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RESEARCH COUNCIL OF ALBERTA

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**UPPER CRETACEOUS FORAMINIFERA
FROM THE SMOKY RIVER AREA, ALBERTA**

by

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Upper Cretaceous Foraminifera from the Smoky River Area, Alberta

ABSTRACT

Nineteen species and subspecies of Foraminifera—one of which is proposed as new—from the upper part of the Kaskapau shale and the lower part of the Puskwaskau shale in the Smoky River area of Alberta, Western Canada, are figured and described. The problem of stratigraphic nomenclature within the Smoky River group is reviewed, and a new formational name, Puskwaskau, introduced to designate the shales lying between the Bad Heart sandstone and the Wapiti formation in the Smoky River area. Brief descriptions of the lithology encountered at the two collecting localities on the Smoky and Bad Heart Rivers are given.

Although little change in the general aspect of the microfaunas from the Kaskapau and Puskwaskau shales is noted, a few apparently diagnostic species from each shale unit are listed. The microfaunas are dated Coniacian-Santonian by their association with ammonites of the *Scaphites ventricosus*, *Scaphites depressus*, and *Clioscaphtes vermiformis* zones. The white-speckled, calcareous shale "zone" in the Puskwaskau shale is considered the partial equivalent of the first or upper white-speckled shale "zone" occurring at or near the top of the Colorado shale in other areas of Alberta and northern Montana. The microfauna associated with this "zone" carries elements common to both the Boyne member of the Vermilion River formation of Manitoba and the Niobrara formation of the Central Plains region of the United States.

The foraminiferal assemblages are dominantly arenaceous. The depth of the water appears to have been quite shallow, but deepened considerably at the time of the deposition of the white-speckled shale as revealed by the associated calcareous, pelagic Foraminifera.

INTRODUCTION

During the summer of 1958, two Upper Cretaceous outcrop sections on the Smoky and Bad Heart Rivers were sampled for microfossils. These sections are near the hamlet of Bad Heart, situated a few miles south of the Birch Hills in the Peace River country of northern Alberta (figure 1).

Along the banks of the Smoky and its tributaries in this area, a sequence of Upper Cretaceous rocks is exposed which embraces in ascending order the Kaskapau shale, the Bad Heart sandstone, and the "Upper Smoky River shale" herein named the Puskwaskau shale. This sequence has been variously regarded as a formation and as a group by stratigraphers. Information pertaining to the distribution, lithology, and thickness of these beds

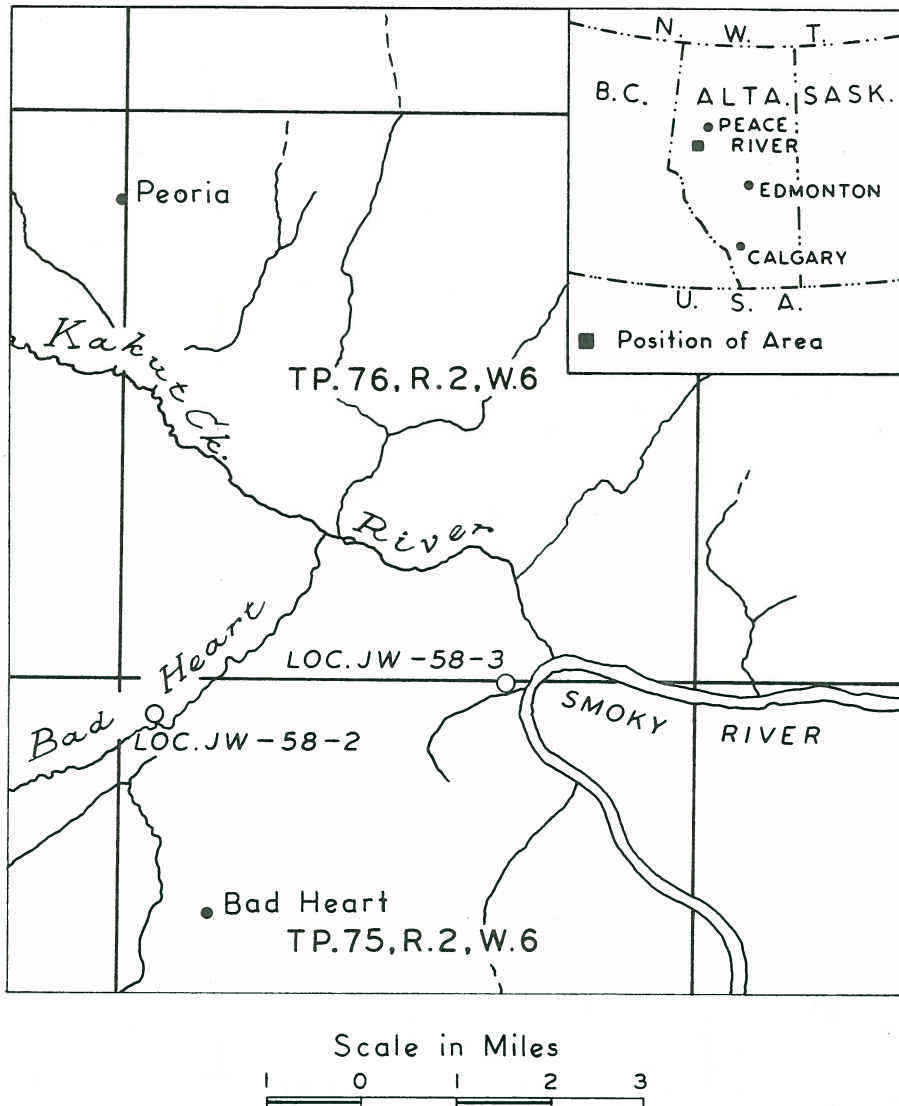


FIGURE 1. Microfaunal collecting localities in Smoky River Area, Alberta

may be readily obtained by reference to the contributions of such previous workers as Rutherford (1930) and Gleddie (1949, 1954).

The author sampled only part of the above sequence with coverage limited to the upper 140 feet of the Kaskapau shale and the lower 150 to 160 feet of the Puskwaskau shale. The highest sample was obtained about 30 feet above the top of the first or upper white-speckled shale "zone" which marks the boundary between the Colorado and Montana groups in other

areas of Alberta and the northern United States. The sampled interval coincides approximately with most of the Coniacian and Santonian stages.

Two pertinent foraminiferal studies in the Upper Cretaceous marine succession of the same general area have been published by Stelck and Wall (1954, 1955). The first of these contributions dealt with the early Turonian Foraminifera from the central part of the Kaskapau formation and the second was concerned with the microfaunas from the lower and central parts of the same formation within the Cenomanian *Dunveganoceras* zone. No previous publication, however, has dealt with the Foraminifera from the upper part of the Kaskapau shale and the Puskwaskau shale.

Nauss (1947) has described the microfaunas of the Lloydminster and Lea Park shales of east-central Alberta which are partly contemporaneous with the faunas described herein. Wickenden (1932b) described some key foraminiferal species from the Upper Cretaceous of Western Canada, a few of which are recorded in the beds described in this report.

STRATIGRAPHIC NOMENCLATURE OF THE SMOKY RIVER GROUP

The various systems of nomenclature employed for the Smoky River formation or group and equivalent beds are summarized in table 1. The formational name "Smoky River" was first applied by G. M. Dawson (1881, p. 115B) for the "upper dark shales" exposed on the Smoky River. McLearn (1919) subdivided the Smoky River formation into three members, namely the "Lower shale", "Bad Heart sandstone", and "Upper shale", and on the basis of fossils he grouped the lower two members together. McLearn (1926) assigned the name "Kaskapau" to the Lower shale member.

CENTRAL FOOTHILLS, ALBERTA STOTT, 1956		WAPITI RIVER, B.C. STELCK, 1955		WESTERN PEACE RIVER PLAINS, ALBERTA GLEDDIE, 1954		SMOKY RIVER, ALBERTA MCLEARN, 1919, 1926		SMOKY RIVER, ALBERTA WALL, 1960			
ALBERTA	GROUP WAPIABI FORMATION	Transition Zone	WAPIABI F.M.	GROUP WAPIABI F.M.	Transition Zone	FORMATION WAPIABI F.M.	Upper Shale Member	PUSKWASKAU SHALES			
		Solomon Sandstone			Chinook Member						
					Upper Speckled Shale Zone						
		Lower Concretionary Siltstone			Bad Heart Member						
					Baytree Member						
	BLACKSTONE FORMATION	BIGHORN FORMATION †	KASKAPAU F.M.	CARDIUM F.M.	SMOKY RIVER GROUP CARDIUM F.M.	KASKAPAU F.M.	FORMATION SMOKY RIVER	Lower Shale Member (1919) Kaskapau Member (1926)	KASKAPAU SHALES		
	Barren Zone	DUNVEGAN FORMATION	DUNVEGAN FORMATION	DUNVEGAN FORMATION	DUNVEGAN FORMATION	DUNVEGAN FORMATION	DUNVEGAN FORMATION				

TABLE 1. Terminology of Smoky River group and equivalents*

*Modified from Stott

†The name Cardium is now recognized by the Geological Survey of Canada (Stott, pers. comm.)

Rutherford (1930) followed essentially McLearn's terminology and discussed the Smoky River formation under the subheadings: Lower Smoky River shale (Kaskapau), Bad Heart sandstone, and Upper Smoky River shale.

Russell (1943) in mapping the Sexsmith-Bison Lake area, which includes the localities examined in this study, used the term "Smoky group" to embrace the Kaskapau formation, Bad Heart formation, and the dark marine shale overlying the Bad Heart which was left unnamed. McLearn and Henderson (1944) proposed that the name "Smoky River" be shortened to "Smoky". They used the name in the group sense to embrace the "Kaskapau, Bad Heart and Upper shale". None of these lesser stratigraphic units was formally proposed as a formation within the Smoky group at that time, although the authors considered the Kaskapau as of formational rank in the Lone Mountain area of northeastern British Columbia. Crickmay (1944) used the term "Smoky group" in the Pouce Coupe-Peace River map-area lying to the north and west of the Smoky River area, but he did not subdivide it into formations or members.

Gleddie (1949) formally 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 assumed that the Bad Heart sandstone of the Smoky River area was the eastern equivalent of the Cardium formation of the British Columbia - Alberta border area. Gleddie (1954) still used the name "Smoky River" as a group to include the Kaskapau, Cardium, and Wapiabi formations with the Bad Heart relegated to member status within the uppermost part of the Cardium. Stelck (1955), in discussing these beds in northeastern British Columbia, considered the Bad Heart sandstone as a member within the Wapiabi formation.

The name "Wapiabi" was first used by Malloch (1911) to include the shales lying above the Bighorn or Cardium formation in the Bighorn coal basin of the central Alberta foothills. This name is in use for essentially equivalent shales far to the north in the Wapiti River and adjacent areas of northeastern British Columbia where the Cardium formation can also be recognized. The name "Upper Smoky River shale" was used by most workers prior to Gleddie to designate the shale beds overlying the Bad Heart sandstone along the Smoky River. Gleddie (1949, 1954), however, extended the application of the name Wapiabi eastward to the Smoky River to include these shales, and discarded the old name "Upper Smoky River shale". The advisability of this action is questioned in the following discussion.

Stelck (1955) has shown paleontologically that the Bad Heart sandstone occupies a higher stratigraphic position than the Cardium sandstone. He considered that the Bad Heart is a member of the Wapiabi formation and that it is separated from the older Baytree member at the top of the Cardium formation by marine shale. Gleddie (1954) regarded the Bad Heart sandstone as the top member of the Cardium formation. In

Stelck's terminology, the Wapiabi formation includes some shale underlying the Bad Heart sandstone, whereas in Gleddie's (1954) terminology, the base of the Wapiabi directly overlies the Bad Heart member.

It is thus apparent that the Wapiabi formation as used by Stelck in northeastern British Columbia includes in the Smoky River area part of the Kaskapau formation. This anomaly arises because only the Bad Heart sandstone and no part of the Cardium formation in the restricted sense of Stelck is recognizable on the Smoky River, and the Bad Heart is here directly underlain by the Kaskapau shale. It seems doubtful, then, whether "Wapiabi" can be correctly used as a formational name in the Smoky River area.

The name "Upper Smoky River" is nomenclaturally inappropriate for the following reason: in view of the proposals of McLearn and Henderson (1944) and Gleddie (1949, 1954) to raise the name "Smoky River" from formation to group rank, one would expect the units within the group to be given formational status eventually. The Kaskapau and Bad Heart are generally regarded as having formational status at present, but "Upper Smoky River" is ineligible for use as a formational name because of synonymy with the group name (Stratigraphic Commission, 1956).

In an effort to resolve the confusion surrounding the present status of the nomenclature within the Smoky River group, the author feels justified in proposing that a new formation, the Puskwaskau shale, be recognized for the shales outcropping along the Smoky River underlain by the Bad Heart sandstone and overlain by the Wapiti formation. The new formational name is derived from the Puskwaskau River which empties into the Smoky River about 6 miles south or upstream from the confluence of the Bad Heart and Smoky Rivers. A partial type section embracing the lower third of the formation is designated at Research Council of Alberta locality JW-58-3 (plates 1, 2) near the confluence of the Bad Heart and Smoky Rivers. Stott (pers. comm.) reported a good exposure of the lower part of this formation near the Puskwaskau-Smoky confluence and isolated small outcrops of the upper part of the formation farther upstream on the Smoky River near Bezanson. Smith in Gleddie (1954) reported a thickness of between 300 and 350 feet for these beds (Puskwaskau) in this area.

In summary, the name "Smoky River" is recognized as a group which includes in ascending order the Kaskapau shale, the Bad Heart sandstone and the Puskwaskau shale.

DESCRIPTION OF COLLECTING LOCALITIES

The sections sampled on the Bad Heart and Smoky Rivers are referred to in this report as Research Council of Alberta localities JW-58-2 and JW-58-3, respectively. The Bad Heart River locality includes only a portion of the Puskwaskau shale. The Smoky River locality embraces in ascending order, the upper part of the Kaskapau shale, the Bad Heart sandstone, and the lower part of the Puskwaskau shale. Each locality is identified geographically and a summary of the lithology given in the following section.

Locality JW-58-2

This outcrop is in Lsd. 11, Sec. 31, Tp. 75, R. 2, W. 6th Mer., on the north bank of the Bad Heart River, about 1,000 feet upstream from the bridge.

At this locality about 60 feet of the Puskwaskau shale are exposed with approximately half of this thickness above the top of the first or upper white-speckled shale "zone" and with a like amount below. The shale at this locality is, in general, medium-grey, fairly soft, platy, and nearly silt-free. White-speckled, calcareous shale occurs sporadically through an 18-foot section of this outcrop. Above the white-speckled shale "zone", there are some thin beds of bentonite and cone-in-cone limestone.

Locality JW-58-3

This outcrop is in Lsd. 13, Sec. 35, Tp. 75, R. 2, W. 6th Mer., near the mouth of a small tributary of the Smoky River, the first upstream from the confluence of the Bad Heart and Smoky Rivers. This outcrop extends from the mouth of the tributary back upstream along the gully walls for about one-quarter mile. The beds are nearly flat-lying and the rather steep gradient of the tributary, which is nearly dry in summer, provides a convenient access route to much of the section (see plate 1).

At this locality, the upper 140 feet of the Kaskapau shale and the lower 120 feet of the Puskwaskau shale were sampled. The sampled interval spans nearly the complete thickness of these shales exposed at this locality. Sampling was carried out in a discontinuous select pattern with about every fifth foot of the Kaskapau and every fourth foot of the Puskwaskau shale being sampled.

The type locality of the Bad Heart sandstone and locality JW-58-3 are nearly coincident as the former is considered to be in the general vicinity of the confluence of the Smoky and Bad Heart Rivers. The Bad Heart



PLATE 1. Locality JW-58-3, near the mouth of a tributary of Smoky River, showing exposure of Kaskapau shale, Bad Heart sandstone and Puskwaskau shale in ascending order

sandstone at locality JW-58-3 consists of an upper, massive, 8-foot-thick unit of fine-grained, yellow-weathering, quartzose sandstone capped by a persistent ironstone layer, 1 to 2 feet thick. This upper unit is underlain by a variable amount of argillaceous sandstone grading below into the silty shales of the Kaskapau. The total thickness of the Bad Heart is in the order of 20 feet. Inasmuch as the lower contact with the Kaskapau is gradational, the top of the Bad Heart was taken as the point of reference for samples obtained from both the overlying Puskwaskau and the underlying Kaskapau shales.

The Kaskapau shale exposed at locality JW-58-3 consists mainly of medium-grey, rather blocky, slightly to moderately silty shale. Three prominent ironstone layers, each about 6 inches thick, were observed at this locality and their positions in the section are shown on chart 1. These

ironstone layers seem to have fair lateral continuity and serve as convenient planes of reference for tracing elevations of sample stations.

The Puskwaskau shale exposed at locality JW-58-3 is similar lithologically to the Kaskapau shale and consists mainly of medium-grey, mostly



PLATE 2. Locality JW-58-3, side gully near the mouth of a tributary of the Smoky River, with Kaskapau shale, Bad Heart sandstone and Puskwaskau shale exposed in ascending order; the first (upper) white-speckled shale "zone" is found at the top of the section

blocky, slightly silty shale. Ironstone is less prominent in the upper shale and only one band, a 3-inch layer near the base of this shale, seems at all laterally continuous. The top six feet of the sampled section fall within the first or upper white-speckled shale "zone" and consist of dark-grey, white-speckled, calcareous shale with a few thin bands of bluish-grey, argillaceous limestone. A thin bentonite seam is present at the top of the section.

STRATIGRAPHIC AND ECOLOGIC ASPECTS OF THE FORAMINIFERA

General Discussion of the Microfaunas

The Kaskapau and Puskwaskau shales disintegrate readily in water and are easily prepared for microfossil extraction. Most of the samples yield fair populations of Foraminifera although the number of species in any one sample is usually small.

The Foraminifera obtained from both the Kaskapau and Puskwaskau shales are dominantly arenaceous with the exception of a pelagic calcareous fauna associated with the first or upper white-speckled shale "zone". *Haplophragmoides* is the dominant genus in this sequence as it is in many other parts of the Cretaceous of Western Canada, and *Dorothia* is next in abundance. *Textularia*, *Trochammina* and *Verneuilinoides* are fairly common in certain samples.

There is no pronounced difference between the general aspect of the microfaunas from the upper Kaskapau shale and from the Puskwaskau shale below the first white-speckled shale "zone". Many of the foraminiferal species occur in both the Kaskapau and Upper Smoky River shales, although some are much more prominent in one than in the other. There are a few species that appear to be confined to one or the other of these shales at the Smoky River locality. The apparently diagnostic species for each shale unit are discussed in the following section (see also chart 1).

KASKAPAU SHALE

Dorothia sp., a rather coarse-grained species, occurs commonly in the lower part of the sampled section and disappears some distance below the Bad Heart sand.

Haplophragmoides collyra bullocki Stelck and Wall was not recorded above the Kaskapau shale in which it occurs sporadically.

Gümbelitria sp. was found in the fine fraction of one sample from the Kaskapau shale.

Reophax sp. B, a robust, coarse-grained species, is virtually restricted to the upper Kaskapau shale but is rather rare.

Reophax sp. A occurs characteristically in the Kaskapau shale but there are a few occurrences in the Puskwaskau shale.

Involutina sp., although characteristic of the Puskwaskau shale, is represented near the top of the Kaskapau shale by an atypical group of individuals with protruding coarse mineral grains.

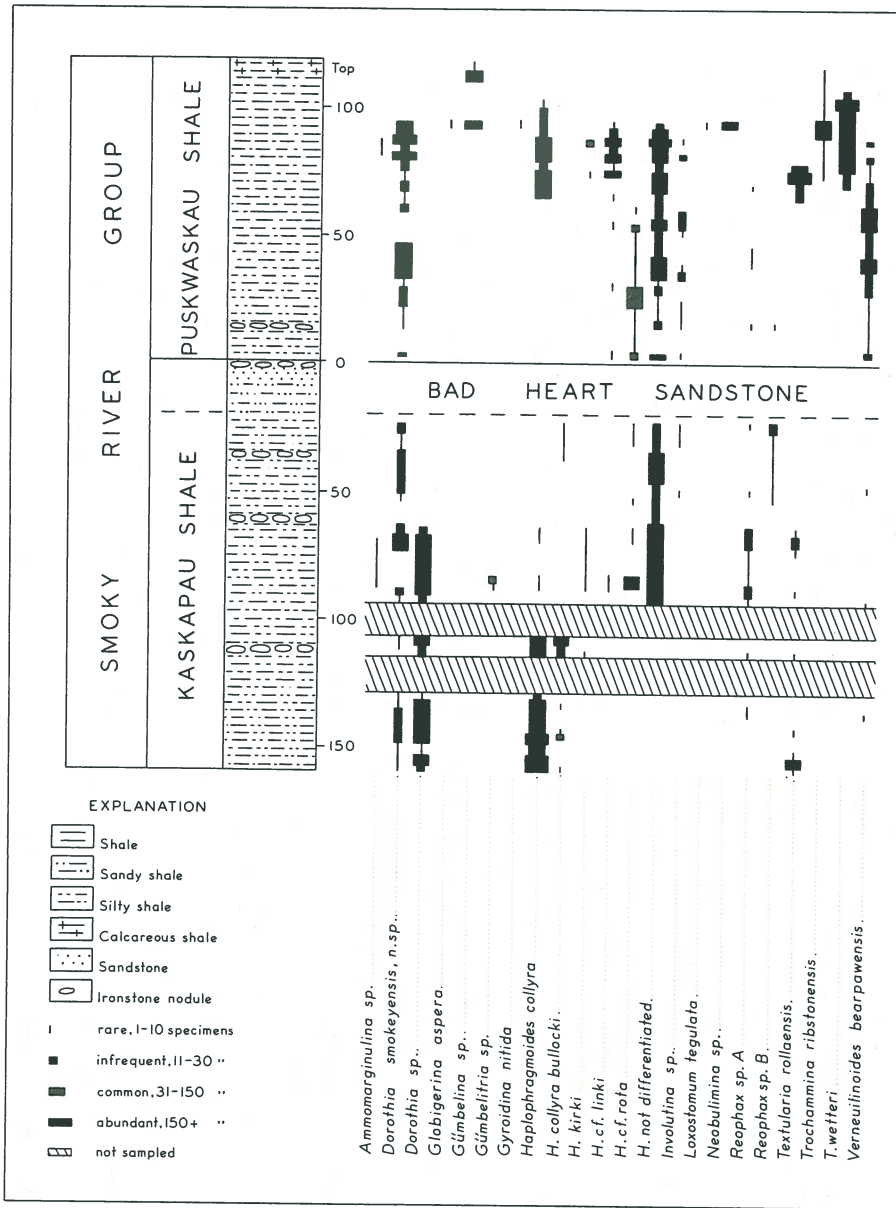


CHART 1. Distribution of Foraminifera at locality JW-58-3, Smoky River

PUSKWASKAU SHALE

Verneuilinoides bearpawensis Wickenden is fairly common in the shales above the Bad Heart sand and is virtually restricted to this level with only a very few specimens being recorded in the Kaskapau.

Involutina sp. is another characteristic species of the Puskwaskau shale, although it is not restricted to this unit.

Trochammina ribstonensis Wickenden is restricted to the Puskwaskau shale. It occurs directly below or in association with the first (upper) white-speckled shale "zone" at the Smoky River locality, whereas on the Bad Heart River, it occurs directly above or in association with the same "zone".

A pelagic microfauna occurs mainly in association with the first or upper white-speckled shale "zone", but at the Smoky River locality, its presence is also indicated about 17 feet below this "zone". *Gümbelina* sp. and *Neobulimina* sp. are common in this assemblage, with *Globigerina* being rather rare.

Age and Correlation of the Microfaunas

The foraminiferal fauna from the upper Kaskapau shale at the Smoky River locality is largely of middle Coniacian age as *Scaphites ventricosus* Meek and Hayden and *Inoceramus umbonatus* Meek and Hayden of the *Scaphites ventricosus* zone were collected from this section and no megafaunal elements of the *Scaphites preventricosus* zone were found.

The Bad Heart sandstone seems to straddle the Coniacian-Santonian boundary as components of both the late Coniacian *Scaphites depressus* zone and the early Santonian *Clioscapites vermiformis* zone were collected from it on the Smoky River. The megafauna identified by C. R. Stelck includes the following species:

- Clioscapites montanensis* Cobban
- C. saxitonianus* (McLearn)
- Inoceramus coulthardi* McLearn
- I. pontoni* McLearn

The foraminiferal fauna from the lower part of the Puskwaskau shale, that is, the portion below the first or upper white-speckled shale "zone", is thus apparently of early Santonian age. The first or upper white-speckled shale in Alberta is usually considered to be of early and middle Santonian age (C. R. Stelck, pers. comm.). The sampled section probably does not include any of the upper Santonian, that is, Telegraph Creek equivalents.

The white-speckled shale "zone" in the Puskwaskau shale is here considered the equivalent of the upper or first white-speckled shale "zone" at the top of the Colorado shales in central and southern Alberta as suggested by Gleddie (1949, 1954). The occurrence of *Trochammina ribstonensis* Wickenden in the basal Lea Park shale of central Alberta and in association with the white-speckled shale "zone" of the Puskwaskau shale provides paleontological confirmation for this correlation, which stratigraphers in recent years have assumed.

This white-speckled shale "zone" has a widespread occurrence in Alberta, Saskatchewan, and northern Montana. It is an incipient chalky deposit, found at or near the top of the Colorado shale and serves in Alberta as the boundary between the Colorado and Montana groups. In the Manitoba escarpment, this "zone" is contained within the Boyne member, a white-speckled, calcareous shale unit of the Vermilion River formation. Wickenden (1945, p. 42) cited the occurrence of *Scaphites ventricosus* Meek and Hayden and *Inoceramus pontoni* McLearn in the Boyne member, and stated that these fossils indicated correlation with the Niobrara formation of the Dakotas, Nebraska, and Kansas.

The microfaunas associated with the white-speckled shale "zone" in the Puskwaskau shale, the Boyne member of the Vermilion River formation and the Niobrara formation (Loetterle, 1937) have a number of species in common including *Globigerina aspera* (Ehrenberg), *Gyroldina nitida* (Reuss), and *Loxostomum tegulata* (Reuss). In addition, species of *Gümbelina* and *Neobulima* have been recorded in these same beds and may be fairly closely related.

Paleoecology

The almost exclusively arenaceous assemblages of Foraminifera in the upper Kaskapau shale indicate a quite shallow, probably cool-water environment. Further shallowing of the sea just prior to the deposition of the Bad Heart sandstone is suggested by the presence, for a short interval below this sand, of coarse-grained representatives of *Involutina*, *Haplophragmoides*, and *Reophax*.

After the deposition of the Bad Heart, the water probably deepened somewhat, although remaining relatively shallow, as revealed by the assemblages of finely arenaceous species in the lower part of the Puskwaskau shale. The occurrence of the pelagic microfauna of *Gümbelina* and *Globigerina* to the virtual exclusion of arenaceous Foraminifera in the white-speckled shale "zone" is indicative of further deepening and of a connection with the vast interior seaway to the south and east.

FORMAL DESCRIPTIONS

Order FORAMINIFERA

Family REOPHACIDAE

Genus REOPHAX Montfort, 1808

REOPHAX sp. A

Plate 3, figure 10

Test small, elongate, subcylindrical in cross section with many individuals bevelled on one side; test consists of from two to four chambers with three in most specimens, in a straight or nearly straight series; chambers rather irregular in size, somewhat constricted, final one subpyriform; sutures indistinct, nearly transverse to somewhat oblique, deeply depressed; wall agglutinated, of coarse quartz and other mineral grains, with little cement, surface very rough; aperture terminal, simple.

Length of figured specimen, 0.58 mm.; greatest width, 0.19 mm.

Locality of figured specimen: JW-58-3, Smoky River, Alberta, from the Kaskapau shale, 70 feet below the top of the Bad Heart sand.

Repository: Res. Coun. Alberta Micropaleont. Type Coll.

Occurrence: This species seems characteristic of the Kaskapau shale and occurs sporadically in the interval 24 to 138 feet below the top of the Bad Heart sand. It is very rare in the Puskwaskau shale.

Remarks: This species seems similar to *Reophax constrictus* (Reuss) Cushman (1946, p. 16, pl. 1, figs. 21, 22) from the Upper Cretaceous of the Gulf Coast region of the United States. The chambers in the Gulf Coast species appear more globular, however, and apparently there is more cement in its wall structure than in that of the Kaskapau species.

REOPHAX sp. B.

Plate 3, figure 9

Test rather large, robust, cylindrical in cross section, consisting of two to three chambers in straight series; chambers subglobular, about same size, somewhat constricted, terminal chamber extended in a neck-like projection; sutures fairly distinct, transverse, deeply depressed; wall agglutinated, of coarse quartz, chert and other grains, with little cement, surface very rough; aperture simple, at the end of the neck-like extension.

Length of figured specimen, 1.09 mm.; greatest width, 0.39 mm.

Locality of figured specimen: JW-58-3, Smoky River, Alberta, from the Kaskapau shale, 24 feet below the top of the Bad Heart sand.

Repository: Res. Coun. Alberta Micropaleont. Type Coll.

Occurrence: This species was observed in the Kaskapau shale in the interval 24 to 54 feet below the top of the Bad Heart sand. It is rare except for the presence of a suite of 11 specimens in one sample obtained a few feet below the base of the Bad Heart sand. Only one specimen was obtained from the Puskwaskau shale, about 14 feet above the Bad Heart sand.

Remarks: As the wall structure in this form is identical with that of *Reophax* sp. A, the two may represent only one species. The robust test and large subglobular chambers of *Reophax* sp. B would seem, however, to justify its assignment to a separate taxonomic unit.

Family TOLYPAMMINIDAE

Genus INVOLUTINA Terquem, 1862

INVOLUTINA sp.

Plate 3, figures 1, 2; Plate 4, figures 1-5

Test medium size, discoidal, planispiral, composed of proloculum and long, undivided tube making three coils around proloculum; tube increasing gradually in diameter in earlier whorls but widening rather sharply in ultimate whorl; coiling generally regular with the exception of some slight overlapping of final coil; spiral suture somewhat obscure in most specimens, depressed; wall finely arenaceous in most specimens, moderate amount of cement giving fairly smooth appearance; large mineral grains to 0.17 mm. in diameter protruding in some specimens (pl. 3, figs. 1, 2); aperture formed by the open end of the tube.

Greatest diameter of specimen (pl. 3, figs. 1, 2), 0.78 mm.; least diameter, 0.66 mm.; thickness, 0.12 mm.

Greatest diameter of specimen (pl. 4, figs. 1, 2), 0.51 mm.; thickness, 0.08 mm.

Greatest diameter of specimen (pl. 4, figs. 3-5), 0.45 mm.; thickness, 0.08 mm.

Locality of specimen (pl. 3, figs. 1, 2): JW-58-3, Smoky River, Alberta, from the Kaskapau shale, 31 feet below the top of the Bad Heart sand.

Locality of specimens (pl. 4, figs. 1-5): as above, from two samples of the Puskwaskau shale. The specimens illustrated as figures 1-2 and 3-5 are from 54 and 81 feet, respectively, above the top of the Bad Heart sand.

Repository: Res. Coun. Alberta Micropaleont. Type Coll.

Occurrence: This species seems more characteristic of the Puskwaskau shale with the largest number of specimens (26) recorded at 81 feet above

the Bad Heart sand. In the Kaskapau shale, this species appears restricted mainly to the interval 23 to 32 feet below the top of the Bad Heart sand, where individuals with protruding coarse mineral grains and rough exteriors are concentrated.

Remarks: There is considerable variation in the size and wall structure of this species. Many of the specimens appear to have been deformed and flattened on fossilization. The pre-Bad Heart individuals, in general, are coarser-grained with rough exteriors.

This species shows a resemblance to *Ammodiscus pennyi* Cushman and Jarvis from the Upper Cretaceous of Trinidad in the small number of coils and general outline, but the latter is much larger and thicker.

Family LITUOLIDAE

Genus HAPLOPHRAGMOIDES Cushman, 1910

HAPLOPHRAGMOIDES COLLYRA Nauss

Plate 3, figures 16-19

Haplophragmoides collyra Nauss, 1947, Jour. Paleont., vol. 21, no. 4, p. 337-338, pl. 49, figs. 2 a-b, 5.

Test planispiral, party evolute with portion of penultimate whorl and, in some specimens, parts of all whorls visible; periphery broadly rounded in undeformed specimens, small to moderate umbilicus developed; seven to ten chambers in ultimate whorl, somewhat inflated, subglobular, but in most specimens flattened by compression and scalloped in some (fig. 19); sutures fairly distinct, slightly thickened, straight or nearly straight, slightly depressed; wall finely arenaceous, of grains averaging 0.01 mm. in diameter, with much cement giving smooth finish; aperture a rather broadly arched opening at the base of the terminal face.

Maximum diameter of hypotype (figs. 16, 17), 0.56 mm.; minimum diameter, 0.47 mm.; maximum thickness, 0.16 mm.

Maximum diameter of hypotype (figs. 18, 19), 0.76 mm.; minimum diameter, 0.62 mm.; maximum thickness, 0.16 mm.

Locality of hypotypes: JW-58-3, Smoky River, Alberta, from the Kaskapau shale, 155 to 160 feet below the top of the Bad Heart sand.

Repository: Res. Coun. Alberta Micropaleont. Type Coll.

Occurrence: At locality JW-58-3, this species occurs throughout the upper Kaskapau and the Puskwaskau shales. It is common to abundant in the interval 107 to 160 feet below the top of the Bad Heart sand, where it is the dominant foraminifer. In the Puskwaskau shale, it is common in the interval 65 to 98 feet above the Bad Heart sand. The base of the

first (upper) white-speckled shale "zone" was recorded at about 111 feet above the top of the Bad Heart sand at this locality.

Nauss (1947, p. 330) indicated this species to be characteristic of the central part of the Lloydminster shale of east-central Alberta. Its occurrence in the Puskwaskau and Kaskapau shales below the upper white-speckled shale "zone" is thus in nearly stratigraphically equivalent beds. This species is, however, not easily differentiated from several similar species which range through much of the Cretaceous sequence in Western Canada, and hence is of limited value in correlation work.

HAPLOPHRAGMOIDES COLLYRA BULLOCKI
Stelck and Wall

Plate 3, figures 13-15

Haplophragmoides collyra bullocki Stelck and Wall, 1955, Res. Coun. Alberta Rept. 70, p. 46-47, pl. 2, figs. 24a-26; pl. 3, figs. 31, 32, 38, 39.

Test planispiral, close-coiled but slightly evolute, periphery broadly rounded except in strongly compressed or deformed specimens; chambers somewhat inflated originally but subsequently flattened in most specimens, seven to nine in ultimate whorl; sutures rather indistinct, slightly curved, depressed; wall arenaceous, grains averaging about 0.04 mm. in diameter, moderate amount of cement failing to cover all of the grains resulting in a rather rough exterior; aperture an arched opening at the base of the terminal face, obscure in most specimens.

Maximum diameter of specimen (fig. 13), 0.56 mm.; minimum diameter, 0.41 mm.; maximum thickness, 0.19 mm.

Maximum diameter of specimen (figs. 14, 15), 0.68 mm.; minimum diameter, 0.56 mm.; maximum thickness 0.14 mm.

Locality of hypotypes: JW-58-3, Smoky River, Alberta, from two samples of the Kaskapau shale. The specimens illustrated as figures 13 and 14-15 are from 113 and 146 feet, respectively, below the top of the Bad Heart sand.

Repository: Res. Coun. Alberta Micropaleont. Type Coll.

Occurrence: *H. collyra bullocki* was recorded only from the Kaskapau shale at locality JW-58-3, where it occurs sporadically in the interval 108 to 160 feet (base of sampled section) below the top of the Bad Heart sand. It appears again higher in the Kaskapau as some large individuals were observed a few feet below the Bad Heart sand. This variety was described originally from the lower and central parts of the Kaskapau formation at

Spirit River. Its occurrence in the upper part of the Kaskapau formation marks an upward extension of its vertical range.

Remarks: As noted by Stelck and Wall (op. cit.), this variety may be distinguished from similar forms by its rather coarsely arenaceous wall and rough exterior.

HAPLOPHRAGMOIDES KIRKI Wickenden

Plate 3, figures 11, 12; Plate 4, figures 10, 11

Haplophragmoides kirki Wickenden, 1932b, Trans. Roy. Soc. Can., 3rd ser., vol. 26, sec. IV, p. 85-86, pl. 1, figs. 1a-c.

Haplophragmoides kirki Wickenden. Cushman, 1946, U.S. Geol. Surv. Prof. Paper 206, p. 21-22, pl. 2, figs. 23a-c.

Test small, planispiral, close-coiled, involute; periphery fairly broad and rather well-rounded; chambers somewhat inflated, of equal size, four and one-half to five and one-half in ultimate whorl; sutures fairly distinct, straight, slightly depressed; wall arenaceous, of mostly fine material but with grains to 0.03 mm. in diameter, moderate amount of cement, smooth; aperture a low arched opening at the base of the terminal face.

Maximum diameter of hypotype (pl. 3, figs. 11, 12), 0.31 mm.; maximum thickness, 0.19 mm.

Maximum diameter of hypotype (pl. 4, figs. 10, 11), 0.43 mm.; minimum diameter, 0.35 mm.; maximum thickness, 0.23 mm.

Locality of hypotype (pl. 3, figs. 11, 12): JW-58-3, Smoky River, Alberta, from the Kaskapau shale, 84 feet below the top of the Bad Heart sand.

Locality of hypotype (pl. 4, figs. 10, 11): as above, from the Puskwaskau shale, 87 feet above the top of the Bad Heart sand.

Repository: Res. Coun. Alberta Micropaleont. Type Coll.

Occurrence: At locality JW-58-3, this species was recorded sporadically in both the Kaskapau and Puskwaskau shales through an interval from the base of the sampled section (160 feet below the top of the Bad Heart sand) to 87 feet above the Bad Heart.

This species is known from higher stratigraphic levels in other areas of Western Canada. The holotype was obtained from the Bearpaw shale of southern Alberta. Wickenden (op. cit.) has also reported the species from the Lea Park and Pakowki formations of southern Alberta and Saskatchewan, and from the Riding Mountain formation of Manitoba.

HAPLOPHRAGMOIDES sp. cf. *H. LINKI* Nauss

Plate 4, figures 12-15

?*Haplophragmoides linki* Nauss, 1947, Jour. Paleont., vol. 21, no. 4, p. 339, pl. 49, figs. 7a-b.

Test planispiral, rather close-coiled but slightly evolute, moderately umbilicate, periphery broadly rounded; chambers somewhat inflated, of equal size, seven to nine in ultimate whorl; sutures rather indistinct in most specimens, straight or nearly straight, flush to very slightly depressed; wall arenaceous, of mostly fine material but with grains to 0.025 mm. in diameter, considerable cement, smooth; aperture an inconspicuous low arched slit at base of terminal face.

Maximum diameter of specimen (figs. 12, 13), 0.35 mm.; minimum diameter, 0.31 mm.; maximum thickness, 0.16 mm.

Maximum diameter of specimen (figs. 14, 15), 0.37 mm.; minimum diameter, 0.31 mm.; maximum thickness, 0.16 mm.

Locality of figured specimens: JW-58-3, Smoky River, Alberta, from the Puskwaskau shale, 87 feet above the top of the Bad Heart sand.

Repository: Res. Coun. Alberta Micropaleont. Type Coll.

Occurrence: This species occurs sporadically in the Kaskapau and Puskwaskau shales at locality JW-58-3. It is common in the interval 73 to 87 feet above the Bad Heart sand.

Remarks: The main difference between this species and *H. linki* is the tendency of the former to become evolute. The sutures in this species are less distinct than in *H. linki*, but this may well be attributed to the usually inferior preservation of outcrop material. Although Nauss listed the involute nature of the coiling as a specific character of *H. linki*, the present author doubts whether partly evolute forms, that are similar in all other respects to *H. linki*, should be excluded from that species. The author has examined large populations of *Haplophragmoides* in the lower member of the Colorado shale of central Alberta from which Nauss obtained his type material, and has observed all gradations between involute individuals of the *H. linki* "class" and completely evolute specimens that in other respects were identical with *H. linki*. Although this problem necessitates much further statistical study, it is obvious that great difficulty may be expected when attempts are made to assign specimens to some of these previously described species of *Haplophragmoides*. The number of legitimate species is probably about half of the number published.

HAPLOPHRAGMOIDES sp. cf. *H. rota* Nauss

Plate 4, figures 6-9

?*Haplophragmoides rota* Nauss, 1947, Jour. Paleont., vol. 21, no. 4, p. 339, pl. 49, figs. 1a-b, 3a-b.

Test planispiral, nearly involute, somewhat scaphitoid in outline, slightly umbilicate, periphery truncate with rounded edges in undeformed specimens, periphery angular in crushed specimens (figs. 8, 9); chambers triangular in outline, seven to nine in mature specimens, gradually increasing in size, in most specimens flattened by compression and scalloped on one or both sides; sutures somewhat indistinct to fairly distinct, straight, radial, flush with surface or slightly depressed; wall arenaceous, grains averaging about 0.015 mm. in diameter with maximum of 0.04 mm., moderate amount of cement, smooth; aperture a low arched opening at the base of the terminal face, not readily visible.

Maximum diameter of specimen (figs. 6, 7), 0.70 mm., minimum diameter, 0.55 mm.; maximum thickness, 0.29 mm.

Maximum diameter of specimen (figs. 8, 9), 0.62 mm.; minimum diameter, 0.51 mm.; maximum thickness, 0.12 mm.

Locality of figured specimens: JW-58-3, Smoky River, Alberta, from two samples of the Puskwaskau shale. The specimens illustrated as figures 6-7 and 8-9 are from 24 and 34 feet, respectively, above the top of the Bad Heart sand.

Repository: Res. Coun. Alberta Micropaleont. Type Coll.

Occurrence: At locality JW-58-3, this species is present in both the Kaskapau and Puskwaskau shales. It was recorded in the interval from 88 feet below the top of the Bad Heart sand to 60 feet above it, and probably is the dominant foraminifer in parts of this section.

Remarks: Undeformed individuals of this species differ from *H. rota* Nauss in being less compressed and in having a more scaphitoid outline. The crushed individuals of this Smoky River species seem indistinguishable from flattened specimens of *H. rota* such as the paratype figured by Nauss. In this regard, crushed individuals of both *H. collyra* and *H. rota* look somewhat alike, but may usually be separated artificially on the basis of the evolute tendency of *H. collyra*.

Genus AMMOMARGINULINA Wiesner, 1931

AMMOMARGINULINA sp.

Plate 3, figures 3, 4

Test medium size, compressed, consisting of a coiled portion only; test evolute with proloculum and the three whorls of chambers exposed; chambers indistinct, seven in final whorl, rather lobate; sutures indistinct, straight, depressed; wall arenaceous, grains averaging about 0.025 mm. in diameter, moderate amount of cement, surface somewhat rough; aperture an elongated opening on the terminal face.

Maximum diameter of figured specimen, 0.66 mm.; minimum diameter, 0.60 mm.; maximum thickness, 0.10 mm.

Locality of figured specimen: JW-58-3, Smoky River, Alberta, from the Kaskapau shale, 84 feet below the top of the Bad Heart sand.

Repository: Res. Coun. Alberta Micropaleont. Type Coll.

Occurrence: Most specimens of this species were obtained from the Kaskapau shale in the interval 69 to 88 feet below the top of the Bad Heart sand. It occurs rarely in the Puskwaskau shale, where it was observed in two samples from 81 and 87 feet above the Bad Heart.

Remarks: The author has not encountered any similar species in the literature of North American Cretaceous Foraminifera. Publication of a new name probably is warranted, but this can well await acquisition of additional suites.

Family TEXTULARIIDAE

Genus TEXTULARIA Defrance, 1824

TEXTULARIA ROLLAENSIS Stelck and Wall

Plate 4, figures 16-19

Textularia rollaensis Stelck and Wall, 1954, Res. Coun. Alberta Rept. 68, p. 30-31, pl. 1, fig. 17.

Textularia rollaensis Stelck and Wall, 1955, Res. Coun. Alberta Rept. 70, p. 55, pl. 2, figs. 34, 35.

Test elongate, tapering, compressed; about 12 chambers in an interlocking biserial arrangement, regularly increasing in size with last two pairs comprising nearly half of length of test; sutures distinct, oblique, depressed; wall finely arenaceous with much cement, smooth; aperture, a prominent notch at the inner margin of the last-formed chamber, extending well up onto the terminal face.

Length of hypotype (figs. 16, 17), 0.53 mm.; maximum width, 0.19 mm.; thickness, 0.10 mm.

Length of hypotype (figs. 18, 19), 0.58 mm.; maximum width, 0.19 mm.; thickness, 0.10 mm.

Locality of hypotypes: JW-58-3, Smoky River, Alberta, from the Puskwaskau shale, 73 feet above the top of the Bad Heart sand.

Repository: Res. Coun. Alberta Micropaleont. Type Coll.

Occurrence: This species occurs sporadically at locality JW-58-3 through the interval from the base of the sampled section, 160 feet below the top of the Bad Heart sand, to 77 feet above the Bad Heart. It is abundant in a short interval in the Puskwaskau shale from 73 to 78 feet above the Bad Heart.

The previously reported occurrences of this species (Stelck and Wall, 1954, p. 31) are in older beds (late Cenomanian) of the lower and central parts of the Kaskapau formation. From this newly reported occurrence on the Smoky River, the vertical range of *T. rollaensis* is thus extended upwards into Coniacian and Santonian beds.

Remarks: The Smoky River specimens apparently lack the twisted early portions of the types, although many of the former suite have their initial ends broken and these may have been slightly twisted. On the basis of partial specimens obtained at the Smoky River locality, this species attained here twice the size of type area specimens. These differences would seem, however, to fall within the scope of individual variability for a species.

Family VERNEULINIDAE

Genus VERNEULINOIDES Loeblich and Tappan, 1949

VERNEULINOIDES BEARPAWENSIS (Wickenden)

Plate 4, figures 20, 21

Verneulina bearpawensis Wickenden, 1932b, Trans. Roy. Soc. Can., 3rd ser., vol. 26, sec. IV, p. 87, pl. 1, fig. 8.

Verneulina bearpawensis Wickenden, Cushman, 1937, Cushman Lab. Foram. Res. Spec. Pub. 7, p. 13, pl. 1, fig. 18.

Verneulina bearpawensis Wickenden, Cushman, 1946, U.S. Geol. Surv. Prof. Paper 206, p. 31, pl. 7, figs. 4-6c.

Test rather elongate, tapering, nearly circular in transverse section; test composed of four to five convolutions of three chambers each, arranged in a *Buliminella*-like spiral, maximum width near apertural end of test;

chambers somewhat inflated, increasing rather rapidly in size in early whorls with more gradual increase in later whorls; sutures distinct, depressed; wall finely arenaceous with much cement, smooth; aperture a rather highly arched opening at the base of the last-formed chamber, infilled or otherwise obscured in most specimens; color generally brownish.

Length of hypotype (fig. 20), 0.47 mm.; maximum width, 0.19 mm.

Length of hypotype (fig. 21), 0.41 mm.; maximum width, 0.21 mm.

Locality of hypotypes: JW-58-3, Smoky River, Alberta, from two samples of the Puskwaskau shale. The specimens illustrated as figures 20 and 21 are from 31 and 87 feet, respectively, above the top of the Bad Heart sand.

Repository: Res. Coun. Alberta Micropaleont. Type Coll.

Occurrence: This species is characteristic of the Puskwaskau shale at locality JW-58-3, where it was recorded from just above the Bad Heart sand upwards to about 25 feet below the first (upper) white-speckled shale "zone". It is fairly common through most of the upper portion of this interval, from 30 feet above the Bad Heart. This species is very rare in the Kaskapau shale at the same locality with only four specimens being obtained from three samples below the Bad Heart.

The occurrences of *V. bearpawensis* reported from other areas are from stratigraphic levels somewhat higher than the Smoky River occurrence. The species seems to have had a fairly long vertical range. The type level and locality of the species is the Bearpaw shale of southern Alberta which is late Campanian or late Montanan in age. The species has been identified in early Montanan beds from the upper part of the Lea Park formation in eastern Alberta by Wickenden (1941, p. 154). Its occurrence in the Puskwaskau shale marks a further downward extension of its known range into late Coloradoan beds.

The geographic range of the species is quite wide as Cushman (1946) illustrated it from the Ripley formation of Navarro age in Tennessee.

Family VALVULINIDAE

Genus DOROTHIA Plummer, 1931

DOROTHIA SMOKYENSIS Wall, n. sp.

Plate 4, figures 22-28

Gaudryina filiformis Wickenden, 1932a (not of Berthelin, 1880), Jour. Paleont., vol. 6, no. 2, p. 205, pl. 29, fig. 4.

Test rather stubby to elongate, fairly robust, broadly ovoid in transverse section, twisted slightly; early portion of test small and rather indistinct,

of about four whorls beginning with at least four chambers per whorl and reducing to three per whorl; later adult portion distinct, of three to nine pairs, with an average of five pairs of chambers in an interlocking biserial arrangement, the last two chambers added uniserially in a few specimens; chambers in later portion gradually increasing in size as added, becoming progressively more inflated toward apertural end; sutures in later portion distinct, nearly horizontal, depressed; wall finely arenaceous with much cement, smooth; aperture a rather highly arched opening at the base of the inner margin of the last-formed chamber, becoming terminal in individuals with definite uniserial final chamber.

Length of holotype (figs. 26, 27), 0.66 mm.; maximum width, 0.19 mm.; thickness of biserial portion, 0.14 mm.

Length of paratype (figs. 22, 23), 0.35 mm.; maximum width, 0.17 mm.; thickness of biserial portion, 0.12 mm.

Length of paratype (figs. 24, 25), 0.51 mm.; maximum width, 0.17 mm.; thickness of biserial portion, 0.14 mm.

Length of paratype (fig. 28), 0.90 mm.; maximum width, 0.19 mm.; thickness of biserial portion, 0.16 mm.

Type locality: JW-58-3, Smoky River, Alberta, from the Puskwaskau shale, 87 feet above the top of the Bad Heart sand.

Repository: Res. Coun. Alberta Micropaleont. Type Coll.

Occurrence: This species is present in both the Kaskapau and Puskwaskau shales at locality JW-58-3. The specimens are flattened and poorly preserved through most of the sampled section, but in a short interval of the Puskwaskau shale from 80 to 94 feet above the Bad Heart sand, partially pyritized undeformed specimens are abundant. At the Bad Heart River locality of JW-58-2, this species is present but rather rare in the Puskwaskau shale just below the first (upper) white-speckled shale "zone".

Wickenden (op. cit.) recorded this species in the upper part of the Alberta shale of southern Alberta, which is the approximate stratigraphic equivalent of the sampled section at the Smoky River locality.

Remarks: This species is similar to *G. filiformis* Berthelin from the Albian of France, but the finish of the latter species was reported as very rough, whereas *D. smokyensis*, n. sp., is smooth. The author's sketch of the basal view of *G. filiformis* shows only three chambers to the whorl in the initial portion, whereas there are more than three in the earliest whorls of *D. smokyensis*, n. sp.

There is considerable variation in the size and chamber pattern in this new species. About three-quarters of a population of 200 fairly well-preserved individuals at the type locality have from three to five pairs of biserial chambers. From one-fifth to one-quarter of this population have an elongate biserial portion of six or more pairs of chambers. In about 2 per cent of the population, the last two chambers are added uniserially and the aperture is terminal.

It has not been determined whether a megalospheric-microspheric relationship or a trimorphic series is represented in this material because of the poor preservation of the earliest parts of the tests. There are, however, various gradations between the specimens figured and it seems that they constitute probably only one species.

The species is named from its occurrence on the Smoky River, the type locality of the species.

DOROTHIA sp.

Plate 3, figures 5-7

Test short to rather elongate, somewhat tapering, not strongly compressed, broadly ovoid in transverse section; early portion of test indistinct, of two to three whorls beginning with four to five chambers per whorl and reducing to three per whorl; later adult portion of test fairly distinct, biserial, of about four pairs of interlocking chambers becoming progressively more inflated toward apertural end, sutures in biserial portion faint to fairly distinct, depressed; wall rather coarsely arenaceous, amount of cement not great, exterior somewhat rough; aperture a deep notch at the base of the inner margin of the last-formed chamber, extending about half-way up the terminal face, visible in very few specimens.

Length of specimen (figs. 5, 6), 0.64 mm.; maximum width, 0.27 mm.; thickness, 0.19 mm.

Length of specimen (fig. 7), 0.60 mm.; maximum width, 0.25 mm.; thickness, 0.17 mm.

Locality of figured specimens: JW-58-3, Smoky River, Alberta, from two samples of the Kaskapau shale. The specimens illustrated as figures 5-6 and 7 are from 108 and 115 feet, respectively, below the top of the Bad Heart sand.

Repository: Res. Coun. Alberta Micropaleont. Type Coll.

Occurrence: This species is common in the Kaskapau shale at locality JW-58-3 from the base of the sampled section (160 feet below the top of

the Bad Heart sand) upwards to within 64 feet of the top of the Bad Heart, where it disappears.

Remarks: This species appears somewhat like the type figure of *Gaudryina rudita* Sandidge from the Upper Cretaceous of Alabama in that both have a similar chamber arrangement in the later portion and rough exteriors. A comparison made with specimens referred to *G. rudita* in the U.S. National Museum Collections showed these to have more expansive chambers and much smoother finishes than the Kaskapau species. The author has not seen the holotype of *G. rudita* but suspects it is considerably different from the specimens which had been referred to the species. Further comparative study is necessary to determine whether this Kaskapau species should be proposed as new.

Family TROCHAMMINIDAE

Genus TROCHAMMINA Parker and Jones, 1859

TROCHAMMINA RIBSTONENSIS Wickenden

Plate 5, figures 7-12

Trochammina ribstonensis Wickenden, 1932b, Trans. Roy. Soc. Can., 3rd ser., vol. 26, sec. IV, p. 90-91, pl. 1, figs. 12a-c.

Trochammina ribstonensis Wickenden. Cushman, 1946, U.S. Geol. Surv. Prof. Paper 206, p. 50, pl. 15, figs. 9a-c.

Trochammina ribstonensis Wickenden. Nauss, 1947, Jour. Paleont., vol. 21, no. 4, p. 340, pl. 49, figs. 6a-c.

Test small, periphery subangular to narrowly rounded, the margin slightly lobulate; test trochoid with low spiral development of three whorls, ventral side with rather wide and prominent umbilicus; chambers very gradually enlarging in size from the proloculum, subglobular, six to nine in ultimate whorl, all chambers visible from dorsal side, only those of final whorl visible ventrally; sutures depressed, slightly curved on dorsal side, nearly straight and radial on ventral side; wall finely arenaceous with considerable cement, smooth; aperture a low arched slit on the inner margin of the ventral side of the last-formed chamber, not apparent in most specimens.

Maximum diameter of hypotype (figs. 7-9), 0.27 mm.; maximum thickness, 0.10 mm.

Maximum diameter of hypotype (figs. 10-12), 0.17 mm.; maximum thickness, 0.06 mm.

Locality of hypotype (figs. 7-9): JW-58-3, Smoky River, Alberta, from the Puskwaskau shale, 81 feet above the top of the Bad Heart sand, or about 30 feet below the first (upper) white-speckled shale "zone".

Locality of hypotype (figs. 10-12): JW-58-2, Bad Heart River, Alberta, from the Puskwaskau shale, 2 feet above the first (upper) white-speckled shale "zone".

Repository: Res. Coun. Alberta Micropaleont. Type Coll.

Occurrence: In the Smoky River area, this species is restricted to the Puskwaskau shale, where it occurs in association with the first or upper white-speckled shale "zone". At locality JW-58-3, the species occurs fairly commonly for about 40 feet below the lowest recorded occurrence of this "zone". There are a few poorly preserved specimens in the few feet of white-speckled shale exposed at the top of the sampled section at this locality. At the Bad Heart River locality, this species is common for 22 feet above the highest recorded occurrence of the first white-speckled shale. It is present here as well in the 17-foot zone of speckled shale and in the five feet underlying the "zone" down to the base of the sampled section.

Nauss (op. cit.) stated that *T. ribstonensis* is restricted to the lower 40 feet of the Lea Park shale in the Vermilion area of east-central Alberta. The base of the Lea Park formation is drawn at the highest occurrence of the first or upper white-speckled shale "zone", which is also regarded as the division between the Colorado and Montana groups. With this newly reported occurrence of *T. ribstonensis* from the Peace River area, the geographic range of the species is extended considerably and its usefulness in the recognition of basal Lea Park equivalents becomes even more apparent.

TROCHAMMINA WETTERI Stelck and Wall

Plate 5, figures 1-6

Trochammina wetteri (nomen nudum), 1954, Res. Coun. Alberta Rept. 68, p. 10, 11, 13.
Trochammina wetteri Stelck and Wall, 1955, Res. Coun. Alberta Rept. 70, p. 59-60,
 pl. 2, figs. 1-3, 6a-c.

Test medium size, periphery fairly broad and round, lobate in side view; test trochoid with rather low spiral development of about three whorls, ventral side with prominent umbilicus; four to five chambers in final whorl much larger than those in earlier whorls, inflated, globigerinoid, all chambers visible from dorsal side, only those of ultimate whorl visible

ventrally; sutures fairly distinct, strongly depressed, very slightly curved dorsally, straight ventrally; wall finely arenaceous with considerable cement, smooth; aperture rarely visible, a rather broadly arched opening on the ventral side in the middle of the base of the terminal chamber, opening into umbilicus.

Maximum diameter of hypotype (figs. 1-3), 0.29 mm.; minimum diameter, 0.27 mm.; maximum thickness, 0.16 mm.

Maximum diameter of hypotype (figs. 4, 5), 0.29 mm.; minimum diameter, 0.27 mm.; maximum thickness, 0.17 mm.

Maximum diameter of hypotype (fig. 6), 0.35 mm.; minimum diameter, 0.31 mm.; maximum thickness, 0.17 mm.

Locality of hypotypes: JW-58-3, Smoky River, Alberta, from the Puskwaskau shale, 86 to 91 feet above the top of the Bad Heart sand.

Repository: Res. Coun. Alberta Micropaleont. Type Coll.

Occurrence: This species was found in only the Puskwaskau shale at locality JW-58-3. It occurs in the interval from 69 to 94 feet above the Bad Heart and is fairly common from 80 to 94 feet above it. A large number of flattened specimens of *Trochammina* observed between 94 and 103 feet above the Bad Heart may belong to this species.

Stelck and Wall (1955, p. 59) reported this species as common in the lower Kaskapau formation of late Cenomanian age in the subsurface at Spirit River, Alberta. Its presence in the Puskwaskau shale shows a recurrence of the species in considerably younger beds.

Remarks: Some of the Smoky River specimens as shown by figure 6 have more inflated, globigerinoid chambers than the types from Spirit River, but this feature seems to come within the range of intraspecific variation.

Family HETEROHELICIDAE
Genus GÜMBELINA Egger, 1899
GÜMBELINA sp.

Plate 5, figures 23-30

Test small, elongate, compressed, initial end very slightly twisted and bluntly pointed; periphery rounded, faintly lobate; chambers biserial, six to nine pairs present, earliest chambers very small, later chambers increasing regularly in size and partially inflated but not globular; sutures distinct,

depressed, somewhat oblique; wall calcareous, finely perforate, smooth; aperture a highly arched opening at the base of the last-formed chamber, rarely with faint lip.

Length of specimen (figs. 23, 24), 0.33 mm.; maximum width, 0.11 mm.; maximum thickness, 0.07 mm.

Length of specimen (figs. 25, 26), 0.21 mm.; maximum width, 0.09 mm.; maximum thickness, 0.07 mm.

Length of specimen (figs. 27, 28), 0.21 mm.; maximum width, 0.10 mm.; maximum thickness, 0.07 mm.

Length of specimen (figs. 29, 30), 0.33 mm.; maximum width, 0.12 mm.; maximum thickness, 0.09 mm.

Locality of specimens (figs. 23-26): JW-58-3, Smoky River, Alberta, from the Puskwaskau shale, 94 feet above the top of the Bad Heart sand, or about 17 feet below the first (upper) white-speckled shale "zone".

Locality of specimens (figs. 27-30): JW-58-2, Bad Heart River, Alberta, from the Puskwaskau shale, in the first (upper) white-speckled shale "zone".

Repository: Res. Coun. Alberta Micropaleont. Type Coll.

Occurrence: This species occurs in the Puskwaskau shale and is associated with the first (upper) white-speckled shale "zone" at the Bad Heart River and Smoky River localities. At the latter locality, it was observed in one sample 17 feet below the lowest recorded occurrence of the upper white-speckled shale. It is common in the washed material of minus 120 mesh.

Remarks: The considerable difference in size between the figured specimens seems to indicate the presence of more than one taxonomic unit or a megalospheric-microspheric relationship. However, as the earlier portions of the tests are not significantly different, and as there are all gradations in size between the specimens figured, they probably represent only one species.

The chambers of this species are more compressed than in typical *Gümbelina* and in this respect it is somewhat reminiscent of *Bolivina*, although it lacks the extreme compression and angularity normally associated with the latter. The species is left unnamed pending further study of related forms from other areas of North America.

The author is aware of the revision of the family Heterohelicidae by Gallitelli (1957) in which the genus *Gümbelina* was suppressed as a

junior synonym of *Heterohelix* Egger. The observation that one-quarter of the individuals in certain populations (from unidentified localities) of *G. globulosa* (Ehrenberg), the type species of *Gümbelina*, have initial coils like *Heterohelix* seems to have been the main basis for this action. The inference one may draw is that species previously referred to *Gümbelina* now must be assigned to either *Heterohelix* or *Chiloguembelina* Loeblich and Tappan. The present author contends that insufficient evidence has been presented to justify suppression of the name *Gümbelina*. Also, the author has examined more than 200 individuals of this species from the Bad Heart and Smoky River localities and did not observe any with an initial coil, although in such a number of specimens, one would reasonably expect this feature in a few individuals if this species belongs to *Heterohelix*. The genus *Chiloguembelina* is biserial throughout but has an asymmetrical aperture commonly with flap (Loeblich and Tappan, 1956). The apertures in the specimens from the Puskwaskau shale are highly arched openings, which are symmetrical and generally simple, although an inconspicuous lip is developed in a very few specimens.

Genus GÜMBELITRIA Cushman, 1933

GÜMBELITRIA sp.

Plate 3, figure 8

Gümbelitria cretacea Stelck and Wall, 1954 (not of Cushman, 1933), Res. Coun. Alberta Rept. 68, p. 23, pl. 2, figs. 23, 24.

Test small, tapering rather sharply, rounded triangular in cross section; test triserial, of about six whorls of chambers; chambers low and very gradually enlarging in early whorls, inflated and rapidly increasing in size in last two whorls; sutures fairly distinct, depressed; wall calcareous, finely perforate; aperture a low arched opening at the inner margin of the last chamber.

Length of figured specimen, 0.21 mm.; maximum width, 0.12 mm.

Locality of figured specimen: JW-58-3, Smoky River, Alberta, from the Kaskapau shale, 84 feet below the top of the Bad Heart sand.

Repository: Res. Coun. Alberta Micropaleont. Type Coll.

Occurrence: This species was found in only the sample yielding the figured specimen and the sample directly below in the Kaskapau shale at locality JW-58-3. Because of its very small size, *Gümbelitria* sp. was seen only in the fine fraction of the washed residues, that is, in the minus 120 mesh material. Although apparently rather rare, the species may well have a wider

distribution than indicated, because of the difficulty of observing it in the residues.

Stelck and Wall (op. cit.) have recorded this species from a lower level in the Kaskapau formation at Spirit River, Alberta, where it is common in Turonian beds below the lower (second) white-speckled shale "zone".

Remarks: It appears that the specimen which Stelck and Wall (op. cit.) referred to *G. cretacea* Cushman is probably not referable to that species. *G. cretacea* seems to have more strongly inflated or globular chambers and a larger aperture than these Alberta specimens.

A species which Fox (1954) described from the upper unit of the Greenhorn formation of South Dakota, *Bulimina wyomingensis*, seems close to this species of *Gümbelitra*, although the present author has not made direct comparison of the two.

Family BULIMINIDAE

Genus NEOBULIMINA Cushman and Wickenden, 1928

NEOBULIMINA sp.

Plate 5, figures 15-22

Test small, elongate, twisted, greatest width about one-third the distance from apertural end, tapering slightly toward initial end; early portion of test triserial, of about three whorls comprising from one-third to one-half of length of test, later portion biserial, of two to three whorls; chambers in triserial portion wider than high, in biserial portion longer than wide and inflated; sutures distinct, strongly depressed; wall calcareous, medium perforate, smooth; aperture a highly arched opening in a large oval depression in the inner face of the terminal chamber.

Length of specimen (figs. 15, 16), 0.21 mm.; maximum width, 0.08 mm.

Length of specimen (figs. 17, 18), 0.21 mm.; maximum width, 0.12 mm.

Length of specimen (figs. 19, 20), 0.27 mm.; maximum width, 0.09 mm.

Length of specimen (figs. 21, 22), 0.27 mm., maximum width, 0.10 mm.

Locality of specimens (figs. 15-18): JW-58-2, Bad Heart River, Alberta, from the Puskwaskau shale, in the first (upper) white-speckled shale "zone".

Locality of specimens (figs. 19-22): JW-58-3, Smoky River, Alberta, from the Puskwaskau shale, 94 feet above the top of the Bad Heart sand, or about 17 feet below the first (upper) white-speckled shale "zone".

Repository: Res. Coun. Alberta Micropaleont. Type Coll.

Occurrence: This species was found in only the two samples from which the figured specimens were obtained. It was observed in only the fine fractions of the sample residues, that is in the minus 120 mesh material, where it is fairly common.

Remarks: This species differs from *N. canadensis* Cushman and Wickenden, described originally from the Lea Park shale of east-central Alberta, in having much longer chambers in its biserial portion.

The present author has noticed a similarity in the elongate biserial chambers of this species and of one referred to *N. canadensis* by Cushman (1946, pl. 52, figs. 12a-b) from the lower part of the Taylor marl of Texas. It is apparent, however, that a number of Cretaceous species of *Neobulimina* from the Gulf Coast region of the United States, which have been referred to *N. canadensis*, are quite different from the holotype of that species. The species in its broad sense has been reported from nearly the entire Upper Cretaceous sequence of Texas (Frizzell, 1954).

This species of *Neobulimina* from the Smoky River area probably is new. The specimens from the Smoky River locality, however, are pyritized and very fragile, and not suitable for selection as types of a new species. The specimens from the Bad Heart River locality are generally smaller than those from the Smoky River locality and have triserial portions occupying half or more of the tests. They probably constitute a population dominated by megalospheric individuals.

Family GLOBIGERINIDAE
Genus GLOBIGERINA d'Orbigny, 1826
GLOBIGERINA ASPERA (Ehrenberg)

Plate 5, figures 13, 14

- Phanerostomum asperum* Ehrenberg, 1854, Mikrogeologie, Leipzig, Deutschland, p. 23, pl. 30, figs. 26a-b; pl. 32 (group 1), fig. 24; pl. 32 (group 2), fig. 42.
Globigerinella aspera (Ehrenberg). Loetterle, 1937, Nebraska Geol. Surv., Bull. 12, 2nd ser., p. 45-46, pl. 7, figs. 4a-b (synonymy).
Globigerinella aspera (Ehrenberg). Nauss, 1947, Jour. Paleont., vol. 21, no. 4, p. 337, pl. 48, figs. 9a-b.

Test rather small, planispiral, evolute with proloculum exposed followed by two whorls of chambers; periphery rounded, lobate; six chambers in ultimate whorl, enlarging fairly rapidly, the last three much

larger and more inflated than previous chambers; sutures distinct, depressed, slightly curved to straight; wall calcareous, finely perforate, smooth to faintly hispid; aperture equatorial, a moderately arched opening bordered with lip.

Maximum diameter of hypotype, 0.18 mm.; minimum diameter, 0.13 mm.; maximum thickness, 0.08 mm.

Locality of hypotype: JW-58-2, Bad Heart River, Alberta, from the Puskwaskau shale, in the first (upper) white-speckled shale "zone".

Repository: Res. Coun. Alberta Micropaleont. Type Coll.

Occurrence: This species was encountered in the first (upper) white-speckled shale "zone" of the Puskwaskau formation on the Bad Heart River. It was recorded in one sample 17 feet below this same "zone" at the Smoky River locality of JW-58-3. It is rare in both places and was obtained from only the washed material of minus 120 mesh.

Nauss (op. cit.) illustrated this species from the lower Lea Park shale of east-central Alberta at a stratigraphic level slightly higher than the Smoky River area occurrences. Wickenden (1945, p. 42) recorded it among the microfauna of the Boyne member of the Vermilion River formation of Manitoba which is considered the correlative of the upper white-speckled shale "zone" of Alberta. Loetterle (op. cit.) reported this species common in the Niobrara formation of the Central Plains region of the United States which is equivalent in part with the upper white-speckled shale "zone".

Remarks: The genus *Globigerinella* Cushman is considered a junior synonym of *Hastigerina* Thomson by Bolli, Loeblich and Tappan (1957, p. 29). These workers stated that Mesozoic species referred to *Globigerinella* will be seen to belong either to *Planomalina* Loeblich and Tappan, *Biglobigerinella* Lalicker or to *Globigerinelloides* Cushman and ten Dam. This particular species, however, does not possess any diagnostic characteristic of either of these three genera. The present author favors its assignment to *Globigerina* d'Orbigny, and in this respect would follow Galloway (1933) and Hofker (1959) in considering *Globigerinella* a synonym of *Globigerina*.

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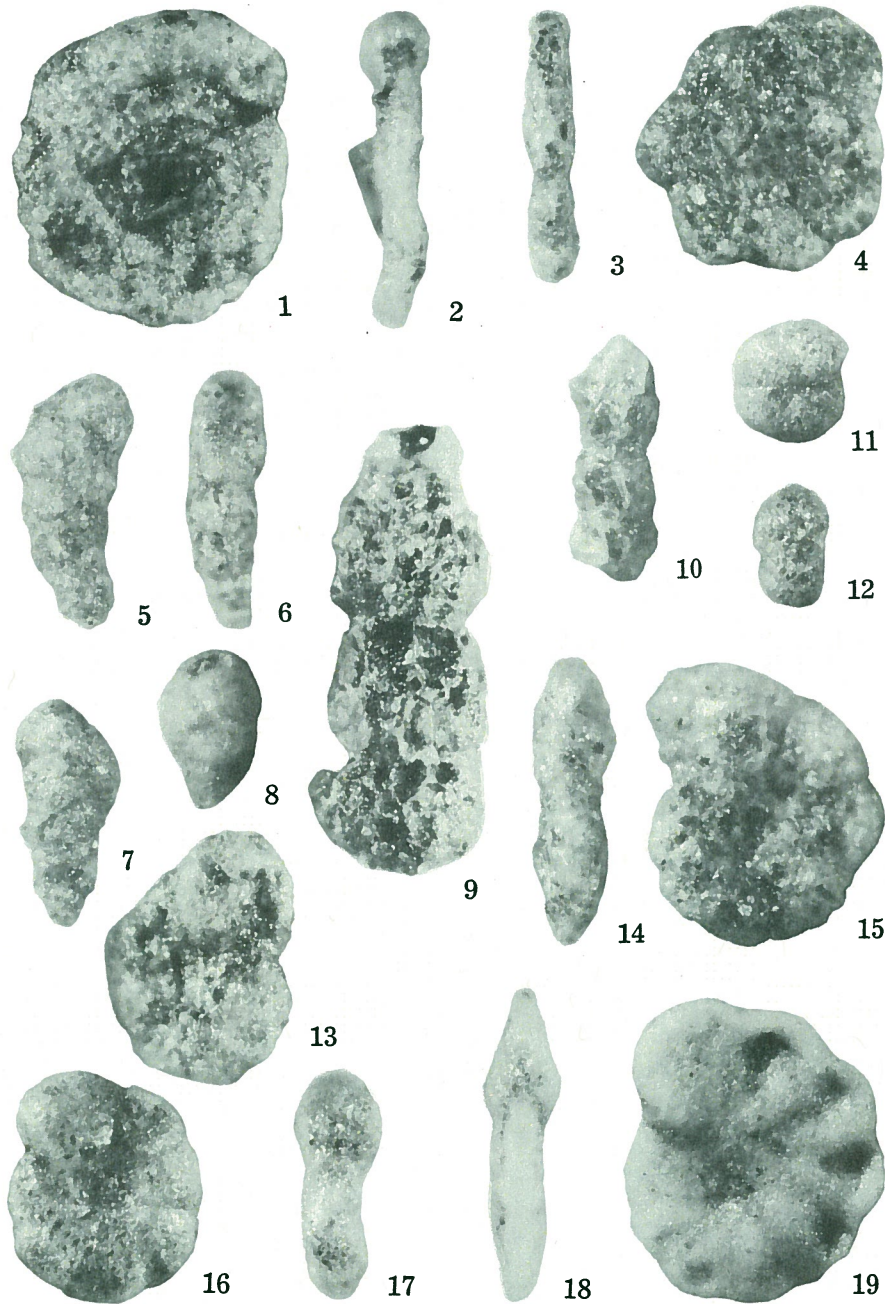


PLATE 3. Foraminifera from the upper Kaskapau shale

EXPLANATION OF PLATE 3

Upper Kaskapau Shale

Smoky River, Alberta

Magnification about x55 except for figure 8 which is x100

- Figures 1, 2: *Involutina* sp.; 1—side view, 2—peripheral view showing large grain protruding (p. 15)
- Figures 3, 4: *Ammomarginulina* sp.—peripheral and side views .. (p. 21)
- Figures 5-7: *Dorothia* sp.; 5, 6—side and apertural views of a specimen; 7—side view of another specimen (p. 25)
- Figure 8: *Gümbelitria* sp.—apertural view (p. 30)
- Figure 9: *Reophax* sp. B. (p. 14)
- Figure 10: *Reophax* sp. A. (p. 14)
- Figures 11, 12: *Haplophragmoides kirki* Wickenden — side and peripheral views (p. 18)
- Figures 13-15: *Haplophragmoides collyra bullocki* Stelck and Wall; 13—side view of distorted specimen showing aperture; 14, 15—peripheral and side views of another specimen .. (p. 17)
- Figures 16-19: *Haplophragmoides collyra* Nauss; 16, 17—side and peripheral views of undeformed specimen; 18, 19—peripheral and side views of crushed specimen (p. 16)



PLATE 4. Foraminifera from the Puskwaskau shale

EXPLANATION OF PLATE 4

Puskwaskau Shale

Smoky River, Alberta

Magnification about x55

- Figures 1-5: *Involutina* sp.; 1, 2—side and peripheral views of a specimen; 3, 4, 5—views of opposite sides and peripheral view of another specimen (p. 15)
- Figures 6-9: *Haplophragmoides* cf. *H. rota* Nauss; 6, 7—side and peripheral views of large, undeformed specimen; 8, 9—side and peripheral views of crushed specimen (p. 20)
- Figures 10, 11: *Haplophragmoides kirki* Wickenden — side and peripheral views (p. 18)
- Figures 12-15: *Haplophragmoides* cf. *H. linki* Nauss — side and peripheral views of two specimens (p. 19)
- Figures 16-19: *Textularia rollaensis* Stelck and Wall — side and apertural views of two specimens (p. 21)
- Figures 20, 21: *Verneuilinoides bearpawensis* (Wickenden)—apertural views of two specimens (p. 22)
- Figures 22-28: *Dorothia smokyensis* Wall, n. sp.; 22, 23—side and apertural views of paratype (juvenile); 24, 25—side and apertural views of paratype (intermediate); 26, 27—side and apertural views of holotype; 28—side view of paratype with uniserial termination (p. 23)

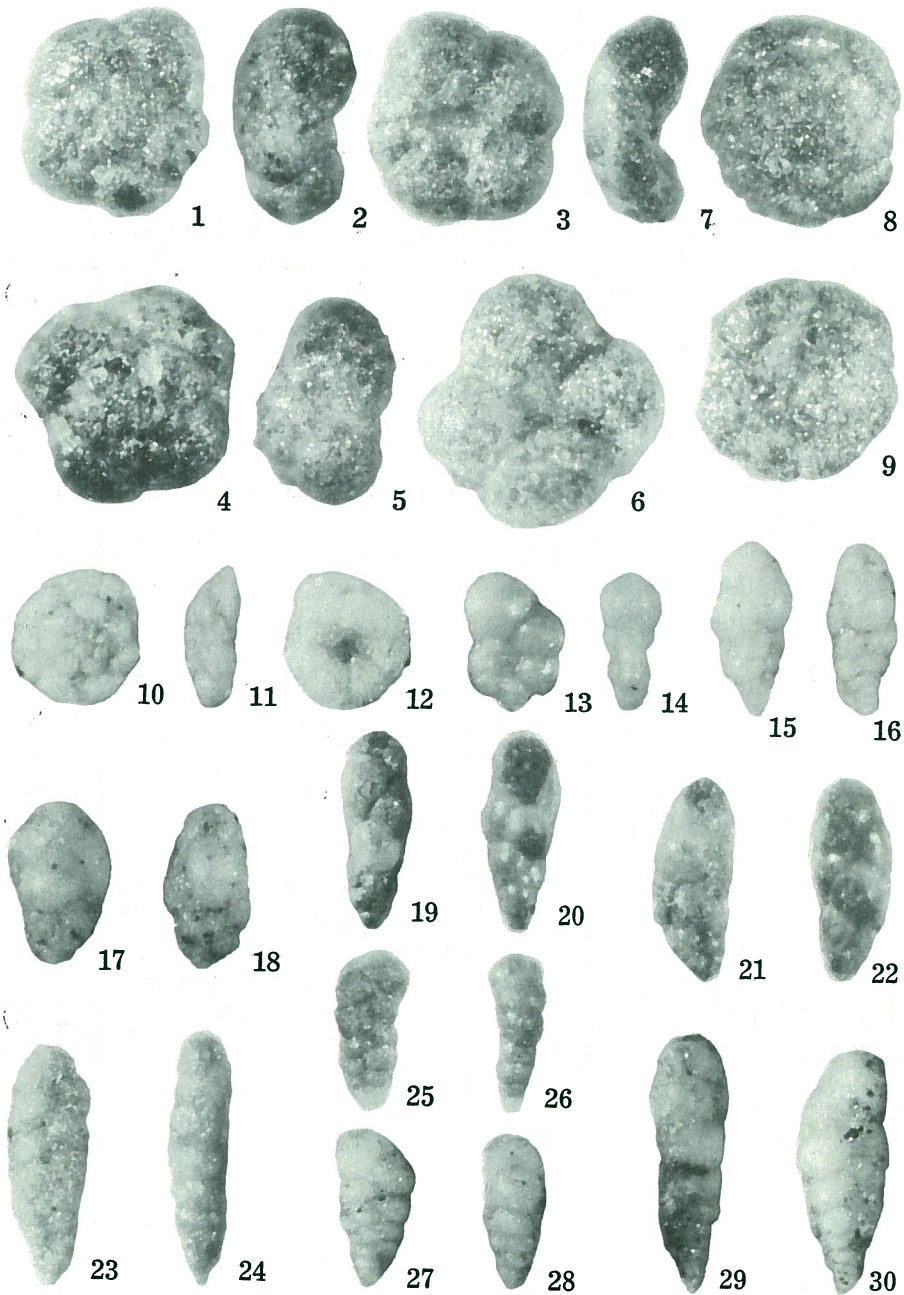


PLATE 5. Foraminifera from the Puskwaskau shale

EXPLANATION OF PLATE 5

Puskwaskau Shale

First (Upper) White-Speckled Shale "Zone"

Smoky and Bad Heart Rivers, Alberta

Magnification about x100

- Figures 1-6: *Trochammina wetteri* Stelck and Wall from Smoky River; 1, 2, 3—dorsal, peripheral, and ventral views of a specimen; 4, 5—dorsal and peripheral views of another specimen; 6—ventral view of a different specimen showing aperture opening into umbilicus (p. 27)
- Figures 7-12: *Trochammina ribstonensis* Wickenden; 7, 8, 9 — peripheral, dorsal, and ventral views of large specimen from Smoky River; 10, 11, 12—dorsal, peripheral, and ventral views of a specimen from Bad Heart River (p. 26)
- Figures 13, 14: *Globigerina aspera* (Ehrenberg) from Bad Heart River — side and apertural views (p. 32)
- Figures 15-22: *Neobulimina* sp.; 15, 16, 17, 18—side and apertural views of two specimens from Bad Heart River; 19, 20, 21, 22 —apertural and side views of two pyritized specimens from Smoky River (p. 31)
- Figures 23-30: *Gümbelina* sp.; 23, 24, 25, 26—side and apertural views of elongate and short specimens from Smoky River; 27, 28, 29, 30—side and apertural views of short and elongate specimens from Bad Heart River (p. 28)