; 6, 7, opposite sides.

Fig. 8, 9: *Haplophragmoides diversitatum* Stelck and Wall, n.sp., paratype, from Kiskatinaw River, B.C.; 8, 9, opposite sides.

Fig. 10, 11: *Proteonina arrasensis* Stelck and Wall, n.sp., holotype, from Kiskatinaw River, B.C.; 10, apertural view; 11, side view.

Fig. 12, 13: *Trochammina kiskatinawensis* Stelck and Wall, n.sp., holotype, from Kiskatinaw River, B.C.; 12, view of spire, 13, umbilical view.

Fig. 14, 15: *Trochammina latumbilicata* Stelck and Wall, n.sp., holotype, from Kiskatinaw River, B.C.; 14, umbilical view; 15, view of spire.

Fig. 16: *Proteonina? eurekaensis* Stelck and Wall, n.sp., holotype, from Dunvegan, Alberta.

Fig. 17: *Textularia rollaensis* Stelck and Wall, n.sp., paratype, from Kiskatinaw River, B.C.

Fig. 18: *Haplophragmoides howardense* var. *manifestum* Stelck and Wall, n.var., paratype, from Kiskatinaw River, B.C.

Fig. 19: *Ammobaculites pacalis* Stelck and Wall, n.sp., paratype, from Dunvegan, Alberta.

Fig. 20: *Haplophragmoides howardense* Stelck and Wall, n.sp., paratype, from Kiskatinaw River, B.C.

Fig. 21, 22: *Ammobaculites albertensis* Stelck and Wall, n.sp., paratypes, from Dunvegan, Alberta.

Fig. 23: *Flabellammina succedens* Stelck and Wall, n.sp., holotype, from Kiskatinaw River, B.C.

Fig. 24, 25: *Flabellammina gleddiei* Stelck and Wall, n.sp., paratypes, from Kiskatinaw River, B.C.

Fig. 26: *Flabellammina bessboroensis* Stelck and Wall, n.sp., holotype, from Kiskatinaw River, B.C.

EXPLANATION OF PLATE 2

Central Part of Kaskapau Formation

Magnification x45 except where otherwise designated.

Fig. 1, 2: *Haplophragmoides howardense* var. *manifestum* Stelck and Wall, n.var., from Henderson Creek, Alberta; 1, holotype, a, b, side and peripheral views; 2, paratype, a, b, side and peripheral views.

Fig. 3: *Haplophragmoides diversitatum* Stelck and Wall, n.sp., holotype, from Kiskatinaw River, B.C.; a, b, opposite sides.

Fig. 4: *Haplophragmoides hendersonense* Stelck and Wall, n.sp., holotype, from Henderson Creek, Alberta; a, c, opposite sides, b, peripheral view.

Fig. 5, 6: *Haplophragmoides howardense* Stelck and Wall, n.sp.; 5, holotype, from Howard Creek, Alberta; a, b, side and peripheral views; 6, paratype, from Henderson Creek, Alberta.

Fig. 7, 8, 9: *Haplophragmoides spiritense* Stelck and Wall, n.sp., from Spirit River, Alberta; 7, holotype, a, b, side and peripheral views; 8, 9, paratypes.

Fig. 10: *Haplophragmoides bonanzaense* Stelck and Wall, n.sp., holotype, from Henderson Creek, Alberta; a, b, side and peripheral views.

Fig. 11: *Trochammina webbi* Stelck and Wall, n.sp., holotype, from Spirit River, Alberta; a, view of spire, b, peripheral view, c, umbilical view.

Fig. 12, 13, 14: *Tritaxia spiritensis* Stelck and Wall, n.sp., from Spirit River, Alberta; 12, holotype; 13, 14, paratypes.

Fig. 15: *Tritaxia spiritensis* var. *elongata* Stelck and Wall, n.var., holotype, from Spirit River, Alberta.

Fig. 16: *Flabellammina gleddiei* Stelck and Wall, n.sp., holotype, from Henderson Creek, Alberta.

Fig. 17, 18: *Flabellammina hendersonensis* Stelck and Wall, n.sp.; 17, x38, holotype, from Henderson Creek, Alberta; 18, x45, paratype, from Kiskatinaw River, B.C.

Fig. 19: *Gümbelitria cretacea* var. *albertensis* Stelck and Wall, n.var.; x77, holotype, from Spirit River, Alberta.

Fig. 20: *Gümbelina globulosa* (Ehrenberg), x85, plesiotype, from Spirit River, Alberta; a, b, side and apertural views.

Fig. 21, 22: *Globigerina cretacea* d'Orbigny, x85, plesiotypes, from Spirit River, Alberta; 21a, 21b, spiral and peripheral views of plesiotype; 22, umbilical view of another plesiotype.

Fig. 23, 24: *Gümbelitria cretacea* Cushman, x85, plesiotypes, from Spirit River, Alberta; 23, side view of plesiotype; 24, side view of another plesiotype, showing aperture.