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UPPERMOST CRETACEOUS AND PALEOCENE NON-MARINE MOLLUSCAN FAUNAS OF WESTERN ALBERTA

BY

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PREFACE

The correlation of the uppermost Cretaceous (Mesozoic) and the Paleocene (lowest Tertiary) formations and the fixing of the position of the contact between them are major and important geological problems of the Foothills of Alberta and the Great Plains to the east. Certain of the formations of these ages contain large deposits of coal, and in order to prepare useful geological maps and cross-sections a knowledge of the relative age of the formations is essential. In such formations the accurate identification of the contained fossils gives the most conclusive data available to judge the age of the enclosing strata in the geological time-scale and thus to fix the position of the different coal-bearing beds in the section. Evidence bearing on these problems from a study of the contained plant remains was presented in Bulletin 13 (1949) and the accompanying report supplements this by giving data from a detailed study of the non-marine molluscan shells collected from the strata of the region at intervals since 1880.

This memoir summarizes particularly the results of the study of the sediments adjoining the contact between the latest Mesozoic and earliest Tertiary formations together with a detailed description of their known freshwater and terrestrial molluscan species. A correlation table and a series of sections showing the position of the fossil beds are presented, also nine plates containing one hundred and thirty figures illustrating species of the molluscan fauna and six tables listing their distribution in the formations. An index of the exact localities from which the molluscan shells were collected is given, and this and other data will be of great assistance in studying the coal measures, and in preparing sections and correlating the beds encountered in wells drilled through these formations for oil or gas in the underlying strata.

GEORGE HANSON,
Director, Geological Survey of Canada

OTTAWA, May 1, 1954

Uppermost Cretaceous and Paleocene Non-Marine Molluscan Faunas of Western Alberta

INTRODUCTION

PURPOSE AND SCOPE OF STUDY

The purpose of this report is to present the evidence of the molluscan faunas regarding the correlation of the uppermost Cretaceous and the Paleocene formations of southwestern Alberta. These formations reach a thickness of more than 10,000 feet in many parts of the area and in many sections freshwater molluscs are the only fossils available for correlation. In this report the molluscan faunas of these formations are listed, and the stratigraphy and correlation are discussed. In order that the results of this investigation may be applied to the determination and mapping of contacts between the sediments of the late Cretaceous and those of the early Tertiary (Paleocene), the localities of all important fossiliferous beds are given. Particular emphasis has been placed upon the evidence of these faunas regarding the position of the Cretaceous-Tertiary boundary.

HISTORICAL REVIEW

The foundation of all studies concerning the non-marine molluscan faunas of the Upper Cretaceous and the basal Tertiary strata of western North America was laid by F. B. Meek, in his description of the collections from the "Upper Missouri Country" made by the Hayden Survey. Meek's studies were published, with F. V. Hayden, in a number of preliminary reports between 1856 and 1862, and his final report in the monograph entitled "A Report on the Invertebrate Cretaceous and Tertiary fossils from the Upper Missouri Country" (Meek, 1876).[1] Distinctive faunas of non-marine molluscs were described from the Judith River and Fort Union groups. C. A. White continued Meek's work and in a number of papers described molluscan faunas from Wyoming, Colorado, and Utah; in the Third Annual Report of the United States Geological Survey, White (1883b) figured all species of fossil non-marine mollusca then known to occur in North America. In 1883 the stratigraphic relationships of the uppermost Cretaceous and basal Tertiary non-marine formations of the Western Interior were confused. Owing to this fact, in White's work all faunas from the Judith River to the Fort Union group were considered as occurring in the "Laramie", a term originally applied to sediments in the Denver basin of Colorado (Brown, 1943) and now known to be of late Cretaceous age. As a consequence of this error in the use of the term Laramie the strati-

[1] Names and dates in parentheses are those of publications listed in References, pages 95–101.

graphic distribution of these faunas was obscured until Stanton and Hatcher (1905) recognized that the Judith River beds and their Canadian equivalents (the Foremost and Oldman formations) were separated from the Laramie and Fort Union groups by marine strata of Pierre age—the Bearpaw shale.

The first report on late Cretaceous and early Tertiary molluscs in Canada was made by J. F. Whiteaves (1885) in which collections made by G. M. Dawson, R. G. McConnell, J. B. Tyrrell, and T. C. Weston were described. Whiteaves (1887) later described additional material collected by Tyrrell and recognized many Fort Union species in Canada; he also anticipated the recognition of a distinctive fauna in the strata underlying the beds containing Fort Union species by describing new species from the St. Mary River and Edmonton formations. With the exception of the publication by Barnum Brown (1914, pp. 362, 365) of some identifications by T. W. Stanton of material from the Edmonton and Paskapoo formations, no further study of these faunas was made until 1926, when P. S. Warren (1926) and L. S. Russell (1926b) listed and discussed the faunas of the Edmonton and Paskapoo formations respectively. Warren (in Rutherford, 1926, p. 11; 1927, p. 40; 1928, p. 22) listed a number of Paleocene faunules from Bow, Pembina, McLeod, and Embarras Rivers. Russell's investigations continued (1929b, 1931a, 1932b), resulting in the discovery of a rich Paleocene terrestrial fauna and the full appreciation of the distinctive nature of the St. Mary River fauna. This work was summarized in 1932 (Russell, 1932c). Meanwhile, W. S. Dyer (1930 a, b) described some new species and listed the non-marine Upper Cretaceous and Paleocene faunas of Alberta. Dyer's lists are undocumented and include many records that seem unacceptable in the light of existing collections. Junius Henderson (1935) produced an invaluable index to the fossil non-marine mollusca of North America, but the lists of Canadian faunas incorporate a number of errors and should be treated with reservation.

MATERIAL FOR THE PRESENT STUDY

The material on which this study is based was, for the most part, collected during the field seasons of 1949, 1950, and 1951. Collections made by G. M. Dawson, R. G. McConnell, T. C. Weston, J. B. Tyrrell, G. S. Hume, W. S. Dyer, L. S. Russell, O. A. Erdman, and C. M. Sternberg, preserved at the Geological Survey of Canada, have been made available. Through the courtesy of Drs. M. A. Fritz and P. S. Warren the collections in the Royal Ontario Museum and the University of Alberta, respectively, were examined.

ACKNOWLEDGMENTS

This report is based on a thesis submitted in conformity with the requirements for the degree of Doctor of Philosophy in the University of Toronto. Dr. W. A. Bell, formerly Director of the Geological Survey of Canada, suggested the problem and provided the facilities for field work. The work was initiated under the direction of Dr. L. S. Russell, formerly of the University of Toronto and now Chief of the Zoology Section of the National Museum of Canada, who has given invaluable criticism and advice throughout. Dr. M. A. Fritz, Professor of Geology in the University of Toronto, made available the collections in her care. Dr. P. S. Warren, of the University of Alberta, kindly loaned a number of type specimens. Dr. Henry van der Schalie, of the University of Michigan, advised the writer regarding comparisons with the recent fauna. Dr. Teng-Chien Yen offered counsel on a number of taxonomic points and assisted in the use of the collections at the United States National Museum. The writer profited from discussions with Dr. J. B. Reeside, Jr., and Dr. R. W. Brown, of the United States Geological Survey, regarding related stratigraphic problems in the United States. Dr. F. H. McLearn, retired Chief of the Palæontological Division of the Geological Survey of Canada, and his successor, Dr. H. Frebold, have made available casts of type specimens and the collections of the Geological Survey. During the 1949 and 1950 field seasons the writer was attached to a field party in the Pincher Creek area under Dr. R. J. W. Douglas. Dr. Douglas has provided much unpublished stratigraphic information, and during the field work his advice and criticism regarding the stratigraphic problems have been a source of encouragement and stimulation. While in the field with Dr. Douglas in 1949 and 1950 his assistants, namely, O. Gietz, F. D. Anderson, R. E. Wetter, D. K. Norris, D. Barrs, and B. B. Hudson, aided in the collection of fossils. In 1951 R. A. Layock assisted in this work. To all these persons the writer wishes to acknowledge his indebtedness.

STRATIGRAPHY AND CORRELATION

SUMMARY

The uppermost Cretaceous and Paleocene[1] non-marine formations of western Alberta form an elongate terrain on the west side of the western Canada sedimentary basin. Measured across the strike this terrain varies in width from about 30 miles in the southern part, west of Lethbridge, to about 175 miles at the latitude of Edmonton. The major structural feature of this area is the Alberta syncline. This structure was formed on the site of an elongate basin of deposition in which a great thickness of Mesozoic and Tertiary sediments accumulated. The youngest sediments in the basin are of Paleocene age. The deformation of the basin evidently took place contemporary with the structural deformation of the Rocky Mountains and the Disturbed belt. The time of this orogeny is placed between the Paleocene epoch and some time in the late Eocene (Russell and Wickenden, 1933; Russell, 1951). The Alberta syncline is asymmetrical; on the east limb the beds dip at low angles to the west. This limb forms part of the Great Plains physiographic province. The beds on the west limb are more severely deformed; they usually dip at high angles to the east, but between North Saskatchewan and Athabasca

[1] The non-marine Paleocene of North America is defined and subdivided on the basis of mammalian faunas, which permit the recognition, in ascending order, of the following stages: Puercan, Dragonian, Torrejonian, Tiffanian, and Clarkforkian (Wood *et al.*, 1941), and it is in this sense that the term is used in this report. In Europe two divisions, the Montian and Thanetian, are generally referred to the Paleocene and these stages are based on sections of marine strata, but in France a mammal fauna (the Cernaysian fauna) is present in beds correlated with the Thanetian. Vertebrate palæontologists of both Europe and North America correlate the Cernaysian fauna with the Tiffanian (*See* Simpson, 1929, for summary and references). These applications of the term Paleocene seem to correspond moderately closely with respect to the upper limit. Wenz (1923, p. 6) applies the term rather differently, as he includes the European Sparnacian and Ypresian stages within the Paleocene. According to Wood *et al.* (1941), the North American equivalents of these European stages are referred to the Wasatchian, or Lower Eocene.

Rivers a number of broad folds complicate the structure. The western boundary of the Alberta syncline is the eastern limit of the Disturbed belt, which forms the Foothills of the Rocky Mountains.

Sections of the non-marine formations are well exposed on the east and west limbs of the syncline. They also occur within the Disturbed belt, where, as in the Alberta syncline, they constitute the youngest deformed rocks.

Within this area the withdrawal of the Upper Cretaceous seas was a complex event. This resulted from the filling of parts of the basin with clastic sediments, which were derived from a landmass lying to the west. The fauna and flora of these clastic sediments show that they were deposited under non-marine conditions. The last marine transgression that covered the entire area was that responsible for the deposition of the marine shales of the Alberta group. The youngest fauna in this formation is correlated with that of the Telegraph Creek formation of the Western Interior of the United States (McLearn, 1937, p. 118) of Upper Santonian age in the European Chronology (Cobban and Reeside, 1952). On the west side of the syncline north of Highwood River, and on the east side north of Pembina River an uninterrupted sequence of continental sediments, covering late Cretaceous and Paleocene time, rests upon these marine shales. South of these points on each side of the syncline continental sedimentation was initiated after the deposition of the Alberta shale but was interrupted before the end of the Cretaceous by the transgression of the Bearpaw sea[1]. The Bearpaw formation is of Upper Campanian age (Cobban and Reeside, op. cit.).

As a result of the varying extent of these marine transgressions the sequence of non-marine formations differs in various parts of western Alberta. The terminology and distribution of these formations is conveniently summarized thus:

West Side of Alberta Syncline and Disturbed Belt North of Highwood River

In this area a thickness of more than 10,000 feet of non-marine late Cretaceous and Paleocene sediments rest on the marine Alberta shale. The Cretaceous part is referred to the Belly River and Edmonton formations between Highwood and James Rivers. In the region of North Saskatchewan and Athabasca Rivers the Cretaceous rocks are referred to the Brazeau formation. The Paleocene rocks are referred to the Paskapoo formation. On Wapiti and Smoky Rivers Paleocene rocks have not been recognized within the Alberta syncline; here the continental sediments equivalent to the Brazeau are referred to the Wapiti group. Throughout much of this area the Cretaceous-Tertiary boundary is not well marked stratigraphically, but between North Saskatchewan and Athabasca Rivers a conglomerate member, the Entrance conglomerate, appears to mark this horizon.

[1] The non-marine sediments that lie between the Alberta and Bearpaw shales are beyond the scope of this report.

Alberta Syncline South of Township 13

In this area the belt of Uppermost Cretaceous and Paleocene sediments does not exceed 30 miles in width and the formations on the east and west limbs of the syncline are essentially similar. Overlying the Bearpaw shales there are up to 10,000 feet of beds referred to, in ascending order, the Blood Reserve, St. Mary River, Willow Creek, and Porcupine Hills formations. The Cretaceous-Tertiary boundary occurs within the Willow Creek formation.

East Side of the Alberta Syncline between Little Bow and Pembina Rivers

In this area the Bearpaw shale is overlain by the typical Edmonton formation, which is equivalent to the St. Mary River formation and the lower part of the Willow Creek formation. The Edmonton formation is overlain, in places unconformably, by the typical Paskapoo formation, of Paleocene age.

East Side of the Alberta Syncline North of Pembina River

The Bearpaw formation apparently pinches out near Pembina River (Feniak, 1944, p. 15). North of this locality the Edmonton formation rests directly on the non-marine Belly River formation. The overlying Paleocene rocks are referred to the Paskapoo formation.

SEQUENCE OF FAUNAS

Four succesive non-marine molluscan faunas have been recognized in the uppermost Cretaceous and Paleocene formations of southwestern Alberta. The lowest fauna, that of the Blood Reserve formation and the basal member of the St. Mary River formation, consists of a mixture of brackish and freshwater species. Most of the brackish-water species have an extended range in beds of similar facies within the Montana group and, consequently, this fauna does not contribute to the correlation of the enclosing strata. The three succeeding faunas indicate freshwater conditions. They are best developed in the St. Mary River,[1] the lower part of the Willow Creek, and the Paskapoo formations; in the following discussion the faunas are designated by these formational names.

St. Mary River Fauna. The fauna of the St. Mary River formation includes unionids, sphaeriids, freshwater operculate and pulmonate gastropods, and six species of land snails. The terrestrial species at most localities occur with the freshwater forms and this suggests that most of the fossil beds represent accumulations of dead shells. The following species are particularly characteristic and abundant. *Sphaerium heskethense* Warren, *Viviparus westoni* sp. nov., *V. prudentius* White, *Lioplacodes whiteavsi* (Russell), *Oreohelix angulifera* (Whiteaves), *O.? obtusata* (Whiteaves), *Polygyra parvula* (Whiteaves), and *Dimorphoptychia mokowanensis* sp. nov. Among the most common fossils encountered are fragments of large physids, but they are usually indeterminable. Many of

[1] Except when otherwise stated the term "St. Mary River formation" refers to the upper part of the formation of freshwater deposition.

these species are found in the equivalent part of the Edmonton formation, both in the Disturbed belt and the Plains area. In the latter invertebrates are scarce and the fauna differs from that of the St. Mary River formation in the rarity of freshwater pulmonates and the complete absence of land shells. This, coupled with the fact that the Edmonton fauna includes some indigenous species, suggests that the environment of deposition of the two formations was different. Possibly the lower Edmonton beds were deposited under somewhat brackish-water conditions.

The St. Mary River fauna is not well represented in the sections of the western United States, although *V. prudentius* was described from the Laramie formation of Colorado. On the basis of stratigraphy, the rocks enclosing this fauna are dated as representing an upper part of the Pierre and the Fox Hills stages. As marine and brackish-water conditions prevailed in the western United States during most of this time, the restriction of the St. Mary River fauna to Alberta, where truly non-marine conditions prevailed, is to be expected.

Lower Willow Creek Fauna. The fauna of the lower part of the Willow Creek formation has many species in common with that of the underlying St. Mary River formation, but the two indigenous forms, *Viviparus prudentius willovensis* subsp. nov. and *Pseudocolumna spitzia* sp. nov., are abundant, and render the fauna distinctive. An identical fauna is present in the upper beds of the Edmonton formation in the Disturbed belt, but the upper part of the Edmonton, on the Plains that is equivalent to the lower part of the Willow Creek, is not known to carry determinable molluscan remains. The Lower Willow Creek fauna is not known elsewhere in North America, presumably because the facies of the Canadian strata enclosing this fauna is not duplicated. The Lower Willow Creek fauna, therefore, cannot be applied to a correlation with the section in the western United States. The complete absence of characteristic Paleocene species suggests a Cretaceous age and this is confirmed by the presence of dinosaur bones and the stratigraphic position, which also suggests a Lance age (late Upper Cretaceous) for the lower part of the Willow Creek formation.

Paskapoo Fauna. The Paskapoo formation and its equivalents contain a rich molluscan fauna including unionids, sphaeriids, and gastropods referable to both aquatic and terrestrial genera. The Paskapoo unionids are difficult to distinguish from those of the preceding faunas, but the aquatic gastropods, most of which were originally described from the Fort Union group of the Missouri and Yellowstone Rivers in North Dakota and Montana, almost without exception, are not known in the older faunas of Alberta. *Viviparus retusus* (M. and H.), *V. planolatere* Russell, *Lioplacodes nebrascensis* (M. and H.), and *Valvata bicincta* Whiteaves are particularly characteristic and widespread members of this fauna. The most striking feature of the Paskapoo fauna is the terrestrial element, which includes at least ten species, of which *Grangerella mcleodensis* (Russell), *Oreohelix thurstoni* (Russell), and *Dimorphoptychia douglasi* sp. nov. are most widespread and distinctive. This terrestrial fauna is known only in Alberta, but within the province occurs also in the Upper Willow

Creek and Porcupine Hills formations. On the west side of the Alberta syncline this fauna has been collected from every important section between Waterton and McLeod Rivers, and in this area provides an excellent criterion for the recognition of deposits of Paleocene age.

BLOOD RESERVE FORMATION

Stratigraphy. The term Blood Reserve was applied to the sandstone overlying the Bearpaw shale on St. Mary and Oldman Rivers by Russell (1932a, p. 32). This sandstone had previously been called "Fox Hills", but Russell (1932c, p. 130) presented evidence that the Blood Reserve is much older than the typical Fox Hills. In Glacier county, Montana, Stebinger (1914, p. 62; 1916, p. 124) named the beds occupying the stratigraphic position of the Blood Reserve the Horsethief sandstone.

In Alberta the Blood Reserve sandstone has been mapped by Russell (1932a) as far north as township 10 on the east side of the Alberta syncline and by Williams (1949) and Douglas (1951) in the Cardston and Pincher Creek map-areas to the west and within the Disturbed belt. North of township 10 equivalents are presumably present in the basal beds of the Edmonton formation on the Plains. In the Disturbed belt the Blood Reserve formation has not been recognized north of Castle River and in Cowley (Hage, 1943), and in succeeding map-areas to the north is included within the St. Mary River formation.

The Blood Reserve formation consists of massive, grey or greenish grey sandstone that weathers buff or a rusty yellow. Crossbedding is commonly developed. The formation (and its equivalent, the Horsethief) thins from south to north and from west to east: from 360 feet in Montana (Stebinger, 1914, p. 62) to about 80 feet and 40 feet on the St. Mary and Oldman Rivers respectively (Russell, 1932a); Williams (1949) reports 100-260 feet in Cardston map-area, and in the Pincher Creek map-area Douglas (1951) states that the thickness is variable but at most points approximates 150 feet.

Fauna and Correlation. The Blood Reserve formation is not very fossiliferous. Russell and Landes (1940, p. 84) report brackish and fresh-water molluscs from a layer near the top and marine forms near the base. The molluscs identified by Russell from near the top are as follows: *Ostrea glabra* M. and H., *Lampsilis consueta* (Whiteaves), *Corbula perangulata* Whiteaves, *Viviparus raynoldsanus* M. and H. ? (=*V. mokowanensis* sp. nov.), *"Melania" wyomingensis* Meek. This fauna is very similar to that of the basal member of the St. Mary River formation. The species are long-ranging, hence do not assist in correlation. The marine species identified by Landes include *Baculites compressus* Say and are stated to confirm the stratigraphic position of the Blood Reserve as pre-Fox Hills.

The correlation of the Blood Reserve formation with the section in the Cypress Hills has been summarized by Russell (1950, p. 36), who concludes that it cannot be regarded as younger than the Black Eagle sandstone member of the Bearpaw shale. Hence, at least 600 feet of marine sediments of Pierre age were deposited in the Cypress Hills after the initiation of the deposition of the Blood Reserve sandstone in southwest Alberta.

ST. MARY RIVER FORMATION

Stratigraphy. The St. Mary River formation was established by Dawson (1883, p. 5) to include the rocks between the "Fox Hill sandstones" (Blood Reserve formation) and the Willow Creek formation. The formation has been identified from Glacier county, Montana (Stebinger, 1916, p. 127), to township 14 in Alberta. To the north, in the Disturbed belt, St. Mary River strata pass into the essentially similar sediments of the Edmonton formation; on the east side of the Alberta syncline beds of St. Mary River lithology interfinger with typical Edmonton sediments, as exposed on Little Bow River (Russell, 1932c, p. 128).

The greater part of the St. Mary River formation consists of hard, green-grey weathering, grey, fine-grained calcareous sandstones alternating with green and grey, friable, silty shales. Thin carbonaceous shales and nodular, rusty weathering limestones are also present in some sections. The individual units are relatively thin, and the alternation of ledgy sandstone and recessive shale imparts a characteristic appearance to outcrops of the formation. The basal zone consists of fissile grey shale, rusty weathering sandstone, coal beds, and coquinoid limestone composed of brackish-water fossils. Williams (1951, p. 894) refers to these beds as the "basal member" and this usage is followed.

On the east side of the Alberta syncline the thickness of the formation is estimated to be 1,160 feet on St. Mary River (Williams, 1951, p. 892) and about 1,500 feet on the Oldman (Russell, 1932a, p. 34). On the east edge of the Disturbed belt Hage (1943, p. 11) estimates a thickness of about 2,500 feet on Castle and Crowsnest Rivers in Cowley map-area. The basal member varies in thickness between from about 250 feet in Pincher Creek map-area (Douglas, 1951) to 60 feet on Oldman River near Monarch (Russell, 1932a, p. 35).

The contact of the basal member with the underlying Blood Reserve sandstone is usually sharp, but upward this member is succeeded transitionally by the freshwater beds without any abrupt lithological change. The basal member has been noted throughout the Disturbed belt (Stewart, 1919; Hage, 1943; Douglas, 1950, 1951; Williams, 1949) and homotaxial equivalents probably are present in the lower part of the Edmonton formation on Highwood River (Slipper, 1921, p. 12). On the Plains this zone has been described on St. Mary and Oldman Rivers (Russell, 1932a; Williams, 1951). At Scabby Butte, east of Nobleford, abundant typical shells of *Corbula perangulata* Whiteaves, a characteristic species of these beds, occur at the mouth of rodent burrows, suggesting that a bed carrying them is present below the exposed section. This is interpreted as indicating the northern continuation of this member.

The greater part of the formation does not lend itself to obvious stratigraphic subdivision, but Douglas (1950, p. 40) has drawn attention to a rather persistent zone of thick-bedded sandstones referred to as the "blocky" sandstones. This member, which is 109 feet thick on Oldman River, in Callum Creek map-area, has been traced from Waterton River to the Oldman. The top of this member varies between 180 and 650 feet below the top of the formation on Waterton River and Pincher Creek respectively. A sandstone member in a similar stratigraphic position is represented in the Highwood River section of the Edmonton formation (*See* Figure 3, in pocket).

On the east side of the Alberta syncline, along Oldman River, a section includes the equivalents of the Kneehills tuff, the "mauve" shale, and the "white" sandstone (Tozer, 1952) described within the Edmonton formation of the Red Deer Valley by Sanderson (1931, p. 65; 1945, p. 57), and which (Sternberg, 1947, p. 10; 1949, p. 33) separate the pre-Lance and Lance parts of that formation. The tuff bed marks the top of the formation on Oldman River and the underlying bentonitic shale and white weathering sandstone, on the grounds of the similarity with the section in the Cypress Hills, are referred to as the Battle and Whitemud equivalents respectively (*See* page 13). These beds have not been recognized elsewhere within the St. Mary River formation.

The stratigraphic relationship between the Edmonton and St. Mary River formations has been described by Russell (1932c, p. 128). Beds of Edmonton lithology extend as far south as Scabby Butte, in secs. 18 and 19, tp. 11, rge. 22, W. 4th mer., where about 80 feet of typical Edmonton sediments overlie equivalents of the basal member of the St. Mary River formation. Sediments of St. Mary River lithology are present a few miles to the west, at Nobleford and 2 miles south of Barons, and at Carmangay they extend as a lentil into the section of the Edmonton exposed on Little Bow River. The lower part of the Edmonton and the top of St. Mary River formations, therefore, interfinger between Oldman and Little Bow Rivers, with typical Edmonton sediments having been deposited to be followed by beds characteristic of the St. Mary River formation, the contact between the two lithofacies apparently rising to the north.

Proceeding north in the Disturbed belt the lithological change between the Edmonton and St. Mary River formations is not marked, but as the former contains a Lower Willow Creek fauna, a change in name is necessary. The relationship between the sections on Oldman and Highwood Rivers, between which this change takes place, is indicated on Figure 3.

Fauna and Correlation. The fauna of the basal member of the St. Mary River formation has not been studied in detail but the following species have been identified from this zone: *Ostrea glabra* M. and H., *Anomia gryphorhynchus* Meek, *A. perstrigosa* Whiteaves, *Corbicula cleburni* White, *C. obliqua* Whiteaves, *Corbula perangulata* Whiteaves, *Unio stantoni* White, *Plesielliptio* sp. indet., *Viviparus mokowanensis* sp. nov., *Lioplacodes limnaeformis* (M. and H.), *Lioplacodes* sp. indet., *"Melania" wyomingensis* Meek, *Goniobasis webbi* Dyer. This fauna of brackish-water and freshwater species does not provide much information regarding the correlation of these beds because all the brackish-water species listed range as high as the Lance. It is of interest to note that *V. mokowanensis* and shells of *Corbula* occur together at many points, suggesting that this species was adapted to somewhat brackish-water conditions. The absence of *V. mokowanensis* in the overlying freshwater beds supports this conclusion.

Table I.

Distribution of molluscan fauna of the St. Mary River formation

Localities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
Unio stantoni White											X																		X													X					
U. sp. cf. *U. proavitus* White																																										X					
Plesielliptio sp. indet.																						X																							X		
Sphaerium gietzi sp. nov.						X														X							X			?				X									X				
S. heskethense Warren				X		X									X									X			X			X			X				X	X	X	X				?		?	
S. livingstonensis Russell																																															X
S. mclearni Russell																																															X
Pisisdium squamula Russell																																															X
Dimorphoptychia mokowanensis sp. nov.								X								X	X											X		X		X															
D. sp. cf. *D. rutherfordi* (Russell)																									X							X															
Viviparus prudentius prudentius White	X	X	X		X				X					X						X						X				X									X								
V. westoni sp. nov.	X	X	X		X	X		X	X	X		X	X	X	X	X			X	X	X	X		X		X	X	X		X		X	X			X			X						X		
Campeloma edmontonensis sp. nov.	X					X		X	X			X				X																							X								
Lioplacodes limnaeformis (M. and H.)	X			?							?					X																															
L. sanctamariensis (Russell)									X					X			X										X	X	X			X					X			X						X	
L. sp. cf. *L. tenuicarinata* (M. and H.)	X				X																									X																	
L. whiteavesi (Russell)			X		X				X				X			X				X										X				X													
Reesidella sp. cf. *R. protea* (Yen)		X			X						?				X			X												X					X	X											
Valvata filosa Whiteaves	X																		X	X												X															
Goniobasis webbi Dyer															X						X																										
Hydrobia sp. indet	X																			X										X		X															
Pleurolimnaea mclearni sp. nov.																																X															
Physa canadensis Whiteaves					X				X										X	X							X			X		X							X					X	X		
Ferrissia sp. indet.																				X														X													
Oreohelix angulifera (Whiteaves)								X	X							X	X			X		X			X					X		X															
O. ? obtusata (Whiteaves)							X	X									X						X		X							X							X								
Polygyra parvula (Whiteaves)						X	X	X	X						X	X				X					X		X		X	X	X	X															
Holospira dyeri sp. nov.		X																X					X									X							X	X							

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The fauna of freshwater and terrestrial molluscs of the upper part of the St. Mary River formation, listed in Table I, page 10, is of interest in that it represents the richest known freshwater fauna occurring between that of the Judith River below and the Fort Union above. This fauna has, with the exception of the unionids and physids, which have not been adequately studied, very little in common with the preceding and succeeding faunas. The non-marine aspect of the fauna is emphasized by the presence of six species of terrestrial gastropods. Many of the St. Mary River species extend up into the lower Willow Creek beds, of Lance age, but, as will be noted below, this fauna contains some significant additions that differentiate it from the underlying fossil assemblage. The value of the St. Mary River fauna as a standard for comparison is enhanced by the stratigraphic correlation of the enclosing beds. The occurrence of Whitemud and Battle equivalents at the top of the formation leads to the conclusion that beds of Lance age are not represented. Stratigraphic comparison with the Cypress Hills section (Russell, 1950, p. 36) suggests that the base of the formation is not younger than the marine sandstones of that area, which extend down well into the Pierre. The invertebrate fauna of the St. Mary River formation may, therefore, be regarded as representing late Pierre and Fox Hills time. Collections have been obtained throughout the entire thickness of the formation, but no faunal zones are distinguishable although an abrupt change from brackish to freshwater species is recognizable at the top of the basal member.

Species of this fauna occur in the lower part of the Edmonton formation, both in the Disturbed belt and on the Plains, and two species have been identified from rather unsatisfactory material collected near the top of the Brazeau formation near Saunders.

In view of the foregoing, the St. Mary River formation may be correlated with the lower part of the Edmonton formation of the Plains area. In the Disturbed belt correlatives are to be found in a lower part of the Edmonton and an upper part of the Brazeau formations. In the Cypress Hills an upper part of the Bearpaw to the Battle, inclusive, are equivalent to the St. Mary River formation.

EDMONTON FORMATION OF THE PLAINS

Stratigraphy. The Edmonton formation was defined by Tyrrell (1887, pp. 127, 132) to include the sediments between the "Fox Hill and Pierre Group" (Bearpaw formation) and the "Paskapoo Series". The top of the formation was drawn at an "extensive coal deposit" (Tyrrell, 1887, p. 132), now known as the Ardley seam in the Red Deer Valley and the "Big Seam" on North Saskatchewan River. Sanderson (1945, p. 62) included sediments above the Ardley seam in the Edmonton formation, and Sternberg (1949, p. 33) states that dinosaur remains occur up to 90 feet above the Ardley seam, thus confirming Sanderson's implication that these beds are of Cretaceous age. It is, however, not easy to define the top of the Edmonton formation stratigraphically, particularly where the upper beds, of Lance age, are present, for these beds are lithologically, similar to those of the overlying Paskapoo formation. The accepted usage is that the top of the Edmonton formation is defined at the base of the Paskapoo, i.e., it is placed at the Cretaceous-Tertiary boundary. On the west side of the Alberta syncline, north of township 15, strata occupying a stratigraphic position roughly similar to that of the typical Edmonton have been designated Edmonton formation. The stratigraphy and correlation of these beds is discussed on pages 16-19. The Edmonton formation outcrops throughout a belt of varying width from Little Bow River to Swan Hills. The best exposures are found in the Red Deer Valley, regarded by many as the type area.

Typical sediments of the Edmonton formation consist of soft, grey to white weathering, bentonitic, feldspathic sandstones and friable, bentonitic, commonly silty, grey and brown shales. Beds of coal and carbonaceous shale are common, as are nodular beds of rusty weathering limestone or "ironstone". The coal deposits of the Edmonton have been described by Allan and Sanderson (1945) and Rutherford (1928). Sanderson (1945) and Sternberg (1947) have investigated the petrology of the sandstones, and the latter has shown that sandstones of the upper Edmonton are coarser and less feldspathic than those of the lower part of the formation and are, in fact, very similar in this respect to those of the overlying Paskapoo formation. In the Red Deer region Allan and Sanderson (1945, p. 36) report a maximum thickness of 1,224 feet for the formation. Rutherford (1928, p. 12) states that on North Saskatchewan River the thickness probably is over 1,000 feet. Stewart (1943, descriptive notes) indicated that 1,050 feet of beds are assigned to the Edmonton formation in a well west of the Bassano sheet. On Little Bow River, probably about 400 feet of strata of Edmonton facies underlie the lentil of beds of St. Mary River lithology.

The contact between the Edmonton and the underlying Bearpaw formation is transitional, as the upper thin beds of the latter usually contain considerable sand. On Little Bow and Bow Rivers, Stewart (1943) has mapped the contact at the base of light grey weathering, bentonitic sandstones 22 and 11 feet thick respectively. At the mouth of Willow Creek, on Red Deer River, a similar sandstone, mapped as basal Edmonton by Allan and Sanderson (1945) is 36 feet thick. At each of these localities the underlying Bearpaw beds consist of chocolate-coloured sandstones and bentonitic shales, thinly interbedded. Oyster beds occur 22 and 94 feet above the base of the Edmonton formation on Little Bow and Red Deer Rivers respectively. Rutherford (1939) mapped the Bearpaw formation on North Saskatchewan River, but exposures are poor and the contact with the overlying Edmonton formation was not observed. Feniak (1944) assumes that the Bearpaw is present on Pembina River, but there are no exposures. On Athabasca River the same author has mapped a contact between the Edmonton and Belly River formations, the Bearpaw being absent. He states: "the position of the upper Belly River contact is suggested only by the general lithological similarity of underlying beds to the Pale beds of Southern Alberta". In the Swan Hills, north of lesser Slave Lake, the lower contact of the beds referred to the Edmonton formation is concealed (Allan, 1919, p. 11). The Bearpaw-Edmonton contact is probably continuous with that between the Bearpaw and Blood Reserve formations on Oldman River, but the contacts may not be contemporaneous but homotaxial equivalents.

In the Red Deer Valley, Sanderson (1945) has described the stratigraphy of the Edmonton formation in some detail. He divided the formation into three members; an upper, a middle with the Kneehills tuff at the top, and a lower with the Drumheller "marine tongue"[1] at the top. These members are approximately 290, 300, and 600 feet thick respectively. The Kneehills tuff, a light grey, fine-grained, siliceous rock, in most sections is less than 1 foot thick, and is underlain over a wide area by two distinctive beds, the "mauve shale" and "white sandstone" of Sanderson. The "mauve shale", a grey bentonitic shale, weathers a characteristic mauve tint, and this combined with the underlying light grey to white weathering sandstone make these two zones distinctive units. Their combined thickness varies from 20 to 50 feet, but in most sections the thickness is about 35 feet. These beds have been correlated by Sanderson (1931, p. 66), Russell (1932c, p. 127), and Furnival (1946, p. 88) with the Battle and Whitemud formations of Cypress Hills, and these characteristic beds within the Edmonton are designated the Battle and Whitemud equivalents.

The Drumheller member, in Horseshoe Canyon, sec. 28, tp. 28, rge. 21, W. 4th mer., is 31 feet thick and consists of soft grey sandstone with a 1·5-foot coquina of *Corbicula* shells at the top, a 2-foot oyster bed 15 feet above the base, and another 6-inch oyster bed at the base. This unit exhibits great lateral variation and at Horseshoe Canyon the coquinoid limestones are lenticular. In several local sections only one coquina, either of *Corbicula* or oyster shells, is present. The Drumheller member is not present throughout the Red Deer section: it apparently pinches out between Morrin Ferry and Trochu. On Bow River, a bed of brackish-water fossils, 1 foot thick, occurring at the mouth of East Arrowwood Creek (Russell, 1932c, p. 127) is probably a correlative of some part of the Drumheller member. As this member has a limited geographic extent the nomenclature of Bell (1949, p. 17) is followed and the Edmonton formation is divided into a lower and an upper part, the line of separation being at the top of the Kneehills tuff. As will be noted below, this stratigraphic division corresponds with a well-defined faunal break.

The Battle and Whitemud equivalents are present on Bow River (Rutherford, 1947, p. 55) and north of Gleichen (Furnival, 1946, p. 88). In the Bow River section the conglomeratic basal sandstone of the Paskapoo rests upon, and locally truncates, these beds. Upper Edmonton beds are, therefore, absent in this section (Tozer, 1952, p. 5).

On Little Bow River the section includes about 400 feet of typical Edmonton sediments at the base overlain by, in the vicinity of Carmangay, hard sandstones and friable shales of St. Mary River lithology (Russell, 1932c, p. 128). Above the beds at Carmangay exposures are poor, but in SW. $\frac{1}{4}$ sec. 11, tp. 14, rge. 25, W. 4th mer., soft grey sandstones and rubbly green shales with white weathering concretions are present. From this outcrop Russell reported the occurrence of the metatarsal of a hadrosaurian dinosaur. Farther upstream, in NW. $\frac{1}{4}$ sec. 26, tp. 14, rge. 25,

[1] The fauna of this unit suggests brackish-water rather than truly marine conditions. It is, therefore, here referred to as the Drumheller member. Sanderson's (1945, p. 79) record of the marine Fox Hills species *Cucullaea shumardi* (M. and H.), *Callista deweyi* (M. and H.), and *C. nebrascensis* M. and H. from the "marine tongue" was based upon incorrect identifications. Sanderson's collections are at the Royal Ontario Museum, Toronto; his *C. shumardi* proves to be an indeterminable nuculid and his identifications of *C. deweyi* and *C. nebrascensis* were based on specimens of *Corbicula occidentalis* (M. and H.).

W. 4th mer., mottled shales with a profusion of white weathering concretions are exposed and these occurrences suggest the northern continuation of the Willow Creek formation. The adjacent outcrop upstream is a conglomeratic sandstone correlated by Bell (1949, p. 12) with the base of the Paskapoo formation. Although sediments typical of the Willow Creek and St. Mary River formations are represented in the Little Bow River section, probably all the beds below the conglomerate are best referred to the Edmonton formation, for owing to lack of outcrops in the critical part of the section, the horizon equivalent to the St. Mary River-Willow Creek contact cannot be recognized.

The contact between the Edmonton and the overlying Paskapoo is discussed under the latter formation.

Fauna and Correlation. Fossil invertebrates are not widely distributed stratigraphically in the Edmonton formation. Coquinoid limestones of oyster shells occur near the base on Little Bow and Red Deer Rivers, and brackish-water fossils are also present in the Drumheller member. From the Red Deer Valley in the vicinity of Drumheller, Warren (1926) has recorded the following species from this member: *Nucula subplana* M. and H. ?, *Anomia micronema* Meek, *Mytilus albertensis* Warren, *Volsella dichotoma* Whiteaves, *Ostrea glabra* M. and H., *Corbicula occidentalis* (M. and H.), *C. cytheriformis* (M. and H.), *Corbula subtrigonalis* M. and H., *Panope ? simulatrix* Whiteaves, *Lunatia obliquata* (Hall and Meek), *L. dakotensis* (Henderson). At the mouth of East Arrowwood Creek on Bow River, the following species were collected from the Drumheller member: *Anomia micronema* Meek, *Mytilus* sp. indet., *Ostrea glabra* M. and H., *Unio stantoni* White, *Corbicula occidentalis* (M. and H.), *Sphaerium heskethense* Warren, *Panope ? simulatrix* Whiteaves, *"Neritina" bruneri* White, *"Melania" wyomingensis* Meek ? . The fauna of the Drumheller member on Bow River differs from that of the typical development in that freshwater genera are present, which presumably indicates less saline conditions of deposition. These faunules do not assist in correlation as most of the species are characteristic of brackish-water beds throughout the Montana group.

Determinable freshwater molluscs are known only in the lower part of the Edmonton formation. The composition and distribution of this fauna is shown in Table II, page 15. The freshwater fauna of the lower Edmonton is closely related to that of the St. Mary River formation, but it differs in the paucity of freshwater pulmonates and the complete absence of terrestrial species. The relative persistence of many horizons within the formation suggests moderately uniform conditions of deposition over a wide area and the intercalation of the Drumheller member indicates deposition close to the strand line for the lower part of the formation. A number of the species referred to freshwater genera that occur in the Edmonton are rare or absent in the contemporary St. Mary River beds that undoubtedly represent a freshwater facies. *Corbula* cf. *subtrigonalis* M. and H. occurs with freshwater genera in the Edmonton formation. This genus, which may be interpreted as indicating somewhat brackish-water conditions, is quite unknown in the freshwater beds of the St. Mary formation. It, therefore, seems likely that *Viviparus tasgina* Dyer,

Table II.

Distribution of molluscan fauna of the Edmonton formation of the Plains

Localities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Unio sandersoni Warren					×											
U. stantoni White		×	×	×	×		×	×		×		×				
Plesielliptio sp. indet.											×					
Sphaerium heskethense Warren	×			×			×	×	×		?		×			
Corbula sp. cf. *C. subtrigonalis* M. and H.							×	×								
Viviparus prudentius prudentius White															×	
V. tasgina Dyer					×	×	×	×			×					
V. westoni sp. nov.			×		×		×	×	×			×		×	×	
Campeloma edmontonensis sp. nov.					×			×	×		×	?				×
Lioplacodes limnaeformis (M. and H.)	×			×	×			×			×		×			×
L. sanctamariensis (Russell)	×								×							
L. sp. cf. *L. tenuicarinata* (M. and H.)					×											
L. whiteavesi (Russell)													×			
Reesidella sp. cf. *R. protea* (Yen)														×	×	
Goniobasis webbi Dyer	×				×		×	×	×							×
Valvata filosa Whiteaves							×									
Pleurolimnaea mclearni sp. nov.							×									
Physa spp. indet.							×		×			×		×		

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Lioplacodes limnaeformis (M. and H.), and *Goniobasis webbi* Dyer all of which are common in the Edmonton, and the first of which is absent and the other two scarce in the St. Mary River beds, may have become adapted to somewhat brackish-water conditions.

The vertebrate faunas of the Edmonton formation provide the most satisfactory evidence regarding its age. Sternberg (1947, 1949) has recently shown that two dinosaur faunas are present. The lower fauna, which occurs below the Battle equivalent, presumably represents late Pierre and Fox Hills time; the upper fauna, which includes *Triceratops*, is confined to the upper Edmonton beds and indicates a correlation with the Lance, Hell Creek, and Frenchman formations of Wyoming, Montana, and the Cypress Hills of Saskatchewan respectively. This evidence establishes that the Battle and Whitemud equivalents mark the Fox Hills-Lance boundary, and according to Fraser *et al.* (1935, p. 35) the stratigraphic correlation of the typical Whitemud formation with the Colgate sandstone, at the top of the Fox Hills in Montana and North Dakota, leads to the same conclusion. The stratigraphic correlation with the section on Oldman River made possible by these ubiquitous units has been described on page 9 and the consequent correlation of the lower Edmonton with the St. Mary River formation and the upper part with the lower part of the Willow Creek is in harmony with the available evidence of the molluscan faunas, although as yet the characteristic fauna of the lower Willow Creek beds has not been found in the upper Edmonton. It is possible (*See* page 17) to establish that equivalents of the upper and lower parts of the typical Edmonton are present in the Edmonton beds of the Disturbed belt, south of Bow River, but in the beds to the north, and in the Brazeau formation, palæontological evidence is available for the recognition of lower, but not upper, Edmonton equivalents.

EDMONTON FORMATION OF THE DISTURBED BELT

Stratigraphy. Cairnes (1906, p. 63) first applied the term "Edmonton" to strata in the Disturbed belt believed to occupy the same stratigraphic position as the typical Edmonton formation. Slipper (1921), Hume (1931, 1936, 1941, 1942, 1949), Rutherford (1927), MacKay (1938), and Beach (1942 a, b) have mapped the Edmonton in the Disturbed belt between townships 15 and 34. Between North Saskatchewan and Athabasca Rivers MacKay (1943 a, b) has mapped certain strata as the Edmonton formation but these beds have been shown by Lang (1947) and Bell (1949) to be of Paleocene age. The definition of the Edmonton formation north of Highwood River is not easy, as the marine Bearpaw shale, the top of which is defined as the base of the typical Edmonton formation, is replaced by continental sediments similar in appearance to those of the basal Edmonton.

In the Disturbed belt, the sediments of the Edmonton formation comprise hard, medium-grained, grey to buff weathering sandstones; soft grey sandstones; and friable, silty, grey and green shales. In Marble Mountain map-area Beach (1942b, p. 11) described the sandstones as bentonitic and white weathering. MacKay (1938) and Rutherford (1927) note thin coal seams in this area and elsewhere. Various estimates of the thickness have been given, but owing to the uncertain nature of the position of the top and bottom of the formation precise determinations are impossible at present. In the vicinity of Turner Valley, Hume (1949) recorded 1,100 feet in the Arca well, but on Highwood River, 15 miles to the north, the writer has referred 1,800 feet of beds, without an exposed base, to the formation. The difference in thickness is accounted for by the inclusion of beds mapped as Paskapoo by Hume in the Edmonton as defined by the writer. In Fallentimber map-area MacKay (1938, p. 4) estimates a thickness of 3,000 feet, and on James River Beach (1942, p. 2) records a thickness of approximately 3,800 feet for the Edmonton formation.

Various criteria have been employed to define the base of the Edmonton formation in the Disturbed belt. South of Highwood River the Bearpaw can be recognized but here owing to poor exposures and also to faulting the actual contact has not been observed.

On Highwood River, in sec. 9, tp. 18, rge. 2, W. 5th mer., an intensely faulted section exposes fissile shales, coal beds, and oyster coquinas (Slipper, 1921, p. 13). The precise relationship between these beds and the unfaulted Edmonton section, which starts about 1 mile to the east (*See* Figure 3, in pocket), cannot be determined but these beds may be regarded as a homotaxial equivalent of the basal member of the St. Mary River formation, and presumably constitute the basal part of the Edmonton. On Bow River, Rutherford (1927, p. 35) and Russell (1932c, p. 143) place the contact at the coal seams at the mouth of Grand Valley Creek, but Hume (1932, 1942) has mapped the contact lower in the section. In Wildcat Hills and Marble Mountain map-areas Hume (1936, p. 6) and Beach (1942a, p. 11) define the base of the Edmonton at a conglomerate carrying pebbles and cobbles of quartzite, porphyry, and coloured cherts. In the intervening Fallentimber map-area, MacKay (1938, p. 7) maps a 6-foot coal seam as the basal Edmonton stratum.

Traceable horizons within the Edmonton formation have not been recognized except on Highwood River where a zone, approximately 100 feet thick, and consisting of medium-grained, buff weathering sandstone, is present 940 feet from the top of the formation. This may represent the "blocky sandstone" member of the St. Mary River formation mapped by Douglas (1950, 1951) in the southern Foothills (*See* Figure 3).

The contact with the overlying Paskapoo formation is discussed below (*See* page 31).

Fauna and Correlation. The fauna of the Edmonton formation in the Disturbed belt is listed in Table III, page 18. Two faunas are represented, a lower one closely related to that of the St. Mary River formation, and an upper fauna, including *Viviparus prudentius willovensis* subsp. nov. and *Pseudocolumna spitzia* sp. nov., indicating a correlation with the lower part of the Willow Creek. It has not been possible, as yet, to relate these faunas to mappable units within the formation. The upper fauna is present on Highwood River, Jumpingpound Creek, and Bow River. North of Bow River the Edmonton beds are not very fossiliferous, but unio beds in the lower part of the formation on Bow and Little Red Deer Rivers have yielded an unusually rich fauna (Russell, 1932c, p. 143). *Proparreysia holmesiana* (White) and *Plesielliptio brachyopisthus* (White), present in the Little Red Deer bed, are not known at any other locality in Canada.

Table III.
Distribution of molluscan fauna of the Edmonton formation of the Disturbed belt

Localities	1	2	3	4	5		6	7	8	9
	Lower Fauna						Upper Fauna			
Unionidae genus indet.	×			×			×			×
Unio stantoni White					×					
Plesielliptio brachyopisthus (White)					×					
Proparreysia holmesiana (White)					×					
Sphaerium gietzi sp. nov.								×		
Viviparus prudentius prudentius White			×							
V. prudentius willovensis subsp. nov.							×	×	×	×
V. westoni sp. nov.		×	×		×		×	×		×
Campeloma edmontonensis sp. nov.	×									
Lioplacodes limnaeformis (M. and H.)	×									
L. sp. cf. *L. tenuicarinata* (M. and H.)	×							×	×	
L. whiteavesi (Russell)	×									
Reesidella sp. cf. *R. protea* (Yen)		×	×					×		
Valvata filosa Whiteaves								×	×	×
Hydrobia spp. indet.							×	×		
Physa canadensis Whiteaves	×						×	×	×	
Oreohelix angulifera (Whiteaves)			×							
Polygyra parvula (Whiteaves)		×								
Pseudocolumna ? spitzia sp. nov.							×	×	×	

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These species were described from "alternating brackish-water and fresh water beds" (Henderson, 1935, p. 32) at Black Buttes, Wyoming, which Stanton (in Henderson, 1935) considers of Lance age, but from the stratigraphic position of these shells in Alberta probably they represent a pre-Lance horizon.

In conclusion, in the Disturbed belt between Highwood and Bow Rivers the Edmonton formation may be correlated with the St. Mary River and the lower part of the Willow Creek formations. North of Bow River, equivalence with the St. Mary River formation may be assumed, but palæontological evidence for correlation with younger beds is not available.

BRAZEAU FORMATION

Stratigraphy. The term Brazeau was first applied to the continental sediments overlying the Wapiabi shale in the Bighorn coal basin by Malloch (1911, p. 37), but in this basin the Brazeau is the youngest formation present and the top cannot be defined. In mapping between North Saskatchewan and Athabasca Rivers MacKay (1943b, p. 4) defined the top of the Brazeau at a conglomerate exposed on Blackstone River, which was regarded as marking the top boundary with the Edmonton formation. A conglomerate has been mapped in a similar stratigraphic position in the Entrance map-area by Lang (1947). Lang originally considered this bed, named the Entrance conglomerate, to mark the lower boundary of the Edmonton formation, but the palæobotanical studies of Bell (1949, p. 10, and in Lang, 1947, p. 37) have shown that an Edmonton flora is present below the conglomerate. Bell also reports Paleocene plants from horizons 900 and 400 feet respectively above an equivalent of the Entrance conglomerate at Coalspur and on North Saskatchewan River. Thus, probably the Brazeau as mapped by MacKay and Lang includes equivalents of the Belly River, Bearpaw, and Edmonton formations farther south, and the term is now restricted by the Geological Survey to include the continental beds between the Wapiabi shale and the Entrance conglomerate (Bell, 1949, p. 5). As such, the Brazeau formation can be mapped from the North Saskatchewan to Wildhay River (Irish, 1946); farther north exposures are not plentiful in the area of the upper boundary (Irish, 1950, p. 21; 1952, p. 22). The Brazeau formation, thus defined, constitutes the Cretaceous part of the Saunders group (Allan and Rutherford, 1923, p. 51) and the Foothills series (Allan and Rutherford, 1934, p. 34).

In Marble Mountain map-area Beach (1942a, p. 10) referred to the Brazeau formation beds underlying a conglomerate on James River. These beds are apparently equivalent to the Belly River formation, and the usage of Brazeau as synonymous with the Belly River, is very different from the usage of Bell (1949, p. 5) in the area farther north.

The lithology of the Brazeau formation has been described by MacKay (1943b), Lang (1947, p. 32), and Irish (1946, p. 3; 1950, p. 31). At the base about 100 feet of buff weathering, fine-grained, greenish grey sandstone is referred to as the Solomon sandstone member. The succeeding 2,000 feet is characterized by sandstone, at many places conglomeratic, interbedded with friable shales. In the upper part conglomerate is less common and the lithology closely resembles that of the Edmonton and

St. Mary River formations in the Disturbed belt farther south. On Wildhay River, Irish (1946, p. 2) estimated the thickness of the formation as 7,000 feet, Lang (1947, p. 33) reported 6,000 feet in Entrance map-area and in Wawa Creek map-area, and MacKay (1943b, p. 3) indicated that 4,700 feet of Brazeau beds are present.

Fauna and Correlation. Molluscan remains are rare in the Brazeau formation. On Shunda Creek 1 mile west of Stolberg (locality 12337 of Erdman, 1950, p. 87) the writer collected some poorly preserved molluscs that include *Viviparus* cf. *westoni* sp. nov., *Sphaerium* cf. *heskethense* Warren, and *Sphaerium* sp. indet. With these shells a tooth fragment of an armoured dinosaur[1] was collected. The bed from which these fossils were collected is close to the axis of the Stolberg anticline, but owing to faulting and discontinuous exposures the precise relationship to the outcrop of the Entrance conglomerate (Erdman, 1945, p. 12; Bell, 1949, p. 6) on North Saskatchewan River cannot be determined. This faunule, which suggests equivalence with the St. Mary River formation, is, however, presumably from the upper part of the Brazeau.

The stratigraphic and palæobotanical evidence suggests that the Brazeau formation includes the equivalents of the Belly River and Edmonton formations farther south. Unfortunately neither the molluscs nor the fossil plants (Bell, 1949, pp. 20, 21) provides definite information as to whether or not upper Edmonton (Lance) equivalents are present.

WAPITI GROUP

Stratigraphy. The Wapiti group was defined by Dawson (1881, p. 115) to include the non-marine "sandstones and shales with lignitic coals" above the Smoky formation on Smoky and Wapiti Rivers. In addition to Dawson, McLearn (1919, p. 5), Rutherford (1930, p. 30), Evans and Caley (1930, p. 38), and Allan and Carr (1946, p. 14 *et seq.*) have described the lithology and stratigraphy of the Wapiti group, and Bell (1949, p. 8) has summarized the work of the above authors. Allan and Carr (op. cit.) divided the group into five members, designated A-E in ascending order and respectively 1,000-1,300, 500, 1,000, 500, and 1,000 feet thick. Members B, C, and E carry coal seams.

Fauna and Correlation. Apparently the lower part of the Wapiti group is not very fossiliferous, although scattered dinosaur bones occur. Allan and Carr (op. cit., p. 23) mention that invertebrates are common in members D and E. The material of the collections from the Wapiti group made by L. D. Burling in 1945 is not well preserved. Five lots are present (G.S.C. collections 14389-14393) for all of which the catalogued locality is "Nose Mountain". According to Allan and Carr (op. cit., pp. 19, 21), the strata at this locality are referable to members D and E. The fauna of the four lots other than 14392 comprises the following species: *Sphaerium* sp. indet., *Viviparus prudentius* White ?, *V. westoni* sp. nov., *Lioplacodes whiteavsi* (Russell) ?, *Reesidella* sp. indet., *Polygyra parvula* (Whiteaves), *Polygyra* ? sp. Lot 14392 includes some very crushed

[1] Identified by Dr. L. S. Russell, Chief, Zoology Section, National Museum of Canada

sinistral shells, which may be referred to as *Pseudocolumna spitzia* sp. nov. ?. The faunules with *P. parvula* suggest a correlation with the St. Mary River formation; the crushed shells referred tentatively to *P. spitzia* indicate a correlation with the lower part of the Willow Creek formation, but as the determinable species from the lots other than 14392 range up into the lower Willow Creek fauna, all the collections probably indicate the latter correlation, and this implies that the Wapiti group includes equivalents of the upper Edmonton. This conclusion is in agreement with that of Bell (1949, p. 21), based upon his study of the flora.

WILLOW CREEK FORMATION

Stratigraphy. The Willow Creek formation was defined by Dawson (1883, p. 3) as the middle of the three divisions of the "Laramie" of southwestern Alberta and was separated from the underlying St. Mary River and overlying Porcupine Hills formations primarily on the basis of the reddish coloration of the shales, but also, to some extent, on its weathering characteristics.

The Willow Creek formation extends from Glacier county, Montana (Stebinger, 1916, p. 127), to about township 14 in Alberta. South of the Peigan Indian Reservation the formation lies across the axis of the Alberta syncline and the top is the recent erosion surface. At the Indian Reservation an outlier of the Porcupine Hills formation overlies the Willow Creek beds. North of Oldman River, which cuts through the Porcupine Hills formation, the Willow Creek beds form two belts of outcrop, the one on the east and the other on the west side of the Alberta syncline.

Typical sediments of the Willow Creek formation comprise soft, grey, medium-grained sandstones, and friable or clayey shales of grey, green, and pink colour. The shales in many outcrops carry an abundance of white weathering calcareous concretions. Thin beds of grey, fossiliferous limestone are present in the upper part west of Granum. In the upper part of the Willow Creek formation massive and crossbedded, buff weathering sandstones occur and these express the transitional relationship with the overlying Porcupine Hills formation. The typical, lower part of the formation at some localities weathers to form "badlands", which, in some areas, such as Mokowan Butte, in the Blood Indian Reserve, reach spectacular proportions.

On Castle River, in the Disturbed belt, 4,135 feet of beds are referred to the Willow Creek formation (*See* Figure 3). In the Plains area, on Oldman River, Russell (1932c, p. 140) estimated the Willow Creek formation to be about 1,200 feet thick. The uncertain situation (page 27) regarding the equivalence of the contact with the overlying Porcupine Hills formation on the east and west sides of the Alberta syncline suggests that these divergent thicknesses do not represent contemporaneous accumulation of sediment.

On the east side of the Alberta syncline, on Oldman River, the base of the formation is placed at the top of the Battle equivalent of the St. Mary River formation (Tozer, 1952, p. 7). This contact is close to that defined by Russell (1932c, p. 139; 1940, p. 92) and about 200 feet below the contact mapped by Williams and Dyer (*See* Map 204A), who regarded the lowest red shale horizon as the base of the Willow Creek formation. The writer is in agreement with Russell's (1932c, p. 139) conclusion that the 200 feet of sombre-coloured beds below the lowest red shale are more suggestive of the Willow Creek than the St. Mary River formation. Furthermore, the placing of the contact at the top of the Battle equivalent alines the St. Mary River-Willow Creek boundary with that between the lower and upper parts of the Edmonton formation.

On Milk River, Russell (1940, p. 92) describes the lithological break with the underlying St. Mary River formation as abrupt, but apparently the Whitemud and Battle equivalents are unrecognizable in this section.

North of Oldman River the principal outcrops are of Willow Creek. The lithology is typical but the pink coloration is not well developed.

Beds of Willow Creek lithology are present on Little Bow River, below the conglomerate correlated with the basal Paskapoo by Bell (1949, p. 12). Above this conglomerate beds of Willow Creek type are present on Mosquito Creek, 5 miles southeast of Nanton, and intervening outcrops are of rocks of typical Paskapoo lithology. In this area the rock sequences typical of the eastern and southern parts of the Alberta syncline are clearly interfingering (*See* also page 9) and the point at which the nomenclatorial change takes place, therefore, is arbitrary. The writer proposes that at township 13 the terms Edmonton and Paskapoo be substituted for St. Mary River, Willow Creek, and Porcupine Hills of the south: the choice of township 13 is largely one of convenience for north of this latitude exposures are poor along the interval followed by the St. Mary River-Willow Creek boundary, which falls within the Edmonton formation.

On the west side of the Alberta syncline detailed studies of the Willow Creek formation have been made by Douglas (1950, and personal communication). In Callum Creek map-area Douglas (op. cit., p. 45 *et seq.*) divides the Willow Creek formation into five members, designated A to E in ascending order. Member A consists of soft grey sandstone and grey, green, and purplish shales some of which carry abundant calcareous concretions. Member B differs from member A in that red shales are also present. Member C consists of relatively coarse to conglomeratic, grey weathering sandstone. Soft grey sandstone and varicoloured shales with concretions comprise member D. Member E, the uppermost, is characterized by the appearance of thick beds of massive, buff weathering sandstone interbedded with more normal Willow Creek sediments. On Oldman River, members A, B and C are 536, 246, and 15-30 feet thick respectively. Members D and E are poorly exposed and combined consist of about 1,900 feet of strata.

These zones have been recognized by Douglas (1951, and personal communication) on Crowsnest and Castle Rivers and Pincher Creek, and doubtfully on Waterton River. Their relative thicknesses and relation to fossiliferous beds are summarized in Figure 3.

The contact with the underlying St. Mary River formation is transitional in the Disturbed belt. Beds of the Whitemud and Battle equivalents have not been observed. Douglas (1950, p. 44) draws the contact at the point of change from hard, fine to medium-grained, green weathering, grey sandstones to soft, medium-grained, grey weathering sandstones. The green weathering sandstones are characteristic of the upper part of the St. Mary River formation, and relatively thick beds of the grey weathering sandstone type are present in most sections of the lower part of the Willow Creek formation. Corresponding with this change in the character of the sandstones, white weathering concretions appear in abundance, and the interbedded shales become less coherent.

Douglas' stratigraphic studies suggest that member A becomes thinner when traced south from Oldman River, and on Waterton River, probably is absent (*See* Figure 3). The first appearance of red shale is not a reliable horizon, for this probably rises in the section from south to north on both sides of the Alberta syncline. No apparent correlation is evident between these members in the Disturbed belt and the Willow Creek beds on the east limb of the Alberta syncline.

Bell (1949, p. 11) has proposed a stratigraphic division of the Willow Creek formation on the east limb of the Alberta syncline at the base of a conglomeratic sandstone occurring on Willow Creek, southwest of Granum, in NE. $\frac{1}{4}$ sec. 12, tp. 10, rge. 27, W. 4th mer. Bell correlates this bed with the conglomerate considered the base of the Paskapoo on Little Bow River (*See* page 30). Paleocene molluscs have not been found below this horizon but are common above, and this conglomerate probably marks the Cretaceous-Tertiary boundary.

The relationship between the Willow Creek and the overlying Porcupine Hills formation is discussed below (*See* page 27).

Fauna and Correlation. The Willow Creek formation contains two distinct molluscan faunas that will be discussed separately. The composition and distribution of the fauna of the lower part of the Willow Creek formation is summarized in Table IV, page 24. This fauna consists largely of aquatic molluscs, but two gastropods of undoubted terrestrial habitat are represented. All collections have been obtained from sections adjacent to the Disturbed belt, where fossils are very common but are generally poorly preserved. The lower part of the Willow Creek formation on the east side of the Alberta syncline is apparently quite unfossiliferous. In the disturbed hill a moderately rich fauna has been obtained and its composition is of considerable interest. With two exceptions, all determinable species also occur in the St. Mary River formation. The presence of *Viviparus westoni* sp. nov. and *Polygyra parvula* (Whiteaves), in particular, emphasizes the close relationship between the faunas of the St. Mary River and lower Willow Creek beds. Apart from indeterminable fragments of physids, the two species encountered in most beds are *Viviparus prudentius willovensis* subsp. nov. and *Pseudocolumna? spitzia* sp. nov. These species are confined to the lower Willow Creek and the equivalent part of the Edmonton formation of the Disturbed belt. Fortunately, they possess distinctive characters that enable their identification at many localities where the other fossils are poorly preserved. The most noteworthy feature of the lower Willow Creek fauna is the complete absence of characteristic Fort Union species such as *Viviparus retusus* (M. and H.) and *Lioplacodes nebrascensis* (M. and H.), which are common in the fauna of the upper part of the formation.

Table IV.

Distribution of molluscan fauna of the Willow Creek formation (lower part)

Localities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Unio stantoni White					×		×													×			
Sphaerium gietzi sp. nov.													×										
S. heskethense Warren					?	?					?												
Dimorphoptychia sp. cf. *D. rutherfordi* (Russell)	×																						
Viviparus prudentius prudentius White											×												
V. prudentius willovensis subsp. nov.	×	×								×		×	×	×				×	×				
V. westoni sp. nov.				×	×	×		×			×									×			
Campeloma edmontonensis sp. nov.											?												
Lioplacodes limnaeformis (M. and H.)											?												
L. sanctamariensis (Russell)					?																		
L. sp. cf. *L. tenuicarinata* (M. and H.)				×							×	×					×					×	
Reesidella sp. cf. *R. protea* (Yen)											×										×		×
Valvata filosa Whiteaves		×		×							×						×						
Hydrobia sp. indet.	×	×		×													×					×	
Pleurolimnaea mclearni sp. nov.															×		×						
Physa canadensis Whiteaves								×								×						×	×
Ferrissia sp. indet.									×														
Polygyra parvula (Whiteaves)			×						?					×									
Pseudocolumna ? spitzia sp. nov.	×	×	×	×							×			×	×	×	×						

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This fauna is distributed throughout members A, B, and the lower part of member D, of the Willow Creek formation. Member C has not yielded molluscs but a large dinosaur bone[1] collected from this member on Crowsnest River indicates a Cretaceous age for the beds as high as member C. The occurrence of the Battle equivalent at the top of the St. Mary River formation on Oldman River (*See* page 9), suggests that the lower part of the Willow Creek formation is of Lance age in that section. If a correlation of the base of the Willow Creek formation across the Alberta syncline be accepted, a Lance age for members A, B, and C of the Willow Creek of the southern Disturbed belt is postulated.

The molluscan fauna of the Lance and equivalent Hell Creek formation, however, does not support this correlation. Published lists (Henderson, 1935, p. 33) of the Lance invertebrate fauna include genera such as *Ostrea, Anomia, Corbicula,* and *"Melania"*, which indicate a brackish-water environment, such as prevailed during the deposition of the basal member of the St. Mary River formation. From the Hell Creek formation of Montana, Whitfield (1903, 1907) has described a rich fauna of highly sculptured unionids. As noted by White (1877) the rich and varied unionid faunas of the uppermost Cretaceous usually occur in brackish-water sediments, or strata interbedded therewith, and the occurrence of *Corbicula subelliptica* (M. and H.) in the Hell Creek beds supports the application of this conclusion to this fauna. It would, therefore, appear that the environment of deposition of the Lance and Hell Creek formations precludes a correlation with the truly non-marine lower Willow Creek beds by means of molluscan faunas. Nevertheless, the available evidence, both palæontological and stratigraphic, supports the correlation of the lower Willow Creek beds with the upper part of the typical Edmonton formation and, therefore, with other formations of Lance age.

The upper part of the Willow Creek formation contains a typical Paskapoo-Fort Union molluscan fauna, the composition of which is shown in Table V, page 26. Aquatic species, such as *Viviparus retusus* (M. and H.), *V. planolatere* Russell, *Lioplacodes nebrascensis* (M. and H.), and the land snails, *Dimorphoptychia douglasi* sp. nov., *Oreohelix thurstoni* (Russell), and *Grangerella mcleodensis* (Russell), are abundant and widely distributed. None of these species occurs in the lower beds of the formation, and all occur in the Paskapoo, of Paleocene age. This fauna is well developed in member E within the Disturbed belt, but on Waterton River a molluscan faunule, probably of Paleocene age, was collected 5 feet below the sandstone identified provisionally as the base of this member (locality 23). On the east side of the Alberta syncline the Paleocene faunules occur above the conglomeratic bed described by Bell (1949, p. 12), but on the west side the appearance of the Paleocene molluscs is not apparently related to any mappable stratigraphic horizon. It is not possible to differentiate molluscan faunas within the Paleocene but in view of the conformable relations between the Cretaceous and Paleocene parts of the Willow Creek

[1] Identified by Dr. L. S. Russell, Chief, Zoology Section, National Museum of Canada.

Table V.
Distribution of molluscan fauna of the Willow Creek formation (upper part)

Localities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Unio sp. cf. *U. proavitus* White				X																			
Plesielliptio priscus (M and H.)			X				X		X											X			
Sphaerium aequale Russell	X							X															
S. formosum (M and H.)	X								X														
Dimorphoptychia douglasi sp. nov.																		X	X	X		?	
D. rutherfordi (Russell)					X	X						X					X		X	X		X	X
Grangerella mcleodensis (Russell)											X	X	?				X				X		
Viviparus leai (M and H.)		?				?	?							?		?							
V. planolatere Russell									X							X							
V. retusus (M and H.)							X			X	X												
Lioplacodes limnaeformis (M and H.)			X						X					X									
L. nebrascensis nebrascensis (M and H.)			X							X													
L. nebrascensis producta (White)							X		X		X			X									
L. tenuicarinata (M and H.)	X	X							X		X												
Reesidella sp. cf. *R. protea* (Yen)											X					X							
Valvata sp. cf. *V. subumbilicata* (M and H.)	X																						
Hydrobia spp. indet.	X					X			X														
Pleurolimnaea tenuicosta (M and H.)[1]																							
Physa canadensis Whiteaves	X	X	X				X		X		X		X			X			X	X			
Oreohelix thurstoni (Russell)					X	X	X	X			X	X			X			X					
Pseudocolumna haydeniana (Cockerell)	X															X	X						

[1] Russell, 1932c, p. 140

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on the west side of the syncline probably Lower and Middle Paleocene equivalents are present. With this reservation it is only possible to state that the upper part of the Willow Creek formation is of Paleocene age, and correlated with part of the Paskapoo formation of central Alberta, the Ravenscrag of Saskatchewan, and the Fort Union group of North Dakota, Montana, and Wyoming.

PORCUPINE HILLS FORMATION

Stratigraphy. The Porcupine Hills formation comprises the uppermost division of the "Laramie" of Dawson (1883, p. 4) in southwestern Alberta. The typical area for the formation is between Oldman River and township 13. In this region the topographic expression of the hard sandstones, characteristic of the formation, forms the range of hills from which the beds take their name. The formation also outcrops as an outlier between Oldman and Waterton Rivers in the Peigan Indian Reservation.

Typically, the Porcupine Hills formation consists of thick, crossbedded, moderately coarse, grey, buff weathering sandstones that alternate with lesser amounts of friable, grey, silty shale. True conglomerate is rare, but autochthonous conglomerates of calcareous, argillaceous, and carbonaceous material embedded in a coarse sandstone matrix are widespread, and are commonly developed at the lower contact of the sandstone beds. In Callum Creek map-area Douglas (1950, p. 50) reports the Porcupine Hills formation as about 4,000 feet thick.

On the east side of the Alberta syncline the Willow Creek-Porcupine Hills contact has been mapped by Williams and Dyer (*See* Map 204A). The authors note that "the line between the Willow Creek and Porcupine Hills formations is vague owing to the transitional relations, but is drawn at the point where hard beds of sandstone begin to comprise the major part of the rock" (Williams and Dyer, 1930, p. 39). One mile west of Brocket, a coarse sandstone outcrops above the railway grade. Typical Willow Creek sediments, which include red shale, outcrop at the highway below. R. J. W. Douglas (personal communication) considers this sandstone to represent the continuation of a limestone pellet conglomerate exposed on a tributary to Crowlodge Creek, placed at the base of the Porcupine Hills formation on the Pincher Creek sheet (Douglas, 1951).

On Castle River, on the west side of the Alberta syncline, excellent exposures reveal a transitional relationship between the Willow Creek and Porcupine Hills formations. This section is summarized in Figure 3. The horizon selected by Hage (1943) as the Willow Creek-Porcupine Hills contact is lower in the section than the sandstone exposed near Brocket. Douglas (personal communication), from an examination of air photographs, suggests that an approximate equivalent of the bed at Brocket is present on Castle River in l.s. 2, sec. 24, tp. 7, rge. 1, W. 5th mer. At this locality a 20-foot thick bed of crossbedded, buff weathering sandstone overlies typical Willow Creek sediments, including soft grey sandstone, black shales, and a 1-foot bed of reddish shale. The base of this sandstone is approximately 1,300 feet above the contact as mapped by Hage (1943).

This sandstone may be correlated with a somewhat similar sandstone overlying typical Willow Creek sediments on Oldman River near the centre of sec. 35, tp. 7, rge. 1, W. 5th mer. The base of the sandstone here is 440 feet above the contact suggested by Bell (1949, p. 12) and 1,090 feet above that mapped by Hage (1943).

Douglas (1950, p. 44 *et seq.*) has described an erosional unconformity between the Willow Creek and Porcupine Hills formations in Callum Creek and Langford Creek map-areas. The basal sandstone of the Porcupine Hills formation from south to north is stated to rest upon members D, C, and B of the Willow Creek formation on North Creek, Rice Creek, and east of the Chain Lakes respectively. Although the successive zones of the Willow Creek formation are truncated, it is possible that the stratigraphic equivalent of the sandstone at the base of the Porcupine Hills formation in Langford Creek map-area is within member E of the Willow Creek formation on Castle River.

Bell (1949, p. 12) doubts the significance of the unconformity mapped by Douglas, and the situation is anomalous in view of the transitional relationship between the formations at the same latitude on the east side of the Alberta syncline. Possibly the unconformity described by Douglas in Langford Creek map-area is the correlative of the horizon dividing the Willow Creek formation west of Granum (Bell, 1949, p. 12) (*See* page 25), which probably represents the Cretaceous-Tertiary boundary. This interpretation, which the writer proposes, is in harmony with the available palæontological evidence but cannot be confirmed owing to the present difficulty of tracing lithological units in these beds across the Alberta syncline.

The Willow Creek-Porcupine Hills contact does not present a reliable chronological marker and a more reliable stratigraphic datum might be the lowest point at which Paleocene molluscs appear in the section. On the west side of the Alberta syncline this corresponds fairly closely with the base of member E of the Willow Creek formation, i.e., the horizon at which buff weathering sandstones of Porcupine Hills type appear in the section. The base of member E, however, is lower in the section than the point at which Porcupine Hills sediments succeed typical Willow Creek sediments on the east side of the Alberta syncline, for Paleocene molluscs occur near Granum in beds at least 400 feet below the Willow Creek-Porcupine Hills boundary as placed on the Calgary sheet.

Fauna and Correlation. The only determinable fossils from the Porcupine Hills formation as delimited above are *Grangerella mcleodensis* (Russell) and *Oreohelix thurstoni* (Russell), collected from the Oldman River section. These species are characteristic members of the Paleocene fauna in Alberta, and they confirm the stratigraphic correlation of the Porcupine Hills formation with an upper part of the Paskapoo.

PASKAPOO FORMATION

Stratigraphy. The Paskapoo formation was defined by Tyrrell (1887, p. 137E) as "all the Laramie rocks lying above the Edmonton series . . . ". The top of the Paskapoo is the recent erosion surface; the formation is thick and outcrops over a large area. Most workers are in agreement that few, if any, beds within the Paskapoo formation can be traced for any considerable distance along their strike; furthermore, correlations of beds across the strike are most unsatisfactory. In the area where the Paskapoo is developed, the Cretaceous-Paleocene boundary on the west side of the Alberta syncline is the only definite feature that can be correlated with the typical Edmonton-Paskapoo boundary on the east side of this structure. All the strata occupying the syncline above this contact, therefore, with propriety, may be referred to the Paskapoo formation. The original definition of Paskapoo, accordingly, is amended to include all Paleocene rocks in western Alberta north of township 13. As will be noted below, however, these contacts may not be strict correlatives in age, for probably older Paleocene sediments were deposited on the west than on the east side of the syncline. Thus, defined, the Paskapoo formation includes the Paleocene part of the Saunders group (Allan and Rutherford, 1923, p. 51) and the Foothills series (Allan and Rutherford, 1934, p. 34) as mapped within the central Foothills; it also includes the post-Brazeau, Paleocene beds of Irish (1946, p. 4) and Lang (1947a, p. 34; 1947b, p. 13) as defined in the Disturbed belt of the Athabasca River area.

The Paskapoo formation consists of massive, frequently crossbedded, buff weathering, moderately coarse-grained sandstones; hard to soft, grey, fine-grained sandstones; and green and grey, friable, frequently silty shales. Thin beds of argillaceous and siliceous, fossiliferous limestone are also present. Algal limestone has been noted at various localities by Rutherford (1947, p. 53). Conglomerate is rare and is usually present as thin lenticular cobble layers, notable exceptions being the basal conglomerate (Entrance conglomerate) developed at the western contact of the formations between Wildhay and North Saskatchewan Rivers, and a thick local cobble conglomerate on High Divide Ridge, south of Athabasca River (Rutherford, 1925, p. 46; Lang, 1947a, p. 35). Thick coal seams of economic importance, the "Saunders Coal Series" of Allan and Rutherford, are developed in the lower part of the formation between North Saskatchewan and Athabasca Rivers adjacent to the Disturbed belt. On the east side of the Alberta syncline a single bed of coal 12-15 feet thick occurs in the lower part of the formation on North Saskatchewan River at Rocky Rapids, west of Berrymoor (Tyrrell, 1887, p. 106; Rutherford, 1928, p. 18). Tyrrell (1887, p. 68) has also noted a 5-inch lignitic seam on Blindman River at an horizon estimated to be about 300 feet above the Ardley seam of the Edmonton formation. Bell (1949, p. 14) considers these occurrences of coal as a local facies within the Paleocene of the Alberta syncline.

The thickness of the Paskapoo has been estimated at 3,000 feet in southern Alberta (Slipper, 1919, p. 14). Allan and Rutherford (1923) and Erdman (1945, 1950) estimate a thickness of over 6,500 feet for the Paleocene strata in the area between the Brazeau Range and Rocky Mountain House.

The writer's study of the Paskapoo has been chiefly on its molluscan faunas and their position in relation to the lower contact. At some localities the present mapped contacts require revision, but it has not always been possible to suggest an alternative position. It, nevertheless, is desirable to point out discrepancies in the past mapping of the contact from the evidence presented by the molluscan faunas in spite of the fact that, in some cases, no solution can be offered at the present time.

On the east side of the Alberta syncline the Paskapoo overlies the Edmonton formation. Typical sediments of the two formations are readily differentiated, but Sternberg (1947, p. 8) has noted the occurrence of massive, buff weathering sandstones, similar to those present within the lower Paskapoo, within the upper part of the Edmonton formation. With the recognition that such sandstones occur within the Edmonton formation, the reliability of the position of contacts mapped without palæontological control becomes questionable.

On Little Bow River, Bell (1949, p. 12) has suggested drawing the base of the Paskapoo at a conglomerate in N.W. $\frac{1}{4}$ sec. 26, tp. 14, rge. 25, W. 4th mer. Paleocene molluscs have been collected stratigraphically above the conglomerate at the next outcrop upstream, at the junction with Mosquito Creek.

On Bow River, the contact mapped by Williams and Dyer (*See* Map 204A) may be accepted with some confidence. A conspicuous conglomerate occurs at the contact (Williams and Dyer, 1930, p. 46; Russell, 1932c, p. 135; Tozer, 1952, p. 5) and Paleocene molluscs occur within 300 feet stratigraphically above the base of the conglomerate. At this locality the basal Paskapoo rests upon, and locally truncates, the Battle and Whitemud equivalents of the Edmonton formation. Over 200 feet of beds that overlie the Battle equivalent in the Red Deer Valley, and which carry vertebrate fossils of Lance age (Sternberg, 1947), are absent on Bow River. The Paskapoo on Bow River is, therefore, unconformable on the Edmonton.

In the Red Deer Valley, Allan and Sanderson (1925, 1945) report a marked unconformity between the Edmonton and Paskapoo formations. Palæontological evidence to support this unconformity, however, is lacking, and possibly the buff weathering sandstones at Munson Ferry and elsewhere, identified by these authors as basal Paskapoo and resting upon the lower part of the Edmonton, probably represent channel-fill sandstones within the Edmonton formation.

On North Saskatchewan River, in secs. 13 and 14, tp. 50, rge. 6, W. 5th mer., Rutherford (1928, p. 16) has described massively bedded sandstones which he referred to the basal Paskapoo. The adjacent outcrop downstream is the "Goose Encampment", the outcrop of the "Big Seam" of the Edmonton formation that is generally correlated with the Ardley and Pembina seams of Red Deer and Pembina Rivers respectively. The evidence from a study of excellently preserved Paleocene molluscs in the University of Alberta collections from Bucklake Creek, near Berrymoor, supports Rutherford's conclusions regarding the position of this contact (*See* locality 14, Paskapoo formation).

On Pembina River at Evansburg the contact has been drawn by McEvoy (1900, p. 24) at the base of a massively bedded, buff weathering sandstone about 60 feet thick. With respect to this contact, Rutherford (1928, p. 18) stated "the beds immediately underlying it (the massive sandstone), which are largely clay shales and argillaceous sandstones with occasional beds of carbonaceous shale or thin coal seams, are more like the Paskapoo than the Edmonton. At this locality there are about 100 feet of such beds beneath the massive sandstone and above the first appearance of the typical light-coloured Edmonton beds which prevail along the north". Rutherford also noted that this sandstone lenses out, and is replaced by alternating beds of shale and argillaceous sandstones at a point 5 miles south of Evansburg. Bell (1949, p. 86) has described the occurrence of Paleocene plants below this sandstone, and molluscs obtained by the writer from loose "ironstone" blocks at water level at the Evansburg bridge, also below the sandstone, include *Viviparus planolatere* Russell and *Lioplacodes tenuicarinata* (M. and H.), which also suggest a Paleocene age, consequently, the massive sandstone at Evansburg is not the basal Paskapoo stratum as defined in this report.

Rutherford (op. cit., p. 13, Map No. 13) has mapped the eastern boundary of the Paskapoo at the point where thick-bedded sandstones appear in the section on McLeod River, in tp. 58, rge. 13, W. 5th mer. Palæontological evidence is not available to confirm the placing of this boundary but provisionally it is accepted. Rutherford mapped the western boundary of the Paskapoo on McLeod River in tp. 57, rge. 13, W. 5th mer.; this position cannot be accepted, however, for Warren (in Rutherford, 1926, p. 12; 1928, p. 22) and Russell (1932c, p. 145) report exposures southwest of the western boundary as placed by Rutherford that carry a Paskapoo-Fort Union molluscan fauna of Paleocene age. These faunules also occur, at intervals, as far southwest as Robb, on Embarras River, where the highest beds of the Saunders coal series of Allan and Rutherford (1924) appear in the section below the fossiliferous beds. These coal seams also occur about 5 miles southwest of Robb, in the Coalspur region, being separated from the Robb outcrops by an anticlinal structure apparently continuous with the Prairie Creek anticline of the Entrance area (Lang, 1947, p. 40). Bell (1949, p. 21) has recorded the occurrence of Paleocene plants below the lowest coal seam (the Mynheer) in the Coalspur area. The area between tp. 57, rge. 13, W. 5th mer., where Rutherford mapped the west boundary of the Paskapoo, and Robb, to the southwest, therefore, is underlain by rocks of Paleocene age, and, consequently, Rutherford's western and eastern boundaries of the Paskapoo cannot be considered to represent equivalent stratigraphic horizons. The Paleocene rocks are referred to the Paskapoo formation as redefined and the western boundary is placed at the base of the Entrance conglomerate, which underlies the coal seams at Coalspur (*See* page 33).

The contact mapped on Athabasca River by Allan and Rutherford (1934, p. 26) is based upon a reconnaissance survey and no stratigraphic or palæontological information is available.

Allan (1919, p. 10) has recorded about 1,000 feet of Paskapoo strata in the Swan Hills, south of Lesser Slave Lake. No information regarding the contact with the Edmonton formation was given, but the well-preserved Paleocene molluscs collected by Allan (Russell, 1926b, p. 212; locality 1 of present report) establish definitely the presence of the Paskapoo formation in this area.

On the west side of the Alberta syncline, the lower limit of the Paskapoo is particularly hard to define on a lithological basis due to the marked similarity in facies between the Paskapoo and underlying Cretaceous rocks.

North of Bow River, continental sediments succeed the marine Alberta shale, and from the top of the marine beds to the Paleocene strata no lithological changes of pronounced and widespread character are present as a basis to delimit formations. South of Bow River Cretaceous and Paleocene molluscs are common and are of great assistance in defining the Cretaceous-Tertiary boundary. North of the Bow invertebrates are rare in the Cretaceous part of the section but are widespread in the Paleocene; they can, therefore, be applied only to the determination of an upper limit for the boundary in most instances.

In the section on Highwood River (*See* Figure 3) little unanimity prevails regarding the position of the Edmonton-Paskapoo contact. Hume (1931, 1938) and Gallup (1951) have mapped the contact at three different positions, but all are too low, as representatives of the Lower Willow Creek fauna have been collected about 150 feet above the highest contact mapped by them, in l.s. 9, sec. 10, tp. 19, rge. 2, W. 5th mer. (*See* locality 7, Edmonton formation, Disturbed belt). A sandstone with 6-inch cobbles of quartzite occurs in l.s. 11, sec. 11, tp. 18, rge. 2, W. 5th mer., 430 feet above the horizon carrying the lower Willow Creek (uppermost Cretaceous) fauna. This horizon is provisionally regarded as the Edmonton-Paskapoo contact, although similar lenticular conglomerates are present in the Cretaceous part of the section on Elbow River and Jumpingpound Creek. Paleocene molluscs were not obtained in the measured section on Highwood River but were collected 2 miles to the south on Pekisko Creek from an horizon estimated to be about 1,700 feet above sandstone with quartzite cobbles.

Between Highwood and Bow Rivers exposures of the Edmonton and basal Paskapoo are poor, and consist largely of projecting sandstone outcrops, with recessive covered intervals, presumably composed largely of shale. At Priddis (Hume, 1927, p. 7) and on Elbow River, 10 miles south of Cochrane (Hume, 1938, p. 6), conglomeratic beds have been mapped as basal Paskapoo. On Elbow River a large bone fragment, presumably dinosaur, was collected 80 feet stratigraphically above this conglomerate and on Jumpingpound Creek a Lower Willow Creek fauna was obtained from horizons up to 58 feet above a 30-foot sandstone bed with quartzite cobbles at the base (locality 8, Edmonton formation Disturbed belt). It is, therefore, apparent that lenses of conglomerate are present in the upper part of the Edmonton formation in this area, and it is unlikely that they form reliable stratigraphic markers.

On Bow River, Paleocene molluscs have been obtained by Rutherford (1927, p. 40, locality 2) in l.s. 2, sec. 18, tp. 26, rge. 4, W. 5th mer., from an horizon 900 ± 100 feet above the uppermost Cretaceous fauna (*idem*, locality 14). As noted by Russell (1932c, p. 144) this necessitates placing the Edmonton-Paskapoo contact higher than the horizon mapped by Hume (1931, 1942).

On Little Red Deer River, MacKay (1938, p. 8) has mapped a 115-foot, massive, buff weathering sandstone as basal Paskapoo. A rich faunule of Paleocene molluscs (*See* locality 25) has been obtained about 75 feet below this sandstone, indicating that this contact is too high. Nearby, on Silver Creek, a tributary of Little Red Deer, the Edmonton formation is well exposed but Cretaceous fossils were not obtained, hence the Edmonton-Paskapoo contact in this section cannot be placed precisely.

On Red Deer and James Rivers, H. H. Beach collected Paleocene molluscs (*See* localities 21 and 22) from the lower part of the Paskapoo to provide some palæontological evidence of the position of the contact of the Edmonton and the Paskapoo.

Important deposits of coal in the Paleocene have directed attention to the section on North Saskatchewan River. In this area Allan and Rutherford (1923, p. 51) designated the non-marine sediments above the Alberta shale as the Saunders formation, and divided this into the Lower Saunders, 5,500 feet thick, the Saunders coal series about 170 feet thick, and the Upper Saunders, 6,000 feet thick. These authors considered the Saunders formation to be of Montanan age, but subsequent studies by Russell (1932c, p. 147; 1948) and Bell (1949, p. 21) have shown that the greater part of the formation is of Paleocene age. Russell (1948) has recorded the presence of a tooth of the Middle Paleocene mammal, *Pantolambda*, from an horizon from 300 to 400 feet above the "Saunders coal series". Extensive fossil collections by Erdman were described by Bell (1949, and in Erdman, 1945) and these prove the entire "Saunders coal series" is of Paleocene age. Paleocene plants, identified by Bell, occur 800 feet below the base of the coal-bearing member and 300-500 feet above a cobble conglomerate exposed on the crest of the Stolberg anticline on North Saskatchewan River (Erdman, 1945, p. 16). With the exception of a single Cretaceous molluscan faunule collected from Shunda Creek, near the axis of the Stolberg anticline (*See* page 20), the fossil vertebrates, plants, and molluscs indicate a Paleocene age for all rocks exposed on North Saskatchewan River from the "Third fault" (Allan and Rutherford, 1923, p. 48), in tp. 40, rge. 13, W. 5th mer., to Rocky Mountain House.

The palæontological evidence suggests a correlation of the conglomerate on North Saskatchewan River with the Entrance conglomerate of Athabasca River (Lang, 1947, p. 34). The Entrance conglomerate, above which Paleocene fossil plants have been described by Bell (1949), has been recognized as far north as Wildhay River (Irish, 1946, p. 4). It apparently marks the Cretaceous-Tertiary boundary. In the Coalspur district a cobble conglomerate is present approximately 900 feet stratigraphically below the Mynheer seam, the lowest of the economic measures, Bell (1949, p. 21) has recorded Paleocene plants from horizons a few hundred feet below this coal seam. On Blackstone River, MacKay (1943b, p. 4) mapped a "cobblestone quartzite conglomerate . . . at a horizon 900 feet below the lowest coal seam". This conglomerate was regarded by MacKay as marking the "Brazeau-Edmonton" contact. The coal seam 900 feet stratigraphically above the conglomerate is in the "Saunders coal series" of Allan and Rutherford, which Bell classifies as Paleocene in age, hence the conglomerate on Blackstone River occupies the same stratigraphic position as the Entrance conglomerate. The available information suggests that this conglomerate maintains its stratigraphic position from the Athabasca to North Saskatchewan River.

Table VI.

Distribution of molluscan fauna of the Paskapoo formation

Localities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
U. sp. cf. *U. proavitus* White																																		X						
Plesielliptio priscus (M. and H.)								X							X							?			X											X			X	
Rhabdotophorus senectus (White)																					X	X																		
Sphaerium aequale Russell	X																X		X												X									
S. formosum (M. and H.)	X																								X						X			X						
S. fowleri Russell																																		X		X			X	
Dimorphoptychia douglasi sp. nov.																							X				X													
D. rutherfordi (Russell)					X																		X				X								X			X		
Grangerella mcleodensis (Russell)				X							X												X				X								X					
Viviparus leai (M. and H.)	X													X		?			X										X											?
V. planolatere Russell									X	X					X											X	X	X			X			X		X				
V. raynoldsanus M. and H.																	X																							
V. retusus (M. and H.)								X		X												X			X					X	X	X				X				
V. trochiformis																X				X	?										X									
Campeloma nebrascensis whitei Russell																									X						X			X		X				
Lioplacodes limnaeformis (M. and H.)															X										X						X	X	X	X		X	X		X	
L. nebrascensis nebrascensis (M. and H.)										X				X			X		X										X				X			X			X	
L. nebrascensis producta (White)								X							X										X															X
L. tenuicarinata (M. and H.)								X	X					X	X														X	X				X						
Reesidella sp. cf. *R. protea* (Yen)																			X																					X
Valvata bicincta Whiteaves	X	X				X	X	X									X	X	X	X	X						X													
V. sp. cf. *V. subumbilicata* (M. and H.)	X	X				X	X	X									X											X			X									
Goniobasis eulimoides (Meek)																																		X						
Hydrobia spp. indet.																X	X	X						X																
Pleurolimnaea tenuicosta (M. and H.)	X																X	X	X		X							X												X
Physa canadensis Whiteaves																	X							X		X		X			X									
Ferrissia minuta (M. and H.)																			X																					
Palaeancylus radiatulus (Whiteaves)																	X	X																						
Glypterpes rotundata (Russell)												X											X																	
Oreohelix thurstoni (Russell)										X														X			X				X				X					
O. sp. cf. *O. megarche* Cockerell and Henderson																											X													
Anguispira russelli sp. nov.		X																																						
Discus sandersoni (Russell)													X																											
Pupilla inermis Russell			X																																					
Albertanella minuta Russell			X																																					
Pseudocolumna haydeniana (Cockerell)																		X													X									

G. S. C.

Fauna and Correlation. The Paskapoo formation contains a rich molluscan fauna, the composition and distribution of which is shown in Table VI, page 34. This list incorporates a number of published records, and noted in the "Index to locality numbers" (*See* page 89).

Most of the aquatic species were originally described from the Fort Union group of the type area, and many have since been reported from the Ravenscrag formation of Saskatchewan (Russell, 1932d), the Polecat Bench formation of Wyoming (Russell, 1931b), the Flagstaff limestone of central Utah (LaRocque, 1951), and from various other localities in Montana and Wyoming (Yen, 1946, 1948). A number of these species also are present in the upper part of the Willow Creek formation. In Wyoming, and elsewhere, these molluscs are associated with Paleocene mammals, but in Alberta a stratigraphic zonation of the invertebrates has not been detected to parallel the sequence of mammalian faunas, which differentiate Lower (Puerco), Middle (Torrejon), and Upper (Tiffany and Clark Fork) Paleocene strata.

The terrestrial molluscs of the Paskapoo comprises ten species, nine of which are confined to the formation and its equivalents, the upper part of the Willow Creek and the Porcupine Hills formation. Terrestrial molluscs are not represented in the typical Fort Union fauna outside Alberta and their restriction in strata of this age to western Alberta probably is best explained by the closer proximity of the site of sedimentation of the Alberta formations to the land mass that provided both sediment and land shells. In support of this hypothesis terrestrial molluscs are much more common in sections on the west side of the Alberta syncline and nearer the assumed land area than they are in those on the east side. The association of the terrestrial species with aquatic Fort Union forms establishes their contemporaneity.

The mammalian faunules of the Paskapoo, which provide the most satisfactory evidence regarding its age, are known from relatively few localities. Upper Paleocene (Tiffanian and Clarkforkian) mammals have been described from Calgary (Russell, 1926a), Red Deer River 8 miles east of Red Deer town (Simpson, 1926), Cochrane (Russell, 1929a, and in Rutherford, 1927, p. 41), and on North Saskatchewan River "not much more than 1,000 feet above the 'Saunders coal series' " (Russell, 1932c, p. 147). A Middle Paleocene (Torrejonian) tooth has been obtained still lower in the section on North Saskatchewan River (Russell, 1948). Both records from the North Saskatchewan were referred by Russell to the Saunders formation, the Paleocene part of which, for reasons given above, is referred to the Paskapoo formation in this report. This is not contrary to Russell's hypothesis, namely, that older Paleocene rocks are present on the west than on the east side of the Alberta syncline, as indicated by the available palæontological evidence.

At present the only conclusion that can be drawn regarding the Paskapoo molluscan fauna *per se* is that it represents Paleocene time. However, as Paleocene molluscan faunules and plant remains are known below the beds carrying Middle and Upper Paleocene mammals, it is possible that Lower Paleocene equivalents may be present within the Paskapoo, particularly on the west side of the Alberta syncline.

SYSTEMATIC PALÆONTOLOGY[1]

Family, Unionidae

Originally most of the North American fossil unionids were referred to *Unio* Retzius, a living Palæarctic genus not recognized in the fauna of this continent. This has been criticized by malacologists, but as the generally accepted classification of living unionids by Simpson (1914), Ortmann (1911), and Walker (1918), is based principally upon the soft anatomy and only to a lesser extent on the shell features, such as dentition and sculpture, more particularly the sculpture of the nepionic shell, it is usually impossible to make a comparison between the extinct and recent species that will fully justify reference of the fossils to living genera. In spite of these difficulties, Russell (1934) revised the classification of the Cretaceous and Paleocene unios of western Canada and referred many of them to living North American genera. Russell's classification is followed in part; particularly with respect to the *Elliptio*-like Cretaceous and Paleocene shells, and the subgenera *Protelliptio* and *Plesielliptio*, erected by Russell, are considered worthy of generic rank. *Rhabdotophorus* Russell (1935, p. 117), founded for the reception of fossil shells that have in common fine curved costæ on the post-umbonal slope, also provides a convenient, and probably natural, receptacle for the species thus sculptured, for example *Unio senectus* White.

The reference of Cretaceous and Paleocene species to *Fusconaia* Simpson and *Lampsilis* Rafinesque, advocated by Russell, is doubtful, for these genera are placed in separate subfamilies on the basis of their soft anatomy, yet in the Cretaceous fauna *Unio consuetus* Whiteaves, and *U. danai* Meek and Hayden, referred to *Lampsilis* and "*Fusconaia* ?" respectively by Russell, are not easily separated on shell features. These species and some others have been returned to *Unio*; this procedure might be criticized as rendering *Unio* a "catch-all" genus, but as the shell features of *Unio danai, U. stantoni,* and *U. consuetus,* for example, seem to be as close to those of *Unio pictorum* (Linnaeus) (the type of the genus according to many authorities) as to any living genus, this course is justified on morphological grounds.

With regard to the classification of the highly sculptured Cretaceous unionids, which clearly do not belong in *Unio,* two alternatives are available. Russell (op. cit.) referred *U. holmesianus* White and other elaborately ornamented Cretaceous species to the living *Quadrula* Rafinesque; Pilsbry (1921) erected the genus *Proparreysia* for *U. percorrugata* Whitfield (1903, p. 486, Pl. 40, figs. 3-9), a species with radial V-like beak sculpture. Henderson (1935, p. 69) included many of the Cretaceous sculptured unionids in this genus. Henderson's course has been followed, for this practice provides a convenient and unambiguous expression of the probable relationship between these extinct species without commitment regarding their relation to the living fauna.

In view of the foregoing, the uppermost Cretaceous and the Paleocene unionids of Alberta are referred to the following genera: *Unio* Retzius, *Plesielliptio* Russell, *Rhabdotophorus* Russell, and *Proparreysia* Pilsbry.

[1]Dimensions are given in mm. Figures in parentheses represent estimates of original dimensions of imperfect specimens. Width measurements for pelecypods are for one valve.

Genus, *Unio* Retzius

Unio sandersoni Warren

Plate I, figure 5

1925. *Unio sandersoni* Warren, Roy. Soc., Canada, Trans., ser. 3, vol. 20, sec. 4, p. 5, pl. 1, fig. 1.

1934. *Lampsilis sandersoni* (Warren); Russell, Can. Field-Nat., vol. 48, No. 1, p. 3.

Material. Hypotype, G.S.C. No. 10317, Edmonton formation (lower part), locality 5.

Dimensions. Specimen 10317: length 71·0; height 45·0; width 11·0.

Remarks. Russell compared this species with the living *Lampsilis ovata* (Say). The absence of a posterior ridge, the compressed shell, and the suggestion of an upper posterior wing are more characteristic of the type species of *Proptera* Rafinesque, *P. alata* (Say) than any species of *Lampsilis.* Both *Proptera* and the related *Paraptera* Ortmann possess concentric umbonal sculpture; as this feature is not known in *U. sandersoni* it is inadvisable to assign *U. sandersoni* to either of these genera.

Occurrence. Edmonton formation (lower part).

Unio stantoni White

Plate I, figures 1, 2

1883. *Unio danae* Meek and Hayden ?; White, U.S. Geol. Surv. Terr., 12th Ann. Rept., pt. 1, p. 68, Pl. 27, figs. 2a-b.

1905. *Unio stantoni* White, Smithsonian Misc. Coll., vol. 48, Pl. 31, fig. 7.

1907. *Unio gibbosoides* Whitfield, Am. Mus. Nat. Hist., Bull., vol. 23, p. 625, Pl. 40, figs. 1, 2.

1926. *Unio minimus* Warren, Roy. Soc., Canada, Trans., ser. 3, vol. 20, sec. 4, p. 5, Pl. 1, figs. 2, 3.

1935. *Unio stantoni* White; Henderson, Geol. Soc. Am., Spec. pap., 3, p. 85.

1953. *Fusconaia stantoni* (White); Liberty, Geol. Ass. Canada, Proc., vol. 6, p. 53, Pl. 1, fig. 3.

[?] 1885. *Unio albertensis* Whiteaves, Geol. Surv., Canada, Contr. Can. Pal., vol. 1, pt. 1, p. 3, Pl. 1, fig. 1.

Material. Hypotype, G.S.C. No. 10314, Edmonton formation (lower part), locality 10; hypotype, G.S.C. No. 10315, Edmonton formation (lower part), locality 4.

Dimensions. Specimen 10314: length 91·0; width 19·0; height 52·0; specimen 10315: width 12·0; height 44·0.

Remarks. *Unio stantoni,* which was described from beds of Lance age in Wyoming, is rather similar to *U. danai* Meek and Hayden, typically a Judith River species; however, the type of *U. danai* is more elongate and less obliquely truncated posteriorly than *U. stantoni.* Most of the specimens from the post-Bearpaw formations of Canada are closer in proportions to *U. stantoni* than to *U. danai.* This determination follows Liberty; Warren (1927, p. 2) and Russell (1934, p. 1) have referred these shells to *U. danai.*

Some shells from the Edmonton formation (e.g., G.S.C. No. 10315, Pl. I, fig. 2) depart from the typical *U. stantoni* in being much less convex; they also lack the well-developed median sinus on the flank, a characteristic of that species. Warren (1927, p. 2) and Russell (1932c, p. 127) apparently have referred these shells to *U. consuetus* Whiteaves, which was described from beds now placed in the Oldman formation. The less inflated shells cannot be separated from the typical varieties for individuals with intermediate characters occur. In some unio beds of the Edmonton formation exposed on Kneehills Creek the complete range of variation in convexity is encountered in one bed. For this reason these differences are attributed to individual variation. *U. minimus* Warren was founded for immature shells from the Edmonton formation that may be placed in *U. stantoni* with confidence. *U. albertensis* Whiteaves, described from the St. Mary River formation (Russell, 1934, p. 4), is based on a shell of which the umbonal region is completely exfoliated and the anterior margin broken; this shell is generically undeterminable but the posterior part seems to resemble the compressed varieties of *U. stantoni.*

Occurrence. Originally described from the "Black Buttes beds", of Lance age (Stanton, 1909, p. 272), of southern Wyoming.

St. Mary River formation, Edmonton formation (lower part), Edmonton formation (Disturbed belt), Willow Creek formation (lower part). From an examination of Canadian material the presence of this species in Paleocene strata, as Russell's (1926b, p. 210) report of *U. danai* from the Paskapoo suggests, is unconfirmed. If *U. stantoni* does range into the Tertiary the occurrence is rare, whereas in the Cretaceous it is locally very abundant.

Unio sp. cf. *U. proavitus* White

Plate II, figure 4

Material. Figured specimen, G.S.C. No. 10316, Willow Creek formation (upper part), locality 4.

Dimensions. Specimen 10316: length 66·0; height 41·5; width 17·5.

Remarks. The anteriorly placed umbones, the subparallel dorsal and ventral margins with the oblique posterior truncation, and the obtuse ridge directed towards the postero-ventral margin, suggest *U. proavitus* White (1883a, p. 65, Pl. 22, figs. 3a-d). *U. proavitus,* however, is described as having a ridge directed at the junction of the posterior and dorsal margins in addition to the one shown by this form. Although this may represent a new species, the few poorly preserved specimens available do not warrant its establishment.

Occurrence. U. proavitus was originally described from the "Black Buttes beds", of Lance age, in Wyoming.

Paskapoo formation, Willow Creek formation (upper part), St. Mary River formation. This species is not common: one specimen is known from the Paskapoo and St. Mary River formations and several from the upper part of the Willow Creek.

Genus *Plesielliptio* Russell

This genus (type species—*Unio priscus* Meek and Hayden) was erected for elongate-ovoid to rhomboid shells characterized by umbonal sculpture of double looped and concentric ridges and two posteriorly directed raised lines, the outer one of which follows the post-umbonal ridge, when developed. From 7 to 12 ridges are developed: initially they are distinctly double looped, or even zigzag; they become less so with age, and before disappearing completely, they follow an uninterrupted concentric course. The ridges are best developed anterior to the outer posterior line, on being traced towards the postero-dorsal margin they usually become less prominent on crossing the outer line, but they may return to prominence on crossing the inner line. Dentition: right valve with small 5a, 3a prominent, 1 absent and a single lateral (3b); left valve with prominent 4a and 2a, laterals (2b, 4b) prominent.

This well-defined genus ranges from the Lower Cretaceous to the Lower Eocene. In the living fauna *Plesielliptio* is probably most closely related to *Unio* Retzius and *Elliptio* Rafinesque, from which it is distinguished by its characteristic sculpture.

Plesielliptio brachyopisthus (White)

Plate I, figures 3, 4

1876. *Unio brachyopisthus* White, in J. W. Powell's Report on the geology of the Eastern Part of the Uinta Mountains, p. 102.

1883. *Unio brachyopisthus* White, U.S. Geol. Surv. Terr., 12th Ann. Rept., p. 64, Pl. 22, figs. 2a, 2b.

1916. *Unio brachyopisthus* White; Stanton, U.S. Geol. Surv., Prof. pap. 98-R, p. 310, Pl. 81, figs. 2, 3.

1931. *Unio tyrrelli* Russell, Roy. Soc., Canada, Trans., ser. 3, vol. 25, sec. 4, p. 10, Pl. 1, figs. 3, 4.

[?] 1903. *Unio postbiplicata* Whitfield, Am. Mus. Nat. Hist., Bull., vol. 19, p. 487, Pl. 39, figs. 1-11.

[?] 1931. *Unio dawsoni* Russell, Roy. Soc., Canada, Trans., ser. 3, vol. 25, p. 9, Pl. 1, figs. 1, 2.

Material. Hypotypes, G.S.C. Nos. 10320, 10321, Edmonton formation (Disturbed belt), locality 5.

Dimensions. Specimen 10320: length 29·0; height 25·2; width 7·0; specimen 10321: length 50·0; height 37·0; width 12·5.

Remarks. On the type of "*Unio*" *brachyopisthus* the umbo bears concentric wrinkles and two posteriorly directed raised lines, the outer one of which follows the post-umbonal ridge; the inner line is poorly defined but can be traced for about 10 cm. These characters suggest that this species is related to "*Unio*" *priscus* Meek and Hayden and its relatives placed in the genus *Plesielliptio* Russell. Although the shell outline of the present species is very different from that of the typical *Plesielliptio*, it is not alone in the combination of an abbreviated outline and *Plesielliptio* sculpture. *P. abbreviatus* (Stanton) from the Judith River and Foremost formations is somewhat similar in outline but is less convex; it also lacks the umbonal ridge defining the flat dorsal region surrounding the ligamental area and accounting for much of the convexity of *P. brachyopisthus*. *Unio postbiplicatus* Whitfield, from the Hell Creek beds, of Lance age (i.e., a contemporary of *P. brachyopisthus*), presents an outline identical with that of *P. brachyopisthus* and has well-defined *Plesielliptio*-type sculpture and probably represents a more sculptured variety of this species. The material from Alberta definitely referred to this species comes from the locality of the types of *U. tyrrelli* Russell. Shells from this bed include some with an outline identical with that of *P. brachyopisthus* (Pl. I, fig. 3); these are linked in a continuous series with those that have the outline of *U. tyrrelli* (Pl. I, fig. 4). All the specimens studied from this locality, including the type of *U. tyrrelli*, are exfoliated at the umbones, but on several specimens, e.g., those figured on Plate I, a faint but distinct line, raised near the beak to become distally a finely impressed groove, is present on the post-umbonal slope. This marking suggests strongly that of the *Plesielliptio* sculpture of the type.

Unio dawsoni Russell was founded on a specimen from the Edmonton formation of the Disturbed belt on Bow River. Most of the specimens collected from this bed (locality 4) are bizarre and variable in outline; the material is not well preserved and many shells are distorted. Specimens presenting a similar outline to that of *U. dawsoni* were not found at this locality, nor in the present collection from the type locality at the University of Alberta. *U. dawsoni*, therefore, is known only from the type specimen. The growth lines of this specimen, at an immature stage, present an identical outline with those of *U. tyrrelli* and the longer varieties of *P. brachyopisthus*, here considered conspecific. *U. dawsoni* probably represents an aberrant individual of *P. brachyopisthus*.

Occurrence. Originally described from the "Black Buttes beds", of Lance age, of Wyoming.

Edmonton formation (Disturbed belt).

Plesielliptio priscus (Meek and Hayden)

Plate II, figures 1, 2

1856. *Unio priscus* Meek and Hayden, Phil. Acad. Nat. Sci., Proc., vol. 8, p. 117.

1876. *Unio priscus* Meek and Hayden; Meek, U.S. Geol. Surv. Terr., Rept., vol. 9, p. 516, Pl. 43, fig. 8.

1883. *Unio priscus* Meek and Hayden; White, U.S. Geol. Surv., 3rd Ann. Rept., p. 432, Pl. 14, fig. 1.

1934. *Elliptio* (*Plesielliptio*) *priscus* (Meek and Hayden); Russell, Can. Field-Nat., vol. 48, No. 1, p. 3.

Material. Hypotype, G.S.C. No. 10319, Paskapoo formation, locality 25; hypotype, G.S.C. No. 10318, Ravenscrag formation (Saskatchewan), west branch Calf Creek, NE. ¼ sec. 5, tp. 8, rge. 22, W. 3rd mer.

Dimensions. Specimen 10318: length 22·0; height 14·0; width 4·5; specimen 10319: length 60·0; height 32·0; width 10·0.

Remarks. P. priscus is characterized by an elongate-ovoid shell and a moderately angular postero-ventral extremity, with the umbones situated about one-fifth of the total length from the anterior margin. Some Cretaceous species of *Plesielliptio* approach *P. priscus* closely, for example, the specimen from the Judith River formation figured by Stanton (1905, p. 107, Pl. 13, fig. 1) as *Unio subspatulus* Meek and Hayden, which is, however, more elongate, with the beaks in an even more anterior position.

Occurrence. Originally described from the typical Fort Union group.

Paskapoo formation, Willow Creek formation (upper part), Ravenscrag formation (Saskatchewan).

Plesielliptio sp. indet.

Remarks. A few poorly preserved shells from the Edmonton formation show the umbonal sculpture of *Plesielliptio,* but they differ from described species in their greater convexity, exceptionally elongate outline, poorly defined umbonal ridge, and obliquely truncated posterior.

Occurrence. Edmonton formation (lower part), St. Mary River formation (basal member), St. Mary River formation.

The specimens from the basal member of the St. Mary River formation are probably conspecific with the Edmonton individuals. The record of this genus from the upper part of the St. Mary River formation is based on immature individuals and fragments showing the characteristic sculpture.

Genus, *Rhabdotophorus* Russell

Rhabdotophorus senectus (White)

Plate II, figures 3a, 3b

1877. *Unio senectus* White, U.S. Geol. Surv. Terr., Bull. 3, p. 600.

1883. *Unio senectus* White, U.S. Geol. and Geog. Surv. Terr., 12th Ann. Rept., p. 69, Pl. 28, figs. 1a-c.

1885. *Unio senectus* White; Whiteaves, Geol. Surv., Canada, Contr. Can. Pal., vol. 1, p. 62, Pl. 10, fig. 2.

1934 *Medionidus? senectus* var. *declivis* Russell, Jour. Wash. Acad. Sci., vol. 24, p. 129, fig. 3.

Material. Hypotype, University of Alberta collections No. Pa 96, Paskapoo formation, Bow River, north side, at mouth of Jumpingpound Creek.

Dimensions. Specimen Pa 96: length 51·0; height 26·0; width 7·5.

Remarks. The figured specimen is immature; the beaks are rather more elevated than usual in this species but in other respects the outline and proportions are identical, at the same stage, with those of *Medionidus? senectus* var. *declivis,* described by Russell from the Paleocene of Montana. The post-umbonal sculpture characteristic of the genus is well developed and consists of anteriorly directed, low, round, bifurcating costæ radiating from the umbo and within the area defined by the weak post-umbonal ridge. The beaks are slightly exfoliated but they show a trace of concentric sculpture and two posteriorly directed lines, one on, and the other within, the post-umbonal ridge. This beak sculpture has not been described on typical examples of *R. senectus* from the Judith River and contemporary formations, nor is it known on the type of *Rhabdotophorus, R. gracilis* Russell; this, however, may be due to poor preservation of the type specimens. The presence of this sculpture, which is rather similar to that of *Plesielliptio,* tends to confirm Russell's conclusion (1935, p. 118) that *Rhabdotophorus* is related to *Protelliptio* and *Plesielliptio.*

Despite the fact that this species is not known from the intervening non-marine formations, a reliable basis for the separation of the Judith River and Paleocene specimens has yet to be found.

Occurrence. Originally described from the Judith River formation of Montana.

Foremost formation, Oldman formation, Paskapoo formation.

Genus, *Proparreysia* Pilsbry

Proparreysia holmesiana (White)

1877. *Unio holmesianus* White, U.S. Geol. and Geog. Surv. Terr., Bull. 3, p. 604.

1883. *Unio holmesianus* White, U.S. Geol. and Geog. Surv. Terr., 12th Ann. Rept., p. 67, Pl. 22, figs. 4a-e.

1916. *Unio holmesianus* White, Stanton, U.S. Geol. Surv., Prof. pap. 98-R, p. 312, Pl. 80, figs. 1-7.

1934. *Quadrula holmesiana* (White); Russell, Can. Field-Nat., vol. 48, No. 1, p. 2.

1935. *Proparreysia holmesiana* (White); Henderson, Geol. Soc. Am., Spec. pap. 5, p. 69.

Occurrence. Originally described from the "Black Buttes beds", of Lance age, in Wyoming.

Russell (1932c, p. 143) discovered the only occurrence of this species in Alberta, namely, in the Edmonton formation of the Disturbed belt, on Little Red Deer River, below the mouth of Grease Creek.

Family, SPHAERIIDAE

Genus, *Sphaerium* Scopoli

Sphaerium aequale Russell

Plate II, figure 5

1926. *Sphaerium aequale* Russell, Roy. Soc., Canada, Trans., ser. 3, vol. 20, p. 214, Pl. 3, figs. 10, 11.

Material. Topotype, G.S.C. No. 10324, Paskapoo formation, locality 1.

Dimensions. Specimen 10324: length 6·0; height 4·6; width 1·3.

Occurrence. Paskapoo formation, Willow Creek formation (upper part).

Sphaerium fowleri Russell

Plate II, figure 6

1931. *Sphaerium fowleri* Russell, Roy. Soc., Canada, Trans., ser. 3, vol. 25, sec. 4, p. 11, Pl. 1, figs. 5-8.

Material. Topotype, G.S.C. No. 10325, Paskapoo formation, locality 36.

Dimensions. Specimen 10325: length 10·3; height 9·2; width 3·0.

Occurrence. Paskapoo formation, Ravenscrag formation (Saskatchewan).

Sphaerium formosum (Meek and Hayden)

Plate II, figure 7

1856. *Cyclas formosa* Meek and Hayden, Phil. Acad. Nat. Sci., Proc., vol. 8, p. 115.

1876. *Sphaerium formosum* (Meek and Hayden); Meek, U.S. Geol. Surv. Terr., Rept., vol. 9, p. 526, Pl. 43, fig. 4.

1926. *Sphaerium formosum* var. *whiteavsi* Russell, Roy. Soc., Canada, Trans., ser. 3, vol. 20, p. 209, Pl. 3, figs. 8, 9.

Material. Hypotype, G.S.C. No. 10128, Willow Creek formation (upper part), locality 8.

Dimensions. Specimen 10128: length 5·0; height 3·5; width 1·0.

Occurrence. Originally described from the typical Fort Union group.

Paskapoo formation, Willow Creek formation (upper part), Ravenscrag formation (Saskatchewan).

Sphaerium gietzi sp. nov.

Plate II, figures 10-12

Material. Holotype, G.S.C. No. 10195, a somewhat exfoliated right valve, St. Mary River formation, locality 6; paratype, G.S.C. No. 10196, a somewhat exfoliated right valve, St. Mary River formation, locality 6; paratype, G.S.C. No. 10197, an internal mould of a right valve, St. Mary River formation, locality 43.

Dimensions.

Specimen	Length	Height	Width
10195	5·2	4·8	1·4
10196	5·2	3·8	1·5
10197	6·0	5·0	2·0

Description. Shell small, of thin substance, moderately convex. Beaks fairly prominent, somewhat elevated above the hinge line, situated at, or slightly in front of, mid-length of shell. Posterior dorsal margin straight, sloping downwards; posterior margin mildly convex, truncated abruptly above; ventral margin convex, abruptly rounded posteriorly, evenly rounded in front; anterior margin well rounded. Cardinal dentition unknown, probably weak. Right valve with two short, weak, anterior lateral teeth (AI and AIII) of Bernard; posterior laterals (PI and PIII) long, slender, weak, extending from posterior dorsal margin for about three-quarters of distance to the beak. Surface marked by well-defined, regular, concentric ridges, uniformly developed over the entire surface, visible on some internal moulds in consequence of the thin shell matter, about 8 ridges in 1 mm. at ventral margin. Specimens of the species vary considerably in the ratio of the height to length, but the limited number of specimens available precludes an analysis of the taxonomic significance of this variation.

Remarks. There are no contemporary sphaeriids with which this species is comparable. In the Paleocene fauna *S. formosum* (Meek and Hayden) has a somewhat similar outline, but is more inequilateral, more produced posteroventrally, and it lacks the well-defined concentric ridges of this species. *S. aequale* Russell is more obliquely truncated in front and behind and it also lacks the distinctive sculpture of *S. gietzi.* The sculpture of *S. gietzi* is very similar to that of the living *S. simile* (Say) and *S. sulcatum* (Lamarck). These species, however, are much larger than *S. gietzi.* The material from the St. Mary River formation described by Whiteaves (1885, p. 61) as "*Sphaerium formosum* ? (Meek and Hayden) var." is exfoliated, but apparently is referable to this species.

This species is named for Mr. Otto Gietz, an assistant in collecting material during 1949 and 1950.

Occurrence. St. Mary River formation, Willow Creek formation (lower part), Edmonton formation (Disturbed belt).

Sphaerium heskethense Warren

Plate II, figures 8, 9a, 9b

1926. *Sphaerium heskethense* Warren, Roy. Soc., Canada, Trans., ser. 3, vol. 23, sec. 4, p. 6, Pl. 1, figs. 10, 11.

Material. Lectotype, University of Alberta collections No. Ct 331 (Warren, 1926, Pl. 1, fig. 11), here selected from the two original syntypes, Edmonton formation (lower part), Red Deer River, vicinity of Munson Ferry, Alberta; hypotypes, G.S.C. Nos. 10322, 10323, Edmonton formation (lower part), locality 1.

Dimensions. Specimen 10322: length 15·0; height 12·0; width 4·2; specimen 10323: length 12·2; height 10·0; width 3·2.

Description. Shell large, of rather thick substance. Beaks not prominent, situated at mid-length of shell in young stages but posterior in adults owing to the proportionally more rapid growth of the anterior end of the shell in later ontogeny. Marginal outline oval, with well-rounded anterior and posterior ends. Dentition imperfectly known; the left valve has at least 2 stout cardinal teeth (2b and 4b ?), lateral teeth wide and prominent. Surface marked only with concentric lines of growth.

Remarks. As Russell (1931a, p. 12) has noted, the distinctive feature of this species is the situation of the umbones posterior to the mid-length of the shell, which is accounted for by the heterogonic growth of the anterior part. The large size is also rather unusual: some fragmentary individuals, apparently referable to this species, with a height of 13 mm. are known.

Occurrence. St. Mary River formation, Edmonton formation (lower part), Willow Creek formation (lower part)?.

Sphaerium livingstonensis Russell

1932. *Sphaerium livingstonensis* Russell, Can. Field-Nat., vol. 46, p. 80, fig. 2.

Occurrence. St. Mary River formation. Known only from the type locality.

Sphaerium mclearni Russell

1932. *Sphaerium mclearni* Russell, Can. Field-Nat., vol. 46, p. 80, fig. 1.

Occurrence. St. Mary River formation. Known only from the type locality.

Genus, *Pisidium* Pfeiffer

Pisidium squamula Russell

1932. *Pisidium squamula* Russell, Can. Field-Nat., vol. 46, p. 81, fig. 3.

Occurrence. St. Mary River formation. Known only from the type locality.

Family, HELICINIDAE

Genus, *Dimorphoptychia* Sandberger

Three species, two of which are new, are provisionally placed in this genus, of which the type is *"Helix" arnouldi* Michaud (De Boissy, 1848, p. 272, Pl. V, figs. 12a-c) from the Paleocene Calcaire de Rilly of the Paris Basin. The type species is a depressed conoid, imperforate, regularly axially sculptured shell with an angular periphery and a thickened and reflected outer lip; the body whorl houses spiral lamellæ, two on the parietal wall and one basal in position on the palatal wall. According to Berthelin (1887, p. 61) these lamellæ are completely resorbed within the shell. The

Canadian species differ from *D. arnouldi* in the arrangement of the lamellæ on the palatal wall; however, the only one in which the parietal wall is known, namely, *"Polygyra" rutherfordi* Russell, has two parietal spiral lamellæ comparable with those of the type species. *"P." rutherfordi* and *D. douglasi* sp. nov. have three palatal lamellæ; *D. mokowanensis* sp. nov. is known to possess only one. The three Canadian species appear to be closely related to one another and they are probably close to *D. arnouldi*. As noted below, *"P." rutherfordi* and *D. douglasi* may be related to *Kanabohelix kanabensis* (White) and the morphology of *D. mokowanensis* is rather suggestive of *Prograngerella* Russell. It is evident that many of the late Cretaceous and early Tertiary gastropods of presumed terrestrial habitat share rather distinctive apertural features and probably form a natural group. *Dimorphoptychia* is classed as a helicinid by Pilsbry (1927, p. 11), with which family the members of the *Grangerellidae,* which includes *Prograngerella,* have been compared by Russell (1931b, p. 26; 1941, p. 310).

Dimorphoptychia douglasi sp. nov.

Plate VII, figures 14-20.

Material. Holotype, G.S.C. No. 10310, a damaged shell, Willow Creek formation (upper part), locality 19; paratype, G.S.C. No. 10309, Willow Creek formation (upper part), locality 19; paratypes, G.S.C. Nos. 10175, 10176, 10177, 10198, 10308, Paskapoo formation, locality 27.

Dimensions.

Specimen	Altitude	Width	Number of whorls
10175	5·0	10·0	6
10176	5·5	11·5	6
10198	5·8	—	6?
10308	—	11·0	6?
10309	5·0	10·5	6
10310	—	10·3	6

Description. Shell obtusely conoid, imperforate. Whorls 6, increasing in size rather slowly, flat to slightly convex above with unimpressed suture. Spiral whorls with angular periphery, body whorl subangular initially, becoming rounded towards the aperture, not descending in front. Aperture rounded-lunate, labral profile retractive (60 degrees), outer lip heavily thickened and prominently reflected, face of peristome evenly convex. Palatal wall with three spiral lamellæ extending within from the lip for about 3 mm.; upper lamella situated about midway between the suture and the periphery; the middle one, just below the periphery; lower lamella is basal in position, placed about 3 mm. from the columellar insertion of the lip, curved rather abruptly in the last millimetre before reaching the lip, which it meets at right angles. Parietal wall not known. First whorl apparently smooth, succeeding whorls have a spiral sculpture of raised lines of varying prominence, about 5 prominent, and a variable number of obscure lines on the upper surface of the whorls; axial sculpture consists of fine, regular, retractive costulæ, about 15 to the mm. on the body whorl. Spiral sculpture present, but less prominent, on the base; axial sculpture ends below the periphery.

Remarks. The position of the palatal lamellæ on this species, as with the others referred to *Dimorphoptychia,* has been determined from shells exfoliated behind the aperture. The lower lamellæ are best shown by the specimens, such as the holotype, from the Willow Creek formation, but one poorly preserved individual from the Paskapoo also has lower lamellæ. The palatal lamellæ of this species resemble those of *D. rutherfordi* (Russell) but the striking spiral sculpture at once distinguishes *D. douglasi* from it and from all other North American fossil land shells. This feature, however, is common among living helicinids, e.g., *Palaeohelicina* A. J. Wagner, hence the evidence of the sculpture of this species corroborates the suggestion that the shells referred to *Dimorphoptychia* represent extinct *Helicinidae.*

This species possibly is related to "*Helix*" *kanabensis* White (1876, p. 120; 1883b, p. 454, Pl. 25, figs. 12-14) from the Upper Cretaceous of Utah, the type of *Kanabohelix* Pilsbry (1927, p. 11). *K. kanabensis* has four palatal lamellæ and is clearly more elevated than *D. douglasi,* but only a fragmentary internal mould is known, consequently, further comparison is impossible.

This species is named for Dr. R. J. W. Douglas, of the Geological Survey of Canada.

Occurrence. Paskapoo formation, Willow Creek formation (upper part).

Dimorphoptychia mokowanensis sp. nov.

Plate VII, figures 5a-c, 6, 7a, 7b

Material. Holotype, G.S.C. No. 10182, a nearly perfect shell with the spire somewhat exfoliated, St. Mary River formation, locality 32; paratype, G.S.C. No. 10183, St. Mary River formation, locality 32; paratype, G.S.C. No. 10199, St. Mary River formation, locality 30.

Dimensions.

Specimen	Altitude	Width	Number of whorls
10182	3·1	5·0	5
10183	3·0+	5·0	5
10199	3·0	4·8	5

Description. Shell small, conoid, imperforate. Whorls 5, increasing in size rather rapidly, almost flat above with unimpressed suture. Body whorl with rounded periphery, descending slightly in the last 1 mm. Aperture broadly lunate, labral profile strongly retractive (about 45 degrees to the axis); outer lip thickened and slightly reflected; palatal wall with a fold-like spiral lamella, 1 mm. long, midway between the suture and the periphery, becoming obsolete and ending just behind the aperture. Reflection of outer lip ceases abruptly near the columellar insertion, producing a slightly retractive notch in the plane of the base of the aperture. Parietal wall with moderately thick callus, apparently without lamellæ. Sculpture consists of fine, regular, retractive growth lines, about 20 to the mm. on the body whorl.

Remarks. The spiral lamella of the outer wall is visible as a slight sinus on the exterior of the holotype, but is best seen as a groove that represents the impression of the lamella, on specimens exfoliated behind the aperture, such as No. 10199.

This species resembles in some respects *Prograngerella sperata* Russell (1941, p. 310, figs. 1-4), from the Oldman formation of Alberta; the two have in common the upper palatal lamella but *P. sperata* differs in having a prominent basal lamella confluent with the lip and also fewer whorls than *D. mokowanensis*. This morphological similarity is interpreted to indicate a close relationship between the shells referred to *Dimorphoptychia* and the *Grangerellidae.*

Occurrence. St. Mary River formation.

Dimorphoptychia rutherfordi (Russell)

Plate VII, figures 8, 9a, 9b, 10a, 10b, 11, 13; Text Figure 4

1929. *Polygyra rutherfordi* Russell, Roy. Soc., Canada, Trans., ser. 3, vol. 23, sec. 4, p. 86, Pl. 1, figs. 12-15.

Material. Holotype, University of Alberta collections, No. Ct 379, Paskapoo formation, locality 5; hypotype, University of Alberta collections, No. Pa 105, locality 23; hypotypes, G.S.C. Nos. 10178, 10179, 10180, 10181, 10297, Paskapoo formation, locality 25.

Dimensions.

Specimen	Altitude	Width	Number of whorls
Ct 379	..	5·3	4
10178	(5·0)	9·2	6 ?
10179	..	9·0	6
Pa 105	..	8·5	..

Description. Shell of medium size, obtusely conoid, imperforate. Whorls 6, those of spire increasing in size slowly, body whorl dilated, width about one-half radius of shell. Whorls slightly convex above with a slightly impressed suture, periphery evenly rounded, body whorl apparently not descending in front. Aperture lunate, labral profile retractive, inclined at about 60 degrees to the axis; outer lip thickened and reflected, expanding at the columellar insertion to form a heavy callus in the umbilical region; face of peristome rounded. The palatal wall houses three spiral lamellæ, which make their appearance about 4 mm. from the aperture and decrease in prominence, or disappear completely as the lip is approached. The upper lamella is about midway between the suture and the periphery, the middle lamella is just below the periphery, and the basal lamella is about 3 mm. from the columellar insertion of the lip. Parietal wall with a heavy callus and two spiral lamellæ apparently symmetrically placed between the columellar and upper insertions of the lip. First whorl unsculptured, succeeding whorls with regular, curved, retractive costulæ, most prominent at the upper suture, becoming less so at the periphery and nearly or entirely absent on the base, about 6 to the mm. on the body whorl. Growth lines fine and regular, about 25 to the mm. on the body whorl, visible on entire surface of whorl. The combination of the costulæ and the fine lines of growth may impart a fasciculate appearance to the sculpture on the upper surface.

Remarks. The holotype of this species is crushed, embedded in matrix, lacks the lip, and probably represents an immature individual. The present description is based principally upon a large collection of fragmentary individuals from Little Red Deer River. The upper lateral lamella is present on several exfoliated specimens from this locality; two show a single lamella on the parietal wall and several show the two lower lateral lamellæ. A single specimen (Plate VII, fig. 13) from Fallentimber Creek, collected by Dr. L. S. Russell, shows two spiral lamellæ on the parietal wall. In this specimen the spire is embedded in matrix but the specimen is from a bed containing shells that show the external characters of *D. rutherfordi.* These lamellæ have not been observed on specimens from other localities referred to this species, on external characters, but for the present their absence is attributed to poor preservation.

D. rutherfordi as interpreted above, is evidently closely related to *D. douglasi* sp. nov., and possibly to *Kanabohelix kanabensis* (White). The relationship of these species is discussed under the description of *D. douglasi* sp. nov. (page 46).

Occurrence. Paskapoo formation, Willow Creek formation (upper part).

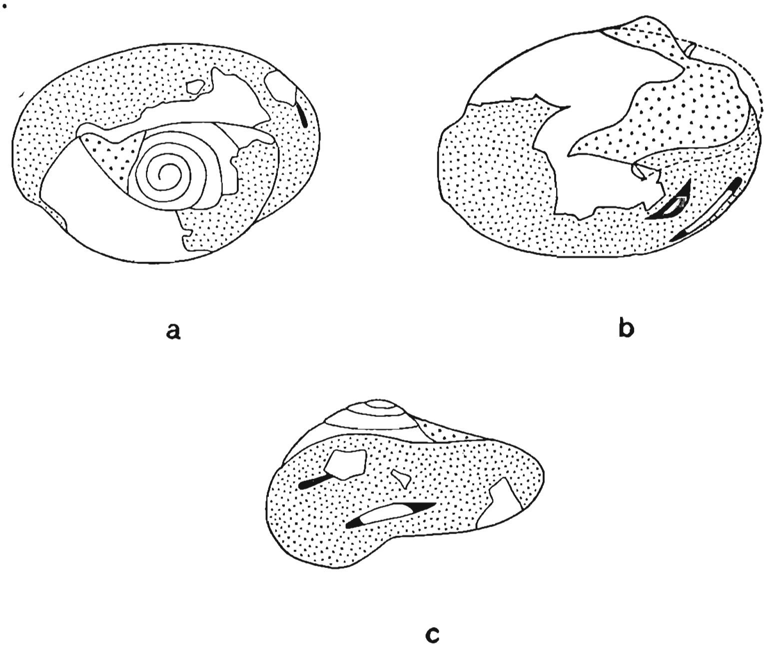

Figure 4. *Dimorphoptychia rutherfordi* (Russell) (x4). Hypotype, G.S.C. No. 10181, showing three lateral lamellæ on palatal wall. Light stipple represents exfoliated shell, heavy stipple matrix, impression of lamellæ solid black. Sculpture omitted.

Dimorphoptychia sp. cf. *D. rutherfordi* (Russell)

Plate VII, figure 12

Material. Figured specimen, G.S.C. No. 10184, St. Mary River formation, locality 32.

Dimensions. Specimen 10184: altitude 7·0 mm.; width 11·1 mm.; number of whorls, 6.

Remarks. A few specimens from the St. Mary River beds and one from the lower part of the Willow Creek formation are very close to *D. rutherfordi.* They agree well in proportions, but the figured example, the best yet obtained from a Cretaceous horizon, is less prominently sculptured than Paleocene specimens. In none of the Cretaceous specimens have internal spiral lamellæ been seen.

Occurrence. St. Mary River formation, Willow Creek formation (lower part).

Family, GRANGERELLIDAE

Genus, *Grangerella* Cockerell

Grangerella mcleodensis (Russell)

Plate VII, figures 1-4

1929. *Euconulus mcleodensis* Russell, Roy. Soc., Canada, Trans., ser. 3, vol. 23, sec. 4, p. 88, Pl. 1, figs. 19, 20.

1931. *Grangerella mcleodensis* Russell, Roy. Soc., Canada, Trans., ser. 3, vol. 25, sec. 4, p. 17, Pl. 2, figs. 16-20.

Material. Holotype, University of Alberta collections, No. Ct 383, Paskapoo formation, locality 5; hypotypes, G.S.C. Nos. 10191, 10192, Willow Creek formation (upper part), locality 17; hypotype, G.S.C. No. 10193, Paskapoo formation, locality 11; hypotype, G.S.C. No. 10194, Porcupine Hills formation, locality 1.

Dimensions.

Specimen	Altitude	Width	Number of whorls	Position of upper insertion of aperture
10191	4·2	6·0+	6½	on 3rd whorl
10192	—	5·5+	—	—
10193	5·0	7·2	6½	on 3rd whorl

Description. Shell of medium size, imperforate. Spire conoid, with slightly convex sides. Whorls 6½, almost flat with suture little impressed above, increasing in size slowly; last half of body whorl dilated, ascending spire, upper extremity of aperture reaching second or third whorl, basal insertion apparently situated just below mid-point between the periphery and the upper suture of the body whorl. Sides of undeflected part of body whorl almost vertical. Aperture broadly lunate, outer lip thickened and strongly reflected; palatal wall with upper and basal lamellæ with corresponding depressions on the outer surface; lamellæ extend within the body whorl from the lip, with which they coalesce, for about 3 mm. Face of peristome subangular, outer part almost at right angles to the axis near the apex. First half whorl smooth, succeeding whorls with sculpture of regular, slightly curved, retractive costulæ, about 25 to the mm. on the first whorl, 8 to the mm. on the body whorl; costulæ well developed on base of shell. Fine growth lines visible on slightly exfoliation, two intercalated between each costula on body whorl.

Remarks. This interesting species was originally described from the "Upper Saunders beds" (= Paskapoo) on the basis of a crushed shell. Russell later collected material from Fallentimber Creek and described the aperture and the deflection of the body whorl, these features indicating that this species is referable to *Grangerella*. The present description is based upon studies of a large collection, from various Paleocene localities, and confirms Russell's interpretation of the aperture. The only respect in which the material now available differs from Russell's specimens from Fallentimber Creek is in the position of the upper extremity of the aperture. Russell described the aperture as abutting the fourth whorl; in most of the specimens studied the upper insertion is in contact with the third whorl, but the lip of a crushed specimen, from Pekisko Creek, is apparently adjacent to the second whorl. *G. mcleodensis*, therefore, is very close to the small specimens from the Gray Bull beds (Lower Eocene) of Wyoming, and referred by Russell (1931b, Pl. 4, figs. 9-15) to *G. sinclairi* (Cockerell), which is characterized by having the posterior angle of the aperture adjacent to the second or third whorl. As interpreted by Russell, however, *G. sinclairi* varies considerably in size, and includes individuals of larger dimensions than *G. mcleodensis*. The data from the study of the new material do not seriously modify Russell's (1941) hypothesis regarding the phylogenetic significance of the apertural position within this group of land shells, but the degree of deflection does vary in this species.

Occurrence. Paskapoo formation, Willow Creek formation (upper part), Porcupine Hills formation.

Family, VIVIPARIDAE

Genus, *Viviparus* Montfort

Viviparus leai (Meek and Hayden)

Plate IV, figures 4a, 4b, 5, 6

1856. *Paludina Leai* Meek and Hayden, Phil. Acad. Nat. Sci., Proc., vol. 8, p. 121.

1876. *Viviparus Leai* (Meek and Hayden); Meek, U.S. Geol. Surv. Terr., Rept., vol. 9, p. 577, Pl. 44, figs. 6a-d.

1883. *Viviparus leai* (Meek and Hayden); White, U.S. Geol. Surv., 3rd Ann. Rept., p. 467, Pl. 27, figs. 10-14.

Material. Hypotype, University of Alberta collections, No. Pa 101, Paskapoo formation, Bucklake Creek, near Berrymoor, Alberta; hypotype, G.S.C. No. 10311, Paskapoo formation, locality 1; hypotype, G.S.C. No. 10134, a crushed specimen showing the sculpture, Paskapoo formation, locality 19.

Dimensions.

Specimen	Altitude	Width	Height of aperture	Number of whorls
Pa 101	20·7	15·2	10·0	6
10130	16·0	12·0	8·5	5

Remarks. This species is recognized by the impressed suture, convex whorls with slightly flattened sides, narrow umbilicus, and sculpture of spiral pits. The peculiar sculpture varies considerably in different specimens. Meek noted its absence on many shells. The crushed hypotype from locality 19 shows the sculpture particularly well; the spiral lines are arranged at regular intervals of about 1 mm. on the body whorl.

Unsculptured shells bear a superficial resemblance to those of the contemporary *V. raynoldsanus* Meek and Hayden, but the two species seem to present considerably different proportions, *V. leai* having a more delicately and closely coiled spire, with more whorls in the same dimensions.

The Cretaceous form, *V. mokowanensis* sp. nov., bears a superficial resemblance to *V. leai*: these species are compared under the description of the former.

Occurrence. Originally described from the typical Fort Union group. Paskapoo formation, Willow Creek formation (upper part) ?, Ravenscrag formation, Saskatchewan.

Viviparus mokowanensis sp. nov.

Plate III, figures 13a, 13b, 14

Material. Holotype, G.S.C. No. 10298, south side Oldman River, NE. ¼ sec. 31, tp. 9, rge. 23, W. 4th mer.; paratype, G.S.C. No. 10299, sec. 27, tp. 3, rge. 27, W. 4th mer.; paratype, G.S.C. No. 10300, Belly River, right side, SW. ¼ sec. 3, tp. 4, rge. 27, W. 4th mer. All from the basal member of the St. Mary River formation.

Dimensions.

Specimen	Altitude	Width	Height of aperture	Number of whorls
10298	27·5	17·3	12·0	last 4
10299	22·3	15·5	11·0	5
10300	25·0	19·0	14·0	last 4

Description. Shell of medium size, of ovate outline. Apex pointed, height of body whorl slightly less than one-half the altitude. Whorls about 6, increasing in size rapidly, mildly convex, periphery rounded-angular, becoming rather well rounded near the aperture. Suture impressed, often particularly prominent behind the body whorl due to the coiling of the body whorl below the periphery of the penult whorl. Aperture subquadrilateral, inner lip almost or completely sealing the umbilicus. Sculpture consists of exceedingly obscure spiral lines; growth lines rather prominent, parasigmoid, prominently curved in front of the suture.

Remarks. *V. mokowanensis* has fewer whorls in the same dimensions, and lacks the characteristic sculpture of the Paleocene *V. leai* (Meek and Hayden). *V. raynoldsanus* (Meek and Hayden), also from the Paleocene, is larger, and typically is prominently sculptured and deeply umbilicate as compared with *V. mokowanensis*. *V. nidaga* Dyer, from the Oldman and Foremost formations, and *V. westoni* sp. nov. differ from this species in having a carinate periphery on the early whorls. *V. prudentius* White is more depressed, has more convex whorls, and is narrowly perforate compared with the present form. Some varieties of *V. tasgina* Dyer present a similar outline to this species but they differ in having a well-rounded apex.

Occurrence. Confined to the basal member of the St. Mary River formation, where it occurs with *Corbula perangulata* Whiteaves, *Anomia perstrigosa* Whiteaves, and *"Melania" wyomingensis* Meek, which are usually considered to indicate brackish-water conditions.

Viviparus planolatere Russell

Plate IV, figures 7, 8a, 8b

1926. *Vivipara planolatere* Russell, Roy. Soc., Canada, Trans., ser. 3, vol. 23, sec. 4, p. 214, Pl. 2, figs. 1, 2.

Material. Holotype, University of Alberta collections, No. Pa 11, Paskapoo formation, Elbow River, Calgary; hypotypes, G.S.C. Nos. 10132, 10133, Paskapoo formation, locality 26.

Dimensions. Specimen 10132: altitude 27·2; width 25·0; number of whorls, last 4½ (5).

Remarks. This species, readily recognized by its flat whorls, angular periphery, and subquadrilateral aperture, is known only from the Paleocene of Alberta. Probably the fragmentary material described as *V. peculiaris* (Meek and Hayden) (Meek, 1876, p. 580, fig. 79), from the Fort Union group near Fort Clarke, North Dakota, is conspecific with *V. planolatere*, but until adult topotypes of the former are available, the identity of these species cannot be determined conclusively.

Occurrence. Paskapoo formation, Willow Creek formation (upper part).

Viviparus prudentius prudentius White

Plate III, figures 7, 8a, 8b, 9

1878. *Viviparus prudentius* White, U. S. Geol. Surv. Terr., Bull. 4, p. 716.

1883. *Viviparus prudentius* White, U. S. Geol. Surv. Terr., 12th Ann. Rept., p. 98, Pl. 28, figs. 5a, b.

1885. *Viviparus prudentius* White; Whiteaves, Geol. Surv., Canada, Contr. Can. Pal., vol. 1, p. 24.

Material. Hypotypes, G.S.C. Nos. 10287, 10288, 10289, St. Mary River formation, Pincher Creek, collected by T. C. Weston.[1]

Dimensions.

Specimen	Altitude	Width	Height of aperture	Number of whorls
10287	21·7(22·0)	17·0(18·0)	12·5	last 3½(5)
10288	24·2	23·0	—	last 3 (5½)
10289	9·0	11·0	—	4

Description. Shell of medium size, depressed turbinate, height of aperture slightly more than half the altitude. Whorls about 5, those of spire increasing in size slowly, body whorl dilated, evenly convex from the suture to the umbilicus, suture well impressed. Aperture obliquely ovate, inner lip not reflected, producing a well-defined umbilical chink. Sculpture consists of variable, but usually obscure, spiral lines; growth lines not prominent.

Remarks. The material from Pincher Creek, which formed the basis for Whiteaves' record of this species from Alberta, is exfoliated, but includes some undistorted specimens. Some crushed specimens from Nobleford that retain the shell matter are apparently conspecific with the Pincher Creek material. They show two rather well-defined spiral lines on the third whorl and obscure spiral sculpture of about 15 lines to the mm. on the body whorl. This sculpture is not developed on the holotype. Owing to the poor preservation of the Canadian specimens, this record cannot be considered entirely satisfactory.

Occurrence. Originally described from the Laramie formation of Colorado. St. Mary River formation, Willow Creek formation (lower part), Edmonton formation (lower part), Edmonton formation (Disturbed belt).

[1] The first fossil collections from Pincher Creek were made by R. G. McConnell and T. C. Weston, in 1881 and 1883 respectively. This material was described by Whiteaves (1885). All the specimens from Pincher Creek described by Whiteaves are embedded in a hard, massive, calcareous shale, and presumably they were collected from the same bed. With reference to his collections from Pincher Creek, Weston (1899, p. 158) states: "One cliff perhaps 200 feet high holds a thick bed of limestone partly made up of well preserved gasteropods and other shells. The beautiful spiral shell *Physa copei*, described by Mr. Whiteaves..... is very abundant". The only bed exposed on Pincher Creek that matches the matrix attached to McConnell's and Weston's specimens, and that satisfies Weston's description, occurs in l.s. 4, sec. 22, tp. 6, rge. 30, W. 4th mer. This bed is 331 feet from the top of the St. Mary River formation. This horizon is, therefore, the type locality for *Valvata filosa* Whiteaves, *Oreohelix angulifera* (Whiteaves), and *Physa canadensis* Whiteaves. In the list of localities for this paper this bed is referred to as locality 20.

Viviparus prudentius willovensis subsp. nov.

Plate III, figures 10a, 10b, 11, 12

Material. Holotype, G.S.C. No. 10129, an undistorted, but largely exfoliated, fragmentary shell, Edmonton formation (Disturbed belt), locality 7; paratype, G.S.C. No. 10130, Willow Creek formation (lower part), locality 10; paratype, G.S.C. No. 10131, Edmonton formation (Disturbed belt), locality 8.

Dimensions. Specimen 10129: altitude 23·5 (24·0); width 20·0; height of aperture 13·0; number of whorls, last 3½ (5).

Description. Shell of medium size, turbinate, moderately depressed. Height of aperture about half the altitude. Whorls about 5, with even convex side and periphery. Suture well impressed. Aperture obliquely ovate, inner lip apparently not reflected, producing a narrow umbilical chink. Spiral sculpture consists of well-defined, sharp, raised lines; on third and fourth whorls two lines may achieve particular prominence, those of body whorl exhibiting no constant differentiation; about ten lines in 5 mm. on body whorl. Growth lines regular, closely spaced, not prominent.

Remarks. The shell form suggests a relationship between this subspecies and the shells identified as *V. prudentius* White, from the St. Mary River formation, from which *V. prudentius willovensis* differs in possessing prominent spiral sculpture. The two have never been found in the same bed.

Occurrence. Willow Creek formation (lower part), Edmonton formation (Disturbed belt). All occurrences of this subspecies are south of Bow River, in the beds adjacent to the Disturbed belt.

Viviparus raynoldsanus Meek and Hayden

Plate IV, figures 9a, 9b

1861. *Vivipara raynoldsana* Meek and Hayden, Phil. Acad. Nat. Sci., Proc., vol. 13, p. 466.

1876. *Viviparus raynoldsanus* (Meek and Hayden); Meek, U.S. Geol. Surv., Terr., Rept., vol. 9, p. 584, Pl. 44, figs. 7a, b.

1883. *Viviparus reynoldsianus* (Meek and Hayden); White, U.S. Geol. Surv., 3rd Ann. Rept., p. 467, Pl. 25, figs. 22, 23.

1946. *Viviparus raynoldsanus* Meek and Hayden; Yen, Am. Jour. Sci., vol. 244, p. 42, Pl. 1, fig. 3.

1948. *Viviparus raynoldsanus* Meek and Hayden; Yen, U.S. Geol. Surv., Prof. pap. 214-C, p. 40, Pl. 10, fig. 1.

Material. Hypotype, G.S.C. No. 10135. Paskapoo formation, locality 17.

Dimensions. Specimen 10135: altitude 31·0; width 21·8; height of aperture 14·5; number of whorls, 6.

Remarks. Typical specimens of *V. raynoldsanus* are large, rather deeply umbilicate, and have convex whorls with moderately prominent, but variable, spiral sculpture. Specimens from Alberta lack half a whorl compared with typical individuals, but agree well in proportions. They also lack the spiral sculpture and are, in fact, only separable from unsculptured individuals of *V. leai* (Meek and Hayden) on the basis of their more rapidly dilating whorls.

Occurrence. Originally described from the Fort Union group of Wyoming. Paskapoo formation.

Viviparus retusus (Meek and Hayden)

Plate IV, figures 1, 2

1856. *Paludina retusa* Meek and Hayden, Phil. Acad. Nat. Sci., Proc., vol. 8, p. 122.
1876. *Viviparus retusus* (Meek and Hayden); Meek, U.S. Geol. Surv. Terr., Rept., vol. 9, p. 578, Pl. 44, figs. 5a-f.
1883. *Viviparus retusus* (Meek and Hayden); White, U.S. Geol. Surv., 3rd Ann. Rept., p. 467, Pl. 24, figs. 1-3.
1931. *Viviparus retusus* (Meek and Hayden); Russell, Bull. Am. Pal., vol. 18, No. 64, p. 7, Pl. 1, figs. 5, 6.
1948. *Viviparus retusus* (Meek and Hayden); Yen, U.S. Geol. Surv., Prof. pap. 214-C, p. 40, Pl. 10, fig. 3.

Material. Hypotypes, G.S.C. No. 10136, Paskapoo formation, locality 25, G.S.C. No. 10137, Paskapoo formation, locality 32.

Dimensions.

Specimen	Altitude	Width	Height of aperture	Number of whorls
10136	19·5	16·0	(12·0)	5
10137	10·9	15·8	....	4

Description. Shell of medium size, trochiform, with rounded apex. Whorls about 5, first 3 increasing in size very rapidly, sides gently convex or slightly angular, periphery angular to carinate, where carinate the suture is slightly channelled; later whorls with almost or quite flat sides, angular periphery, and unimpressed suture. Aperture subquadrangular, inner lip reflected, sealing the axis. Surface marked by rather prominent, almost straight growth lines, inclined at almost 45 degrees to the axis; irregular spiral lines and ridges usually developed, particularly on the upper whorls.

Remarks. The rounded apex, flat whorls, and angular periphery, which is present at all stages of growth, characterize this species. Small varieties of *V. tasgina* Dyer, from the Edmonton formation, share the rounded apex but they differ in the possession of rounded periphery. In some individuals the spiral sculpture of the upper whorls includes two prominent ridges similar to those of *V. trochiformis* (Meek and Hayden), but the ridges do not develop the prominence and regularity shown in that species.

Occurrence. Originally described from the typical Fort Union group. Paskapoo formation, Willow Creek formation (upper part), Ravenscrag formation of Saskatchewan.

Viviparus tasgina Dyer

Plate IV, figures 10a, 10b, 11a, 11b, 12-14

1930. *Viviparus tasgina* Dyer, Nat. Mus., Canada, Bull. 63, p. 10, Pl. 3, fig. 5.
[?] 1930. *Viviparus crickmayi* Dyer, Nat. Mus., Canada, Bull. 63, p. 8, Pl. 3, fig. 3.

Material. Holotype, G.S.C. No. 6676, Edmonton formation (lower part), Bow River at Blackfoot Crossing, about sec. 8, tp. 21, rge. 21, W. 4th mer., collected by G. M. Dawson, 1881; hypotypes, G.S.C. Nos. 10290, 10291, 10292, Edmonton formation (lower part), locality 5; hypotypes, G.S.C. Nos. 10293, 10294, Edmonton formation (lower part), locality 7.

Dimensions.

Specimen	Altitude	Width	Height of aperture	Number of whorls
6676	51·0	42·0	..	last 4 (6)
10290	36·0	27·2	19·1	5
10291	37·2	..	23·5	last 3 (5)
10292	13·0	12·0	9·0	3½
10293	26·3	21·2	13·0	5
10294	21·4	18·5	13·0	4½

Description. Shell of large size, broadly to very broadly ovate in outline, apex rounded. Shell substance thick. Whorls 5 to 6, increasing in size rapidly. First 3 whorls with mildly convex sides, rounded-angular periphery, and slightly impressed suture; fourth and later whorls with variably developed shoulder anterior to the suture, almost flat sides, and an evenly convex periphery. Aperture subquadrilateral, broadly rounded in front; inner lip somewhat reflected producing a quite imperforate axis. Sculpture consists of obscure, irregular spiral lines; never prominent, frequently obsolete. Growth lines rather strongly parasigmoid.

Remarks. Typical examples of this species are well characterized by the rounded apex, the large size, and the rapidly dilating, shouldered whorls. The writer has also included within this species the shells, such as the hypotypes from Bow River (locality 7) (Plate IV, figures 10, 11), which Dyer (1930b, p. 48) identified with the Paleocene *V. retusus* (Meek and Hayden) and *V. leai* (Meek and Hayden). *V. leai* differs from the Bow River shells in having a more closely coiled spire with a pointed apex. *V. retusus,* which displays the rounded apex and rapidly dilating whorls of *V. tasgina,* differs in that it possesses a conspicuously angular periphery throughout life. These Bow River shells are best referred to the contemporary *V. tasgina,* from the type of which they differ only in having a less conspicuous shoulder on the anterior whorls; in this feature specimens of the typical variety from a single bed exhibit considerable variation.

V. crickmayi Dyer was described from a boulder in sec. 12, tp. 10, rge. 27, W. 4th mer., believed by Dyer to be of Willow Creek formation. *V. crickmayi* has the thick shell, the rounded apex composed of rapidly dilating whorls, and the shouldered lower volutions of *V. tasgina* and differs only in being more slender and having the shoulders more prominently developed. The only specimens available are from the type "locality" (G.S.C. locality No. 8683). The matrix attached to the typical shells of *V. crickmayi* is a fine-grained brown limestone, unknown in the Willow Creek formation near the boulder. The Willow Creek beds in this area are referable to the upper part (Paleocene) of the formation. With *V. crickmayi* in the drift boulder are the following, *Campeloma edmontonensis* sp. nov., *Lioplacodes limnaeformis* (Meek and Hayden), and *Goniobasis webbi* Dyer. All three species are common in the lower part of the Edmonton formation, and two, *C. edmontonensis* and *G. webbi*, are known only from that and contemporary Cretaceous formations. For these reasons the author considers that the boulder from which *V. crickmayi* was collected probably represents an erratic from the Edmonton formation. *V. crickmayi* is, therefore, probably a contemporary of *V. tasgina*, of which it may represent an unusual variety. Dyer (1930a, p. 9) reported an occurrence of *V. crickmayi* from the Edmonton formation of Bow River, but the specimens cannot be located.

Occurrence. Edmonton formation (lower part).

Viviparus trochiformis (Meek and Hayden)

Plate IV, figure 3

1856. *Paludina trochiformis* Meek and Hayden, Phil. Acad, Nat. Sci. Proc., vol. 8, p. 122.
1876. *Viviparus trochiformis* (Meek and Hayden); Meek, U.S. Geol. Surv. Terr., Rept., vol. 9, p. 580, Pl. 44, figs. 2a-e.
1883. *Viviparus trochiformis* (Meek and Hayden); White, U.S. Geol. Surv., 3rd Ann. Rept., p. 467, Pl. 24, figs. 10-16.
1886. *Viviparus trochiformis* (Meek and Hayden); White, U.S. Geol. Surv., Bull. 34, p. 31, Pl. 1, figs. 1-5.

Material. Hypotype, G.S.C. No. 10138, Paskapoo formation, locality 16.

Remarks. This determination is based upon fragmentary individuals showing the pointed apex and the two prominent revolving ridges characteristic of this species.

Occurrence. Originally described from the typical Fort Union group. Paskapoo formation, Ravenscrag formation of Saskatchewan.

Viviparus westoni sp. nov.

Plate III, figures 1-6

Material. Holotype, G.S.C. No. 10122, an exfoliated but undistorted shell lacking the apex, St. Mary River formation, Pincher Creek, Alberta, locality 20, collected by T. C. Weston, 1883 (*See* page 54); paratype, G.S.C. No. 10123, St. Mary River formation, locality 20; paratype, G.S.C. No. 10124, St. Mary River formation, locality 16; paratype, G.S.C. No. 10125, Edmonton formation (lower part), locality 9; paratype, G.S.C. No. 10126, St. Mary River formation, locality 2; paratype, G.S.C. No. 10127, St. Mary River formation, locality 10.

Dimensions.

Specimen	Altitude	Width	Height of aperture	Number of whorls
10122	29·9	24·5	17·5	last 3½ (5½)
10124	23·7	17·2	13·3	5
10125	33·7	24·0	19·0	last 3½ (6)
10126	37·2	32·0	23·0	last 3 (6½)

Description. Shell large, height of body whorl varying between one-half and nearly two-thirds the altitude; spire subconical, body whorl with turbinate base. Whorls 6 to 6½, first 3 with flat to slightly shouldered sides and very angular, a slightly carinate periphery, suture unimpressed; fourth and succeeding whorls of spire with less angular periphery and moderately impressed suture; body whorl evenly convex, bounded behind by a well-impressed suture. Aperture ovate, evenly rounded in front, angular behind; inner lip slightly reflected, producing an imperforate axis. Surface marked by straight to slightly sigmoidally curved lines of growth; early whorls with spiral sculpture of raised lines of varying prominence but without constant differentiation; about twenty such lines on a fourth whorl, varying from very faint to conspicuous.

Remarks. This species is characterized by the combination of an angular periphery on the early whorls and a well-rounded periphery on the body whorl. *V. nidaga* Dyer, from the Foremost and Oldman formations, is a rather similar shell, but it differs in the relatively shorter aperture and the retention of an angular periphery on the body whorl. A large specimen referred to *V. nidaga,* from the Belly River formation of Waterton River, also differs from the present species in that spiral sculpture is developed throughout life. *V. westoni* includes specimens referred, doubtfully, to the Paleocene *V. raynoldsanus* Meek and Hayden by Russell (1932c, p. 131). *V. raynoldsanus* differs from the present species in possessing convex whorls and an impressed suture at all stages of development. The rounded body whorl of *V. westoni* distinguishes it from *V. planolatere* Russell, of the Paskapoo, but the resemblance between young shells of the former and adults of the latter is striking, and the two species are probably closely related. Dyer's (1930b, p. 55) record of *V. planolatere* from the St. Mary River formation refers to specimens of *V. westoni.*

The specific name is for the late T. C. Weston, formerly of the Geological Survey of Canada, who collected the type specimen.

Occurrence. St. Mary River formation, Edmonton formation (lower part), Edmonton formation (Disturbed belt), Willow Creek formation (lower part), Brazeau formation (upper part), Wapiti group. The record from the Brazeau formation is based on rather poorly preserved material.

Genus, *Campeloma* Rafinesque

Campeloma edmontonensis sp. nov.

Plate V, figures 12a, 12b, 13

Material. Holotype, G.S.C. No. 10139, a somewhat exfoliated shell with a damaged apex, Edmonton formation (lower part), locality 5; paratype, G.S.C. No. 10140, Edmonton formation (lower part), locality 5; paratype, G.S.C. No. 10141, Edmonton formation, locality 9.

Dimensions.

Specimen	Altitude	Width	Height of aperture	Number of whorls
10139	29·0	15·8	12·5	last 4
10140	30·0	17·0	17·1	last 2
10141	28·5	15·5	12·7	last 4½

Description. Shell elongate-ovate in outline. Whorls about 6, increasing in size slowly, evenly convex, rather tumid. Periphery well rounded throughout development. Suture well impressed, bounded anteriorly by a poorly defined, but rather constant, narrow shoulder. Aperture pyriform, rounded in front, angular behind; inner lip somewhat reflected, nearly or quite closing the umbilicus. First 2 whorls with sculpture of growth lines only, succeeding whorls with sculpture of spiral raised lines and slightly parasigmoid growth lines of varying prominence; on body whorl spiral sculpture is uniform over entire surface, although in some specimens from 2 to 5 lines are prominent within the 5 mm. anterior to the suture. Growth and spiral lines of about equal strength, intersections somewhat nodose, imparting a reticulate appearance. About 5 spiral lines in 1 mm. on body whorl.

Remarks. This species is apparently closely related to *C. nebrascensis nebrascensis* (Meek and Hayden) of the Paleocene and the shells described as "*C. vetula* var. *tenuis*" by Dyer[1] (1930a, p. 10, Pl. 3, fig. 4) from the Foremost formation. *C. edmontonensis* differs from *C. nebrascensis* in being more slender and less prominently umbilicate; the sculpture of *C. edmontonensis* is also more delicate than that of *C. nebrascensis*. "*C. vetula* var. *tenuis*" presents a similar shell outline, but its whorls are less tumid, and the sculpture is more variable, and is not developed uniformly over the whorl surface as in *C. edmontonensis*. From the material available it would also appear that "*C. vetula* var. *tenuis*" is smaller than *C. edmontonensis*.

Occurrence. Edmonton formation (lower part), Edmonton formation (Disturbed belt), St. Mary River formation.

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[1] *C. vetula* var. *tenuis* Dyer is a junior homonym of *C. tenuis* (Warren) (Russell, 1929b, p. 83, Pl. 1, figs. 4-6) = *Thaumastus limnaeformis* var. *tenuis* Warren (Warren, 1926, p. 7, Pl. 1, figs. 6-8). The writer places Warren's variety in *Lioplacodes limnaeformis* (Meek and Hayden) (*See* page 62), but this does not alter the fact that Dyer's combination was preoccupied at its inception owing to Russell's reference of *Thaumastus limnaeformis* var. *tenuis* to *Campeloma* in 1929. *C. vetula* var. *tenuis* may not be separable from *C. vetula vetula* (Meek and Hayden), and until this relationship is made clear it is inadvisable to re-name Dyer's variety.

Campeloma nebrascensis nebrascensis (Meek and Hayden)

Plate V, figures 11a, 11b

1856. *Bulimus nebrascensis* Meek and Hayden, Phil. Acad. Nat. Sci., Proc., vol. 8, p. 118.
1856. *Paludina multilineata* Meek and Hayden (*non* Say, 1829), Phil. Acad. Nat. Sci., Proc., vol. 8, p. 120.
1876. *Campeloma multilineata* (Meek and Hayden); Meek, U.S. Geol. Surv., Terr., Rept., vol. 9, p. 586, Pl. 44, figs. 1a-c.
1883. *Campeloma multilineata* (Meek and Hayden); White, U.S. Geol. Surv., 3rd Ann. Rept., p. 469, Pl. 27, fig. 1 (*not* figs. 2, 3, 4 = *C. nebrascensis reticulata* Russell; *not* figs. 5, 6, 7 = *Campeloma nebrascensis whitei* Russell).
1948. *Campeloma nebrascensis* (Meek and Hayden); Yen, U.S. Geol. Surv., Prof. pap. 214-C, p. 41, Pl. 10, figs. 4, 4a, 5, 5a-b.

Material. Hypotype, Royal Ontario Museum of Palæontology, No. 4446 Ct, Ravenscrag formation, Estevan, Saskatchewan.

Dimensions. Specimen 4446 Ct: altitude 30·1; width 19·0; height of aperture 15·0; number of whorls, last 4.

Occurrence. Originally described from the typical Fort Union group, Ravenscrag formation, Saskatchewan. This is the only known Canadian occurrence of this species, in the restricted sense. Other Paleocene occurrences in Saskatchewan and Alberta are referable to Russell's subspecies. Dyer's (1930b, pp. 48, 55) records of "*Campeloma multilineata*" from the Edmonton and St. Mary River formations refer to specimens of *C. edmontonensis* sp. nov.

Campeloma nebrascensis whitei Russell

Plate V, figure 10

1883. *Campeloma multilineata* (Meek and Hayden); White, U.S. Geol. Surv., 3rd Ann. Rept., p. 469, Pl. 27, figs. 5, 6, 7.
1931. *Campeloma nebrascensis whitei* Russell, Roy. Soc., Canada, Trans., ser 3, vol. 25, sec. 4, p. 12, Pl. 2, fig. 1.

Material. Hypotype, G.S.C. No. 10142, Paskapoo formation, locality 25.

Dimensions. Specimen 10142: altitude 29·0; width 19·6; height of aperture 16·2; number of whorls, last 4.

Remarks. As noted by Russell, the typical *C. nebrascensis* does not occur in Alberta and it seems probable that *C. nebrascensis whitei* represents a geographical subspecies of the typical form.

Occurrence. Originally described from the Fort Union group of Heart River, North Dakota. Paskapoo formation. White (1883, Pl. 25, fig. 7) has figured a shell, apparently referable to this subspecies, from the Laramie formation of Colorado, but in Alberta *C. nebrascensis whitei* is known only from the Paleocene.

Genus, *Lioplacodes* Meek

This genus was founded by Meek (1864) for the reception of "*Melania*" *veterna* Meek and Hayden, from Jurassic or Lower Cretaceous beds in Wyoming. Until 1932 the genus remained monotypic, when Russell (1932e) described *Lioplacodes bituminis* from the McMurray formation (Lower Cretaceous) of Athabasca River. In describing this species Russell, by comparing it with "*M.*" *nebrascensis* Meek and Hayden (which he placed in *Lioplax* Troschel), anticipated Yen's (1946) proposal to refer "*M.*" *nebrascensis* and "*Bulimus*" *limnaeformis* Meek and Hayden to *Lioplacodes.* More recently Yen (1948) has returned "*M.*" *nebrascensis* to *Goniobasis* Lea, where it had rested for a number of years, and in the same publication he referred "*M.*" *tenuicarinata* Meek and Hayden to *Lioplacodes.* The writer finds Yen's earlier view regarding "*M.*" *nebrascensis* more acceptable as expressing the probable relationship between this species and *L. veternus* and *L. bituminis.*

Lioplacodes is regarded as a moderately prolific late Mesozoic-early Tertiary genus characterized by a narrowly perforate shell of elongate-ovate outline, composed of whorls of variable convexity, with the body whorl little dilated, a continuous peristome, and variably developed spiral sculpture. All the species mentioned above are embraced by this diagnosis. In addition, the characters of "*Goniobasis*" *whiteavsi* Russell and "*G.*" *sanctamariensis* Russell, from the St. Mary River formation, conform with this definition.

Prashad (1928) has placed *Lioplacodes* in synonymy with the living viviparid *Lioplax* Troschel, but Meek (1864) and Yen (1946) maintain that *Lioplax* is more deeply umbilicate, has more convex whorls, and a more dilated body whorl than the present genus.

Although *Lioplacodes* is regarded by most authorities as a viviparid nevertheless the shells are of such generalized form as to give little evidence against placing it as a pleurocerid related to *Goniobasis* Lea. The operculum, which might assist in determining the systematic position of *Lioplacodes,* is not known.[1]

Lioplacodes limnaeformis (Meek and Hayden)

Plate VI, figures 1-8

1856. *Bulimus limnaeformis* Meek and Hayden, Phil. Acad. Nat. Sci., Proc., vol. 8, p. 118.
1876. *Thaumastus limnaeformis* (Meek and Hayden); Meek, U.S. Geol. Surv. Terr., Rept., vol. 9, p. 553, Pl. 44, figs. 8a-d.
1883. *Thaumastus limnaeformis* (Meek and Hayden); White, U.S. Geol. Surv., 3rd Ann. Rept., p. 454, Pl. 25, fig. 24.
1885. *Thaumastus limnaeformis* (Meek and Hayden); Whiteaves, Geol. Surv., Canada, Contr. Can. Pal., vol. 1, p. 20, Pl. 3, figs. 3, 3a, 3b.

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[1]Russell (1932b, p. 81) in describing *Goniobasis sanctamariensis* noted the occurrence of opercula of "*Campeloma*-type" in association with the shells and suggested that they might be related to one another. This association is fortuitous, however, for one of the opercula of common occurrence in the St. Mary River formation has been found within the aperture of a *Fluminicola*-like shell referred to *Reesidella* Yen (*See* page 68).

1926. *Thaumastus limnaeformis* var. *tenuis* Warren, Roy. Soc., Canada, Trans., ser. 3, vol. 20, sec. 4, p. 7, Pl. 1, figs. 6-8.
1926. *Thaumastus limnaeformis* var. *procerior* Russell, Roy. Soc., Canada, Trans., ser. 3, vol. 20, sec. 4, p. 220, Pl. 3, figs. 6, 7.
1929. *Campeloma limnaeformis* (Meek and Hayden); Russell, Roy. Soc., Canada, Trans., ser. 3, vol. 23, sec. 4, p. 81, Pl. 1, figs. 1-3.
1929. *Campeloma tenuis* (Warren); Russell, ibid., p. 83, Pl. 1, figs. 4-6.
1946. *Lioplacodes limnaeformis* (Meek and Hayden); Yen, Am. Jour. Sci., vol. 244, p. 43, Pl. 1, figs. 4a, 4b.
1948. *Lioplacodes limnaeformis* (Meek and Hayden); Yen, U.S. Geol. Surv., Prof. pap. 214-c, p. 41, Pl. 10, fig. 11.

Material. Hypotypes: G.S.C. No. 10149, Edmonton formation (lower part), locality 5; G.S.C. No. 10150, St. Mary River formation, locality 1; G.S.C. No. 10151, St. Mary River formation, locality 9; G.S.C. No. 10152, Paskapoo formation, locality 32; G.S.C. Nos. 10153, 10154, Paskapoo formation, locality 33; G.S.C. Nos. 10155, 10156, Paskapoo formation, locality 25.

Dimensions.

Specimen	Altitude	Width	Height of aperture	Number of whorls
10149	17·0	7·0	7·5	7
10150	20·0	9·3	8·2	7
10151	16·3	7·3	8·4	7
10152	20·3	10·0	....	7
10153	23·0	8·1	8·0	8
10154	18·8	7·5	7·5	7
10155	23·7	10·5	....	last 4
10156	18·2	7·2	7·8	7

Description. Shell of medium size, elongate-ovate in outline. Whorls 7 to 8, sides almost flat, with a narrowly rounded shoulder anterior to the suture, which is slightly channelled. Aperture subovate, rounded in front, angular behind, labral profile vertical, peristome continuous. Axis imperforate or very narrowly perforate. Surface smooth, polished; growth lines not prominent, almost straight and vertical on the sides with a slight parasigmoid sinuosity on the shoulder.

Remarks. The shells of this species from Cretaceous and Paleocene strata are not separable morphologically.

Occurrence. Originally described from the typical Fort Union group. St. Mary River formation, St. Mary River formation (basal member), Edmonton formation (lower part), Edmonton formation (Disturbed belt), Willow Creek formation (lower part) ?, Willow Creek formation (upper part), Paskapoo formation, Ravenscrag formation (Saskatchewan).

Lioplacodes nebrascensis nebrascensis (Meek and Hayden)

Plate VI, figures 17-19

1857. *Melania nebrascensis* Meek and Hayden, Phil. Acad. Nat. Sci., Proc., vol. 8, p. 124.

1876. *Goniobasis nebrascensis* (Meek and Hayden); Meek, U.S. Geol. Surv. Terr., Rept., vol. 9, p. 565, text fig. 73, Pl. 43, figs. 12a-h.

1931. *Lioplax nebrascensis* (Meek and Hayden); Russell, Roy. Soc., Canada, Trans., ser. 3, vol. 25, sec. 4, p. 13, Pl. 2, figs. 2-5.

1948. *Goniobasis nebrascensis* (Meek and Hayden); Yen, U.S. Geol. Surv., Prof. pap. 214-C, p. 42, Pl. 10, fig. 9.

Material. Hypotype, University of Alberta collections No. Pa 102, Paskapoo formation, locality 14; hypotypes, G.S.C. Nos. 10157, 10158, Paskapoo formation, locality 33.

Dimensions.

Specimen	Altitude	Width	Height of aperture	Number of whorls
Pa 102	26·7	12·5	10·7	8
10157	15·3	7·8	7·9	6½
10158	17·0	9·0	7·5	6

Description. Shell moderately broadly ovate in outline, height of body whorl slightly more than one-third the altitude. Whorls 6½ to 8, increasing in size rather rapidly; first 3 with convex sides and impressed suture; later whorls with flat sides, faintly shouldered behind, with the suture slightly channelled. Aperture pyriform, peristome continuous, occasionally somewhat produced in front. Sculpture variable, when well developed consists of spiral raised lines of varying prominence, two of which are well marked on the anterior half of the third and fourth whorls; sculpture exhibits no constant differentiation on later whorls. Growth lines prominent, moderately strongly parasigmoid.

Remarks. The flat whorls, channelled suture, and irregular sculpture of the body whorl distinguish this species from *L. tenuicarinata* (Meek and Hayden).

Occurrence. Originally described from the typical Fort Union group. Paskapoo formation, Willow Creek formation (upper part), Ravenscrag formation (Saskatchewan).

Lioplacodes nebrascensis producta (White)

Plate VI, figures 20a, 20b

1883. *Campeloma producta* White, U.S. Geol. Surv., 3rd Ann. Rept., p. 469, Pl. 26, figs. 21-27.

1931. *Lioplax nebrascensis* var. *producta* (White); Russell, Roy. Soc., Canada, Trans., ser. 3, vol. 25, sec. 4, p. 14, Pl. 2, figs. 6-9.

1948. *Goniobasis nebrascensis producta* (White); Yen, U.S. Geol. Surv., Prof. pap. 214-C, p. 42, Pl. 10, fig. 10.

Material. Hypotype, G.S.C. No. 10159, Paskapoo formation, locality 25.

Dimensions. Specimen 10159: altitude 24·5; width 11·3; height of aperture 10·0; number of whorls, last 5.

Description. Characters as in *L. nebrascensis nebrascensis* but larger, wider, and with more shouldered whorls.

Remarks. Although, as noted by Russell, *Melania nebrascensis* Meek and Hayden and *Campeloma producta* White are end members of a series that cannot be divided specifically, the complete range of variation is not, apparently, encountered within "communities" of these shells; it, therefore, seems reasonable to regard their inter-relationship as subspecific.

Occurrence. Originally described from the typical Fort Union group. Paskapoo formation, Willow Creek formation (upper part).

Lioplacodes sanctamariensis (Russell)

Plate VI, figures 11-14

1885. *Goniobasis nebrascensis* (Meek and Hayden); Whiteaves, Geol. Surv., Canada, Contr. Can. Pal., vol. 1, p. 21, Pl. 3, figs. 4, 4a.
1932. *Goniobasis sanctamariensis* Russell, Can. Field-Nat., vol. 46, p. 81, fig. 4.

Material. Holotype, G.S.C. No. 6789, St. Mary River formation, south side Oldman River, SE. ¼ sec. 3, tp. 10, rge. 24, W. 4th mer.; paratype, G.S.C. No. 5545 (Whiteaves, 1885, Pl. 3, figs. 4, 4a), St. Mary River formation, tp. 1, rge. 25, W. 4th mer.; hypotypes, G.S.C. Nos. 10143, 10144, 10145, St. Mary River formation, locality 32; hypotype, G.S.C. No. 10146, Edmonton formation (lower part), locality 9.

Dimensions.

Specimen	Altitude	Width	Height of aperture	Number of whorls
6789	19·9	10·0	....	last 4
5545	17·0	9·0	8·0	last 5
10143	19·2	10·8	8·7	last 4
10144	16·7	8·7	7·2	last 4
10145	15·0	6·5	....	6
10146	23·0	9·5	9·2	last 6

Description. Shell of medium size, elongate-ovate in outline; height of body whorl rather more than one-third the altitude. Whorls about 7, increasing in size moderately rapidly; sides varying from mildly to rather strongly convex; suture well impressed. Aperture subovate, rounded in front, angular behind, peristome continuous, inner lip detached, producing a small umbilical chink. Sculpture consists of regular, quite undifferentiated, revolving lines, about 12 to the mm. on the body whorl. Growth lines rather strongly parasigmoid.

Remarks. The sculpture of *L. sanctamariensis,* and the proportions of the shell, suggest a close relationship with the contemporary *L. whiteavsi,* which differs in possessing decidedly carinate whorls. *L. praecursa* (Dyer) (*Campeloma praecursa* Dyer) of the Foremost and Oldman formations lacks the distinctive sculpture of the present species and has consistently mildly convex whorls. *L. mariana* Yen, from the Paleocene of Wyoming and Montana, closely resembles certain members of the present species in which the whorls are only moderately convex; however, the spiral sculpture of *L. mariana* is much less prominent than that of *L. sanctamariensis*.

Occurrence. St. Mary River formation, Edmonton formation (lower part), Edmonton formation (Disturbed belt) ?, Willow Creek formation (lower part) ?.

Lioplacodes tenuicarinata (Meek and Hayden)

Plate VI, figures 15a, 15b, 16a, 16b

1857. *Melania tenuicarinata* Meek and Hayden, Phil. Acad. Nat. Sci., Proc., vol. 9, p. 137.
1876. *Goniobasis tenuicarinata* (Meek and Hayden); Meek, U.S. Geol. Surv. Terr., Rept., vol. 9, p. 566, Pl. 43, figs. 14a, b, c.
1883. *Goniobasis tenuicarinata* (Meek and Hayden); White, U.S. Geol. Surv., 3rd Ann. Rept., p. 463, Pl. 26, fig. 11.
1885. *Goniobasis tenuicarinata* (Meek and Hayden); Whiteaves, Geol. Surv., Canada, Contr. Can. Pal., vol. 1, p. 22, figs. 5, 5a.
1948. *Lioplacodes tenuicarinata* (Meek and Hayden); Yen, U.S. Geol. Surv., Prof. pap. 214-c, p. 41, Pl. 10, figs. 7, 7a, b, c, d.

Material. Hypotypes, University of Alberta collections Nos. Pa 103, 104, Paskapoo formation, locality 14.

Dimensions.

Specimen	Altitude	Width	Height of aperture	Number of whorls
Pa 103	19·0	10·0	....	8
Pa 104	10·0	6·5	5·5	6

Description. Shell elongate-ovate in outline, height of body whorl rather more than one-third the altitude. Whorls 7 to 8, convex throughout development, suture well impressed. Aperture pyriform, peristome continuous, inner lip detached, producing a small umbilical chink. First 3 whorls smooth, anterior half of succeeding whorls with regular spiral sculpture consisting of from 3 (on the fourth whorl) to 5 (on the body whorl) regular raised ridges, decreasing in prominence towards the base of the whorls; intervening areas with very fine, regular, spiral lines. Growth lines parasigmoid, obscure, regular.

Remarks. The spiral sculpture of this species resembles that of the early whorls of the contemporary *L. nebrascensis nebrascensis* (Meek and Hayden), from which *L. tenuicarinata* may be differentiated by its convex whorls, and persistent spiral sculpture.

Occurrence. Originally described from the typical Fort Union group. Paskapoo formation, Willow Creek formation (upper part), Ravenscrag formation (Saskatchewan).

Poorly preserved shells with pronounced spiral sculpture are common in the Edmonton, St. Mary River, and Willow Creek (lower part) formations. Their poor state of preservation precludes precise determination, but most of them differ from *L. tenuicarinata* in having spiral sculpture developed above the periphery. In the faunal lists these shells are referred to as *L.* sp. cf. *tenuicarinata.*

Lioplacodes whiteavsi (Russell)

Plate VI, figures 9, 10

1885. *Goniobasis tenuicarinata* Meek and Hayden, var., Whiteaves, Geol. Surv., Canada, Contr. Can. Pal., vol. 1, p. 22, Pl. 3, figs. 6, 6a.

1929. *Goniobasis tenuicarinata* var. *whiteavsi* Russell, Roy. Soc., Canada, Trans., ser. 3, vol. 23, sec. 4, p. 83, Pl. 1, figs. 7, 8.

1930. *Goniobasis whittakeri* Dyer, Nat. Mus., Canada, Bull. 63, p. 12, Pl. 3, fig. 11.

Material. Holotype, University of Alberta collections, No. Ct 377, St. Mary River formation, Oldman River, l.s. 11, sec. 30, tp. 10, rge. 24, W. 4th mer.; hypotype (holotype of *G. whittakeri*), G.S.C. No. 6683, St. Mary River formation, SW. $\frac{1}{4}$ sec. 29, tp. 10, rge. 24, W. 4th mer.; hypotype, G.S.C. No. 5548a (Whiteaves, 1885, Pl. 3, fig. 6a), St. Mary River formation, locality 20.

Dimensions.

Specimen	Altitude	Width	Height of aperture	Number of whorls
Ct 377	19·0	9·7	11·2	last 4
6683	19·6	8·5	....	last 5
5548a[1]	21·7	10·0	9·5	7

[1]Slightly distorted.

Description. Shell of medium size, elongate-ovate in outline; height of body whorl rather more than one-third the altitude. Whorls 7, first 2 or 3 very convex; later whorls strongly keeled near the middle; body whorl becoming somewhat rounded towards the aperture; suture well impressed. Aperture subovate, rounded in front, angular behind; peristome continuous, inner lip detached, producing a narrow umbilical chink. Sculpture consists of fairly regular, quite undifferentiated, spiral raised lines, about 12 to the mm. on the body whorl. Growth lines parasigmoid.

Remarks. This species is well characterized by the carinate whorls and the spiral sculpture, which is quite uniform from the suture to the umbilicus. The spiral and growth lines are usually of about equal prominence, imparting the appearance of a "silky ornamentation" noted by Dyer in his description of *Goniobasis whittakeri*. *L. whiteavsi* is closely related to *L. sanctamariensis* (Russell), which differs only in the possession of rounded rather than carinate whorls.

Occurrence. St. Mary River formation, Edmonton formation (Disturbed belt), Edmonton formation (lower part).

Family, PILIDAE

Genus, *Reesidella* Yen

This genus (type: *Viviparus montanaensis* Stanton, subsequent designation of Yen (1953)) was proposed for imperforate to narrowly perforate shells with a broadly sub-ovate to globose outline, rapidly dilating convex whorls, a well-impressed suture, a continuous peristome, and a pyriform to almost auriform aperture. The genus is also characterized by possessing a calcareous operculum, the characters of which have not been fully described for the type species. MacNeil (1939) first described in detail the calcareous opercula associated with the shells now referred to *Reesidella.* He referred the shells possessing these opercula to *Scalez* Hanna and Gaylord, a genus which was founded on opercula alone from the Pliocene of California. MacNeil described the operculum of *Ampullaria ? powelli* Walcott, which is certainly congeneric with *R. montanaensis*, as having an unusual callus on the inside that is initially sinistrally spiral, viewed from the inside (for 3 to 5 turns), but subsequently increases concentrically. The nucleus of the operculum proper is small and coiled in the opposite direction to that of the spiral on the callus, i.e., it is coiled sinistrally viewed from the outside, as in all dextral shells. Probably this peculiar operculum constitutes one of the diagnostic characteristics of *Reesidella.* Woodring (1926) and MacNeil have noted that similar opercula occur in the Fort Union and Judith River formations; they are also common in the Upper Cretaceous and Paleocene of Alberta, where one has been found in the aperture of a *Reesidella*-like shell. Yen (1948) has described a shell from the Paleocene of Montana as *Fluminicola protea;* this has the shell characters of *Reesidella,* and as Yen notes the occurrence of a calcareous operculum in its aperture it is considered referable to this genus.

It is quite possible that *Reesidella* and *Scalez* are synonymous, but until the shell of the latter is known it seems inadvisable to consider this established.

The type species is from the Kootenai formation (Lower Cretaceous) of Montana and the known range of the genus, as interpreted above, is Upper Jurassic (*R. gilloides* (Yen and Reeside)) to Paleocene (*R. protea* (Yen)).

Regarding the relation of *Reesidella* to the living fauna: Yen considered it an amnicolid and compared the operculum with that of *Bulimus* Scopoli. The operculum of *Bulimus* has a central nucleus and does not suggest that of *Reesidella* in which the nucleus is eccentric. Woodring and MacNeil considered *Scalez* a viviparid. The opercula of *Reesidella* and *Pila* Bolten are externally similar, and the dilated body whorl of the former, although much less globose than that of *Pila,* is also rather suggestive of that genus. Provisionally *Reesidella* is placed in the *Pilidae* (= *Ampullariidae*), but the evidence does not permit an unequivocal conclusion regarding its systematic position.

Reesidella sp. cf. *R. protea* (Yen)

Plate V, figures 5-7, 8a, 8b, 9a, 9b

Material. Figured specimens: G.S.C. No. 10772, a crushed shell with the impression of the operculum in the aperture, St. Mary River formation, locality 5; G.S.C. No. 10279, St. Mary River formation, locality 18; G.S.C. No. 10280, St. Mary River formation, locality 2; G.S.C. No. 10770, an operculum, St. Mary River formation, locality 15; G.S.C. No. 10771, an operculum, Willow Creek formation (lower part), locality 21.

Dimensions.

SHELLS

Specimen	Altitude	Width	Height of aperture	Number of whorls
10772	8·5	7·9	4·5	5
10279	11·3	9·5	(7·0)	last 3½

OPERCULA

	Height	Width	Distance of nucleus from inner edge
10770	6·0	4·2	1·0
10771	5·5	3·7	1·0

Description. Shell broadly ovate in outline. Whorls about 5½, highly convex, increasing in size very rapidly, body whorl dilated. Suture impressed. Aperture broadly pyriform, peristome continuous, inner lip detached, revealing a narrow umbilical chink. Growth lines nearly straight, inclined at about 80 degrees to the axis.

Operculum calcareous, moderately thick, pyriform. Inner margin straight, anterior margin broadly rounded. Exterior slightly concave, nucleus apparently amorphous, situated close to the inner margin; growth lines concentric; a well-defined crease runs from the nucleus to the posterior point. Inner surface with conspicuous callus, spiral for at least 5 turns, thereafter the spirals abut the inner margin, rendering it impossible to determine whether increase is spiral or concentric; about 14 spiral (and concentric ?) turns developed.

Remarks. This species is very similar to *"Fluminicola" protea* Yen (1948, p. 41, Pl. 10, fig. 12) from the Paleocene of southern Montana. The Canadian shells are larger than the type and the nucleus of the operculum in the Canadian specimens is more eccentric than that preserved in one of the topotypes. The preservation of the Canadian material precludes a more precise determination.

Occurrence. St. Mary River formation, Edmonton formation (lower part), Edmonton formation (Disturbed belt), Willow Creek formation (lower part), Willow Creek formation (upper part), Paskapoo formation. In Alberta this species is more frequently encountered in Cretaceous than in Paleocene strata, despite the fact that *R. protea* is typically a Paleocene species.

Family, VALVATIDAE

Genus, *Valvata* Muller

Valvata bicincta Whiteaves

Plate V, figures 4a, 4b

1885. *Valvata bicincta* Whiteaves, Geol. Surv., Canada, Contr. Can. Pal., vol. 1, p. 25, Pl. 3, figs. 8, 8a, 8b.

Material. Holotype, G.S.C. No. 5570, Paskapoo formation, locality 18; hypotypes, G.S.C. Nos. 10304, 10305, Paskapoo formation, locality 17.

Dimensions.

Specimen	Altitude	Width	Number of whorls
5570	..	4·9	3½
10304	2·0	3·5	3
10305	..	3·0	3

Remarks. The prominent linear keels on the upper and lower surfaces of the whorls, and the circular aperture, which barely touches the penult whorl, characterize this species. Warren (in Rutherford, 1926, p. 12) and Russell (1938, p. 506) suggest that this species is identical with *V. parvula* Meek and Hayden, from the typical Fort Union group, the type of which is lost and was never figured. From Meek's (1876, p. 591) description this seems plausible. Yen (1948, p. 43) has recently revived *V. parvula* by referring some shells from the Fort Union formation of Montana to *Gyraulus parvulus* (Meek and Hayden). These specimens bear a single poorly defined keel just below the periphery and are quite distinct from *V. bicincta.*

Occurrence. Paskapoo formation.

Valvata filosa Whiteaves

Plate V, figures 1, 2

1885. *Valvata filosa* Whiteaves, Geol. Surv., Canada, Contr. Can. Pal., vol. 1, p. 25, Pl. 3, figs. 7, 7a.

Material. Holotype, G.S.C. No. 5568, St. Mary River formation, locality 20 (*See* page 54); hypotype, G.S.C. No. 10301, St. Mary River formation, locality 1; hypotype, G.S.C. No. 10302, Willow Creek formation (lower part), locality 11.

Dimensions.

5568: width 3·0; number of whorls, 3
10301: width 2·0; number of whorls, 2½
10302: width 3·2; number of whorls, 3

Owing to the poor preservation the altitude of these shells is not determinable.

Remarks. This species is characterized by a pointed apex and convex whorls that increase in size slowly. The whorls are sculptured with faint but regular, thread-like raised lines. Russell (1926b, p. 210) has considered that *V. filosa* is identical with *V. subumbilicata* (Meek and Hayden), which was described from the Fort Union group of the Missouri River. The type of *V. subumbilicata* is too poorly preserved to establish this synonymy. *V. filosa* is smaller, has less rapidly dilating whorls, and is apparently less sculptured than the individuals compared with *V. subumbilicata* from the Paskapoo formation.

Occurrence. St. Mary River formation, Willow Creek formation (lower part), Edmonton formation (lower part), Edmonton formation (Disturbed belt).

Valvata sp. cf. *V. subumbilicata* (Meek and Hayden)

Plate V, figure 3

Material. Figured specimen, G.S.C. No. 10303, Paskapoo formation, locality 17.

Dimensions. Specimen 10303: altitude 2·0; width 4·0; number of whorls, 3½.

Description. Shell small, depressed-turbinate. Apex depressed below level of second whorl. Whorls 3 to 3½, very convex, body whorl dilated and descending. Suture well impressed. Width of umbilicus about one-third width of shell. Aperture subcircular, barely touching penult whorl. Sculpture not well known, apparently obscure.

Remarks. Owing to the poor preservation of the types of *V. subumbilicata* and the material from Alberta, it is difficult to determine these rather featureless shells. However, the depressed apex and rapidly dilating whorls distinguish the figured specimen from *V. filosa* Whiteaves.

Occurrence. Paskapoo formation, Willow Creek formation (upper part).

Family, PLEUROCERIDAE

Genus, *Goniobasis* Lea

Goniobasis eulimoides (Meek)

Plate VI, figures 21, 22

1876. *Hydrobia ? eulimoides* Meek, U.S. Geol. Surv. Terr., Rept. vol. 9, p. 573, text fig. 78.

Material. Hypotypes, G.S.C. Nos. 10282, 10283, Paskapoo formation, locality 35.

Dimensions.

Specimen	Altitude	Width	Height of aperture	Number of whorls
10282	15·0	5·3	5·2	last 8
10283	24·5	7·3	....	last 7

Remarks. The specimens from Alberta, which are not well preserved, have up to 3 whorls more than those of the type locality, but they seem to agree closely in proportions and dimensions at the same stage of development. The size and the proportions of the shell, and the aperture, which is apparently quite angular at front, seem more suggestive of *Goniobasis* than a member of the *Amnicolidae.*

Occurrence. Originally described from the typical Fort Union group. Paskapoo formation.

Goniobasis webbi Dyer

Plate VI, figures 23-26

1930. *Goniobasis webbi* Dyer, Nat. Mus., Canada, Bull. 63, p. 13, Pl. 3, fig. 14.

Material. Holotype, G.S.C. No. 6684, Edmonton formation (lower part), Bow River in sec. 8, tp. 21, rge. 22, W. 4th mer.; hypotype, G.S.C. No. 10160, Edmonton formation (lower part), locality 8; G.S.C. Nos. 10161, 10162, 10163, Edmonton formation (lower part), locality 5.

Dimensions.

Specimen	Altitude	Width	Height of aperture	Number of whorls
6684	27·0	9·1	....	8
10160	30·5	10·5	....	last 6
10161	19·7	8·5	....	last 4
10162	25·7	11·3	....	last 3
10163	26·9	9·0	8·5	last 7

Description. Shell elevated, acute. Whorls about 11, increasing in size slowly and regularly, sides flat to mildly convex, periphery carinate to moderately rounded. Suture little impressed. Aperture elongate-ovate, angular but not canaliculate in front, parietal wall with a rather thick callus. Columella apparently straight. Sculpture consists of spiral raised lines, varying from obsolete to prominent, increasing in prominence throughout development when present. About 7 prominent lines in 5 mm. on sides of whorls with lesser ones variably intercalated; about 12 in 5 mm. on base of whorls; the line at the periphery may assume the prominence of a keel. Growth lines moderately parasigmoid, usually well defined.

Remarks. Dyer separated this species from *G. convexa* (Meek and Hayden), of the Judith River formation, on the grounds of lack of spiral sculpture and the possession of a more angular periphery. His description is based upon material from several localities within the Edmonton formation, and it appears that the sculpture is subject to considerable variation. In a large collection from locality 5, most of the specimens show traceable sculpture at all stages of development, but the spiral lines are particularly prominent on the lower whorls. The holotype is quite unsculptured but a near topotype (No. 10160) shows distinct, but obscure, revolving lines distributed in a similar manner to those from locality 5. Apparently sculpture does not provide a reliable criterion for specific differentiation among these shells, and the writer considers that the sculptured and unsculptured individuals may be included within one rather variable species. This variation is comparable with that shown by living pleurocerids such as *Goniobasis virginica* (Gmelin) and *Pleurocera acuta* Rafinesque. The reference of sculptured shells to *G. webbi* eliminates the obvious criterion for the differentiation of this species from *G. convexa*. The sculpture of *G. convexa,* however, is uniformly developed on the sides and the base of the whorls and the periphery of this species is moderately rounded, whereas in *G. webbi* the basal sculpture is distinctly finer than that of the sides and the periphery is frequently angular. In view of the difference in age of the types of *G. convexa* and *G. webbi,* the latter name is retained for the Edmonton specimens, but comparisons of adequate quantities of material from the two horizons may prove that these species are inseparable.

The appearance of this species suggests *Pleurocera* Rafinesque, but it is retained in *Goniobasis* as it lacks the anterior canal and twisted columella characteristic of the former genus.

Occurrence. Edmonton formation (lower part), St. Mary River formation. *G. webbi* is locally very abundant in the Edmonton beds, but it is rare in the St. Mary River formation. So far as the writer can determine Dyer's (1930a, p. 13; 1930b, p. 61) record of *G. webbi* from the Willow Creek formation refers only to a collection from drift boulders, as noted in the discussion of *Viviparus crickmayi* Dyer (page 58); and the Willow Creek occurrence is, therefore, rejected.

Family, AMNICOLIDAE

Genus, *Hydrobia* Hartmann

Hydrobia spp. indet.

Remarks. Small *Hydrobia*-like shells are common in the Upper Cretaceous and Paleocene formations of Alberta, but owing to their fragmentary nature and poor preservation the author agrees with Whiteaves (1885, p. 23) that they cannot be determined satisfactorily.

Occurrence. St. Mary River formation, Willow Creek formation, Edmonton formation (Disturbed belt), Paskapoo formation.

Family, LYMNAEIDAE

Genus, *Pleurolimnaea* Meek

Pleurolimnaea mclearni sp. nov.

Plate IX, figures 12-14

Material. Holotype, G.S.C. No. 10285, a crushed imperfect shell, Edmonton formation (lower part), locality 7; paratype, G.S.C. No. 10296, Edmonton formation (lower part), locality 7; paratype, G.S.C. No. 10200, a crushed shell showing the spire, Willow Creek formation (lower part), locality 17; paratype, G.S.C. No. 10313, St. Mary River formation, locality 32.

Dimensions. Specimen 10295: altitude 12·2; width 3·7; number of whorls, last 4; specimen 10296: altitude 7·0; width 2·5; number of whorls, last 4.

Description. Shell very slender, height of body whorl apparently about equal to that of the spire. Whorls about 6, increasing in size rapidly, of low convexity with a narrow shoulder anterior to the suture on the body whorl, suture little impressed. Aperture elongate-ovate, angular behind, front of aperture and parietal wall not known. First 1 or 2 whorls apparently without sculpture, third to penult whorl with sculpture of regular raised ribs, alternating with fine, slightly sinuous, growth lines. On the holotype there are about 15 ribs in 1 mm. on the third whorl, 7 in 1 mm. on the fourth, 5 in 1 mm. on the fifth, and the body whorl is sculptured with growth lines only.

Remarks. This species resembles *P. tenuicosta* (Meek and Hayden) from which it differs principally in having very obscure or obsolete sculpture on the body whorl. The rib sculpture of *P. mclearni,* as in *P. tenuicosta,* varies considerably in density and prominence but the ribs of the former are decidedly more closely set than on typical examples of the latter. In outline and sculpture *P. mclearni* also resembles some of the shells referred to *Zaptychius* Walcott by Yen (1951), particularly *Z. haldemani* (White) from the Bear River formation (Lower Cretaceous) of Wyoming, which differs in being much smaller and having a much smaller body whorl in proportion to the size of the spire.

This species is named for Dr. F. H. McLearn, retired Chief of the Palæontological Section of the Geological Survey of Canada.

Occurrence. Edmonton formation (lower part), St. Mary River formation, Willow Creek formation (lower part).

Pleurolimnaea tenuicosta (Meek and Hayden)

Plate IX, figure 15

1856. *Limnaea tenuicosta* Meek and Hayden, Phil. Acad. Nat. Sci., Proc., vol. 8, p. 119.

1876. *Limnaea (Pleurolimnaea) tenuicostata* Meek and Hayden; Meek, U.S. Geol. Surv. Terr., Rept., vol. 9, p. 534, Pl. 34, figs. 13a-c.

1885. *Limnaea tenuicostata* Meek and Hayden; Whiteaves, Geol. Surv., Canada, Contr. Can. Pal., vol. 1, p. 13.

1886. *Acella micronema* White, U.S. Geol. Surv., Bull. 34, p. 22, Pl. 2, fig. 14.

1887. *Limnaea tenuicostata* Meek and Hayden; Whiteaves, Geol. Surv., Canada, Ann. Rept. (1886), new ser., vol. 2, pt. E, p. 163.

1911. *Pleurolimnaea tenuicosta* (Meek and Hayden); Baker, Chicago Acad. Sci., Spec. Pub. 3, p. 91, Pl. 16, figs. 9-11.

1911. *Pleurolimnaea tenuicosta* var. *whiteavsi* Baker, ibid., p. 93.

1948. *Pleurolimnaea tenuicosta* (Meek and Hayden); Yen, U.S. Geol. Surv., Prof. pap. 214-C, p. 43, Pl. 10, fig. 15.

Material. Hypotype, G.S.C. No. 10168, Paskapoo formation, locality 1.

Remarks. The characteristic sculpture of this species consists of fine ribs, which appear on the lower whorls to be formed by the fasciculation of the growth lines. On the early whorls these ribs seem to be spaced quite regularly, but on the body whorl the spacing of the ribs on different individuals varies considerably. The extremes of this variation are illustrated by the holotype, which carries about 10 ribs on the body (fourth) whorl, and Yen's figured specimen, which has about 20 on the fourth whorl and 24 on the body (fifth) whorl. Whiteaves (1887) first noted this variation and Baker erected the variety *whiteavsi* for the finely sculptured specimens noted by Whiteaves. Whiteaves' finely sculptured specimens have not been located, but those in the collection that seem to conform with his description appear linked in a continuous series with the typical examples; this variation is, therefore, not known to be either geographically or stratigraphically significant and it is not considered worthy of taxonomic recognition.

Occurrence. Originally described from the typical Fort Union group. Paskapoo formation. Willow Creek formation (upper part) (Russell, 1932c, p. 140).

Family, PHYSIDAE

Genus, *Physa* Draparnaud

Physa canadensis Whiteaves

1885. *Physa copei* White; Whiteaves, Geol. Surv., Canada, Contr. Can. Pal., vol. 1, p. 14, Pl. 2, figs. 4, 4a.

1885. *Physa copei* var. *canadensis* Whiteaves, ibid., p. 14, Pl. 2, figs. 5, 5a, 5b.

1926. *Physa canadensis* var. *parvaturris* Russell, Roy. Soc., Canada, Trans., ser. 3, vol. 20, sec. 4, p. 216, Pl. 2, figs. 3, 4.

1926. *Physa canadensis* var. *media* Russell, ibid., p. 216, Pl. 2, fig. 5.

1926. *Physa canadensis* var. *tenuis* Russell, ibid., p. 216, Pl. 2, figs. 6, 7.

1926. *Physa canadensis* var. *ampla* Russell, ibid., p. 217, Pl. 2, fig. 8.

1926. *Physa galei* Russell, ibid., p. 218, Pl. 3, figs. 1, 2.

1937. *Physa canadensis canadensis* Whiteaves, Clench, Nautilus, vol. 50, pt. 4, p. 144.

[*non*] 1883. *Physa copei* White, U.S. Geol. Surv. Terr., 12th Ann. Rept., p. 84, Pl. 22, fig. 1.

Material. Lectotype (here chosen), G.S.C. No. 5529 (Whiteaves, 1885, Pl. 2, fig. 5), St. Mary River formation, locality 20. Whiteaves figured three specimens as *P. copei* var. *canadensis* without designating a type of which Clench designated two, those represented by figures 5a and 5b, as types. The label of the specimen chosen here states it to be the holotype, so presumably this designation is in accord with Whiteaves' and Clench's intentions.

Remarks. There seems to be no alternative but to regard this as an extremely variable species. Russell, in describing the named varieties from the Paskapoo, states that they are linked by intermediate examples, and as the figured specimens all came from the same bed it seems probable that this variation is that of a single species: there is no evidence to suggest that these varieties merit subspecific rank. *P. galei* was also described from this bed; it has been found impossible to differentiate this species at other localities, so it too is provisionally placed in synonymy with *P. canadensis*. The material from the St. Mary River formation, on which this species is based, exhibits a similar degree of variation, and in spite of Clench's (1937, p. 143) statement to the contrary, it has been found impossible to recognize more than one species of *Physa* among the specimens figured by Whiteaves. Furthermore, it does not seem possible to separate the St. Mary River and Paskapoo specimens. Living species of *Physa*, unlike, say, pleurocerids, are not particularly variable, but this condition does not apply to extinct species. It is worthy of note that *Physa bristovii* (Forbes MS.) Phillips, from the Purbeck beds of England, like *P. canadensis* is most variable in the ratio of the height of the spire to that of the body whorl and the degree of involution shown by the whorls of the spire (Arkell, 1942, p. 106, figs. 33-37, 46-49). *P. canadensis* includes shells that are very similar to *"Bulinus" atavus* White (1883a, p. 86, Pl. 24, figs. 5a, 5b) from the Judith River formations, and *"B". disjunctus* White (ibid., p. 86, Pl. 24, figs. 5a, b) from the Laramie of Crow Creek, Colorado. Evidently Whiteaves originally referred the St. Mary River specimens to *"B." disjunctus* but White discouraged him from adopting this identification. These three species are undoubtedly closely related but until comparisons of large collections from the various localities can be made their relationship cannot be satisfactorily determined.

Occurrence. Oldman and Foremost formations (Russell, 1940, pp. 61 and 72), St. Mary River formation, Edmonton formation (lower part), Edmonton formation (Disturbed belt), Willow Creek formation, Paskapoo formation.

Family, ANCYLIDAE

Genus, *Ferrissia* Walker

Ferrissia minuta (Meek and Hayden)

1856. *Velletia minuta* Meek and Hayden, Phil. Acad. Nat. Sci., Proc., vol. 8, p. 120.

1876. *Acroloxus minutus* Meek and Hayden; Meek, U.S. Geol. Surv. Terr., Rept., vol. 9, p. 543, Pl. 44, fig. 10.

1948. *Ferrissia minuta* (Meek and Hayden); Yen, U.S. Geol. Surv., Prof. Pap. 214-C, p. 42, Pl. 10, fig. 14.

[*non*] 1885. *Acroloxus minutus* Meek and Hayden; Whiteaves, Geol. Surv., Canada, Contr. Can. Pal., vol. 1, p. 17.

Remarks. The writer considers that the specimens from the St. Mary River formation mentioned by Whiteaves are not conspecific with *F. minuta,* which apparently occurs only in Paleocene strata.

Occurrence. Originally described from the typical Fort Union group. Paskapoo formation.

Ferrissia sp. indet.

1885. *Acroloxus Minutus* Meek and Hayden; Whiteaves, Geol. Surv., Canada, Contr. Can. Pal., vol. 1, p. 17.
[*non*] *Velletia minuta* Meek and Hayden = *Ferrissia minuta* (Meek and Hayden) *q.v.*

Remarks. All the ancylids from the St. Mary River formation seen by the writer are larger than individuals referred to *F. minuta* (Meek and Hayden); some show rather prominent concentric wrinkles, a feature not known in that species, but as all are exfoliated a precise diagnosis is not possible.

Occurrence. St. Mary River formation, Willow Creek formation (lower part).

Genus, *Palaeancylus* Yen

Palaeancylus radiatulus (Whiteaves)

1885. *Acroloxus radiatulus* Whiteaves, Geol. Surv., Canada, Contr. Can. Pal., vol. 1, p. 17, Pl. 3, figs. 1, 1a.

Material. Holotype, G.S.C. No. 5533; topotype, G.S.C. No. 5533a; Paskapoo formation, Red Deer River at mouth of Blindman River, Alberta. Collected by J. B. Tyrrell, 1884. The holotype is exfoliated and lacks the apex; the topotype, a fragmentary individual showing an entire apex, is on the rock fragment carrying the external mould of the holotype.

Remarks. The topotype shows an undamaged apex, which possesses a dimple-like depression similar to that of *Palaeancylus radiatus* Yen (Yen, 1948, p. 42, Pl. 10, fig. 13) from the Fort Union formation of Montana. Yen did not compare his species, which is the type of *Palaeancylus,* with "*Acroloxus*" *radiatulus;* probably, however, the two species are congeneric and possibly they are conspecific, but as the material from Montana is well preserved and displays the generic characters adequately no good purpose would be served by placing *P. radiatus* in synonymy with *P. radiatulus.*

Occurrence. Paskapoo formation.

Family, HELMINTHOGLYPTIDAE

Genus, *Glypterpes* Pilsbry

Glypterpes rotundata (Russell)

Plate VIII, figures 1a-1d

1931. *Oreohelix rotundata* Russell, Roy. Soc., Canada, Trans., ser. 3, vol. 25, sec. 4, p. 15, Pl. 2, figs. 10, 11.

Material. Holotype, University of Alberta Collections, No. Ct 395, Paskapoo formation, south side, Fallentimber Creek, in l.s. 5, sec. 31, tp. 30, rge. 5, W. 5th mer.; hypotype, G.S.C. No. 10164, Paskapoo formation, locality 12.

Dimensions. Specimen Ct 395: altitude 14·5 mm.; width 6·1 mm.; number of whorls, 4½; specimen 10164: altitude 11·0 mm.; width 5·5 mm.; number of whorls, 4.

Description. Shell of small size (for *Glypterpes*), depressed conic, narrowly perforate or imperforate. Whorls about 4½, increasing in size rather rapidly, moderately convex above. Suture moderately impressed. Body whorl with well and evenly rounded periphery. Aperture broadly subovate, labral profile inclined at about 45 degrees to the axis, outer lip thickened and reflected, basal lip reflected and nearly or quite sealing the umbilicus at the columellar insertion. Sculpture consists of rather sharp retractive costulæ, about 6 in 1 mm. on penult whorl, 4 in 1 mm. on body whorl, becoming obsolete on the base. Sculpture of embryonic whorls not known.

Remarks. On the holotype the umbilical region is concealed by matrix, but the referred specimen from North Saskatchewan River is apparently imperforate, or very nearly so. A small fragment of the basal part of the outer lip is preserved on the holotype; this is quite heavily thickened and reflected. This character, coupled with the regular sculpture on the body whorl, excludes this species from *Oreohelix* Pilsbry. It is not easy, however, to refer "*O.*" *rotundata* to any other living genus for it lacks really distinctive generic characters. The writer feels that it probably is congeneric with "*Helix*" *veterna* Meek and Hayden (Meek, 1876, p. 596, figs. 84, 85, Pl. 42, figs. 8a, b) from the Wind River beds (Lower Eocene) of Wyoming, which is the type of *Glypterpes* Pilsbry. Both species share rapidly dilating whorls and regular sculpture; furthermore, what is known of the aperture and lip of "*O.*" *rotundata* seems to conform with the characters of *G. veterna* as described by Yen (1946b, p. 498, fig. 9). *G. veterna,* however, is very much larger than the present species.

Occurrence. Paskapoo formation.

Family, CAMAENIDAE

Genus, *Oreohelix* Pilsbry

Oreohelix angulifera (Whiteaves)

Plate VIII, figures 3a-3c

1885. *Patula angulifera* Whiteaves, Geol. Surv., Canada, Contr. Can. Pal., vol. 1, p. 18, Pl. 2, figs. 6, 6a, 6b.

1929. *Oreohelix angulifera* (Whiteaves); Russell, Roy. Soc., Canada, Trans., ser. 3, vol. 23, sec. 4, p. 85, Pl. 1, fig. 10.

Material. Holotype, G.S.C. No. 5538, St. Mary River formation, locality 20 (*See* page 54); hypotype, G.S.C. No. 10165, St. Mary River formation, locality 17.

Dimensions. Specimen 5538: altitude 8·0; width 16·2; number of whorls, 5; specimen 10165: altitude 2·8; width 8·5; number of whorls, 4.

Description. Shell sublenticular, deeply umbilicate, spire obtusely conical, base truncate-conical. Whorls 4 to 5, increasing in size slowly and regularly; first 2 rather convex with an impressed suture, later whorls becoming flatter above with a less conspicuous suture. Periphery angular throughout development. Aperture subtrapezoidal, widest at right angles to the axis of the shell, outer lip apparently thin and simple. Umbilicus prominent, sides steep, nearly circular below due to strongly involute mode of coiling, outer margin forms an acute angle with the lower side of the body whorl, width about one-third shell width. Sculpture of first 2 whorls consists of regular, retractive, curved, rib-like costulæ, about 9 to the mm., on succeeding whorls this sculpture changes abruptly into irregular, retractive growth lines of varying prominence.

Remarks. This species, the oldest known member of the genus, differs from all other fossil oreohelices in the possession of a strongly angular periphery on the body whorl. *O. angulifera* is also smaller than the Paleocene species of this genus.

As noted by Russell, the sculpture closely resembles that of recent species of *Oreohelix.* The regular costulæ of the embryonic whorls are similar to those shown by species of the subgenus *Radiocentrum* Pilsbry.

Most of the specimens encountered by the writer have one whorl less than the holotype; the dimensions of the hypotype, No. 10165, are apparently more typical.

Occurrence. St. Mary River formation, Edmonton formation (Disturbed belt).

Oreohelix thurstoni (Russell)

Plate VIII, figures 4a, 4b, 5a-5c

1926. *Helix (Pyramidula ?) thurstoni* Russell, Roy. Soc., Canada, Trans., ser. 3, vol. 20, sec. 4, p. 219, Pl. 3, figs. 3-5.

1929. *Oreohelix thurstoni* (Russell); Russell, Roy. Soc., Canada, Trans., ser. 3, vol. 23, sec. 4, p. 85, Pl. 1, fig. 11.

Material. Holotype, University of Alberta collections No. Pa 26, Paskapoo formation, Elbow River, Calgary; hypotype, G.S.C. No. 10166, Paskapoo formation, locality 31; hypotype, G.S.C. No. 10167, Willow Creek formation (upper part), locality 7.

Dimensions.

Specimen	Altitude	Width	Number of whorls
Pa 26	13·0	21·0	5½
10166	10·5	20·7	5½
10167	12·0	(22·0)	6

Description. Shell obtusely conoid, perforate. Whorls about 5½, increasing in size rather slowly; spiral whorls flat to mildly convex above with an angular periphery, body whorl subangular initially, becoming rounded towards the aperture. Aperture lunate, outer lip apparently simple, somewhat reflected but not thickened at the columellar insertion. Parietal wall with thin callus. Umbilicus narrow, width about one-seventh that of shell. First $1\frac{1}{2}$ whorls with sculpture of regular, curved, retractive, rib-like costulæ; about 9 to the mm.; succeeding whorls with retractive growth lines of varying prominence.

Remarks. The relatively small size and the narrow umbilicus distinguish this species from the Eocene oreohelices such as *O. grangeri* Cockerell and Henderson. The regular sculpture of the embryonic whorls, and the angular periphery of the volutions of the spire, substantiate Russell's reference of this species to *Oreohelix.* As with most of the fossil species of this genus, the regular apical sculpture is particularly suggestive of the subgenus *Radiocentrum* Pilsbry.

The hypotype, No. 10167, which has a quite undistorted spire, has more convex whorls and is less depressed than the typical specimens. It possibly represents an undescribed species, but the existing material precludes its precise differentiation from *O. thurstoni.*

Occurrence. Paskapoo formation, Willow Creek formation (upper part), Porcupine Hills formation.

Oreohelix sp. cf. *O. megarche* Cockerell and Henderson.

Plate VIII, figures 6a-6c, 7

Material. Figured specimens, G.S.C. Nos. 10306, 10307, Paskapoo formation, locality 27.

Dimensions. Specimen 10306: altitude 10·0; width 28·5; number of whorls, 5; specimen 10307: altitude 13·0; width 22·2; number of whorls, 5.

Remarks. Some large oreohelices from the Paskapoo formation differ from the contemporary *O. thurstoni* (Russell) in being larger, more widely umbilicate, and less elevated. These specimens resemble *O. megarche* Cockerell and Henderson (1912, p. 230, Pl. 22, figs. 4-6; Russell, 1931b, p. 22, Pl. 3, figs. 7-12) from the Lower Eocene of the Bighorn Basin, Wyoming, but they are somewhat smaller and more depressed.

Occurrence. Paskapoo formation.

Oreohelix ? obtusata (Whiteaves)

Plate VIII, figures 8a-8c, 9a, 9b

1885. *Patula obtusata* Whiteaves, Geol. Surv., Canada, Contr. Can. Pal., vol. 1, p. 18, Pl. 2, figs. 7, 7a, 7b.
[*non*] 1929. *Oreohelix obtusata* (Whiteaves); Russell, Roy. Soc., Canada, Trans., ser. 3, vol. 23, sec. 4, p. 84, Pl. 1, fig. 9.

Material. Holotype, G.S.C. No. 5539, St. Mary River formation, Oldman River, near McLeod, Alberta; hypotype, G.S.C. No. 10170, St. Mary River formation, locality 17; hypotype, G.S.C. No. 10171, St. Mary River formation, locality 8.

Dimensions.

Specimen	Altitude	Width	Number of whorls
5539	6·3	12·5	5½
10170	4·5	11·1	5
10171	5·3	9·1	4½

Description. Shell very depressed, obtusely conoid, umbilicate. Whorls about 5, increasing in size slowly, evenly convex above, with moderately impressed suture, periphery well rounded throughout development. Aperture lunate, labral profile slightly retractive (about 70 degrees), lip apparently thin and simple. Umbilicus wide, about one-third shell, deep, nearly circular due to strongly involute mode of coiling below. Embryonic whorls apparently smooth, succeeding whorls with poorly defined, irregular, slightly retractive growth lines.

Remarks. Russell (1929b, p. 84) tentatively referred some strongly sculptured Paleocene shells to this species. The type is exfoliated, but the present collections include specimens from the typical bed which show the sculpture to be obscure, as described above. Russell's figured specimen may represent an immature individual of *Anguispira russelli* sp. nov. *A. russelli* and *O. ? obtusata* are compared under the description of the former.

The absence of *Radiocentrum*-like sculpture, and the rounded periphery at all stages of development render the reference of this species to *Oreohelix* doubtful, but no satisfactory alternative is available.

Occurrence. St. Mary River formation.

Family, POLYGYRIDAE

Genus, *Polygyra* Say

Polygyra parvula (Whiteaves)

Plate IX, figures 9, 10a, 10b, 11a, 11b

1885. *Anchistoma parvulum* Whiteaves, Geol. Surv., Canada, Contr. Can. Pal., vol. 1, p. 19, Pl. 3, figs. 2, 2a, 2b.

1929. *Paravitrea parvula* (Whiteaves); Russell, Roy. Soc., Canada, Trans., ser. 3, vol. 23, sec. 4, p. 89, Pl. 1, figs. 21-24.

Material. Holotype, G.S.C. No. 5541, St. Mary River formation, Oldman River, probably in sec. 16, tp. 10, rge. 24, W. 4th mer.; hypotype, G.S.C. No. 10172, St. Mary River formation, locality 20; hypotype, G.S.C. No. 10173, Willow Creek formation (lower part), locality 3; hypotype, G.S.C. No. 10174, St. Mary River formation, locality 32.

Dimensions.

Specimen	Altitude	Width	Number of whorls
5541	1·4	3·6	6
10172	8·0	11·5	9
10173	5·2+	14·8 (crushed)	9
10174	4·0	6·8	8

Description. Shell depressed-conoid, umbilicate. Whorls about 9, increasing in size very slowly, flat to slightly convex above with slightly impressed suture, periphery evenly convex. Retractively transverse internal barriers, projecting inward and upward from the outer wall, present on sixth and body whorls. Body whorl descending rather abruptly in the last 3 mm. Labral profile retractive (about 45 degrees), aperture obliquely lunate, outer lip thickened and reflected, parietal wall with heavy callus producing a continuous peristome. Umbilicus with steep sides, outer margin subangular, sides steep, almost circular below owing to involute mode of coiling below, width about one-third that of shell. Sculpture consists of very obscure, rather irregular, retractive growth lines.

Remarks. Russell referred *"Anchistoma" parvulum* to *Paravitrea* Pilsbry on the grounds of the appearance of the shell and the possession of an internal barrier. The present collection, obtained from many localities, contains several specimens that show the apertural features described above. The descending body whorl and the thickened peristome are not characteristic of *Paravitrea* and are very suggestive of the *Polygyridae.* The internal barrier of the sixth whorl is known only from the holotype, and a number of partly exfoliated specimens show a strongly retractive groove on the body whorl, suggesting a similar barrier. The collection includes specimens, for example hypotype No. 10174, which form the lip characters on the eighth whorl, whereas the more common, larger individuals, develop the apertural features on the ninth whorl. It might be maintained that this difference should form the basis of subspecific or even specific differentiation, but this course is not adopted as well preserved material is not sufficiently abundant to determine the variability of this feature.

P. parvula, particularly the small variety noted above, is similar to *P. venerabilis* Russell, from the Oldman formation of Alberta. *P. venerabilis,* however, lacks the descending body whorl of *P. parvula,* and has in addition an angular keel on the inner lip of the aperture.

Occurrence. St. Mary River formation, Edmonton formation (Disturbed belt), Willow Creek formation (lower part), Wapiti group.

Russell (1932c, p. 146) recorded *"Paravitrea parvula* (Whiteaves) ?" from the "upper Saunders beds" (= Paskapoo). In the University of Alberta collections, a single specimen, thus labelled, from Fallentimber Creek is apparently an exfoliated specimen of *Dimorphoptychia douglasi* sp. nov., so that there is no evidence that this species ranges into Paleocene strata.

Family, UROCOPTIDAE

Genus, *Holospira* von Martens

Holospira dyeri sp. nov.

Plate IX, figures 6a, 6b, 7, 8; Text Figure 5

1930. *Pupa* sp. indet., Dyer, Nat. Mus., Canada, Bull. 63, p. 14, Pl. 3, fig. 13.

Material. Holotype, G.S.C. No. 10187, St. Mary River formation, locality 32; paratypes, G.S.C. Nos. 10188, 10189, St. Mary River formation, locality 32; paratype, G.S.C. No. 10190, St. Mary River formation, locality 41.

Dimensions.

Specimen	Altitude	Width	Number of whorls
10187	21·0	7·0	about 11
10188	22·0	7·2	about 11
10190	18·8	7·3	11

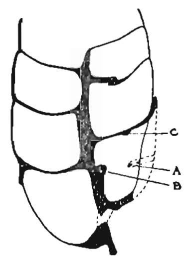

Figure 5. *Holospira dyeri* sp. nov. (x3). Specimen sectioned to show remains of palatal (A), parietal (B) and axial (C) lamellæ. Paratype, G.S.C. No. 10189.

Description. Shell elongate-ovate. Whorls about 11, sides flat, suture unimpressed. Axis apparently narrowly perforate, sealed in front by the reflection of the inner lip of the aperture. Aperture broadly and obliquely pyriform; peristome thickened and slightly reflected, attached to the penult whorl posteriorly; labral profile slightly retractive (about 80 degrees). Palatal wall with spiral lamella about 2 mm. anterior to the suture, appearing at, or just before, the beginning of the body whorl and disappearing at about one-quarter turn from the lip. Columellar wall apparently with parietal lamella in medial position; an axial lamella may also be present. Shell sculptured with very obscure axial striations.

Remarks. The palatal fold of this species is clearly visible on specimens exfoliated behind the aperture, which show distinct grooves carrying shell matter. One specimen was ground down to show the columella and a distinct ridge, interpreted as a parietal lamella, is present (*See* Figure 5). A low anteriorly directed excrescence midway between the columella and the suture on the same specimen suggests the presence of an axial lamella. Sections of the shell transverse to the axis show that it is perforate; the perforation is apparently 1 mm. wide at the eighth whorl of one specimen, another shows only a minute perforation at the same stage.

This species closely resembles *H. eva* Gardner from the Lower Oligocene of northern Mexico from which it differs in having a spire that tapers more acutely. According to Pilsbry's (1953, p. 139) description of the internal characters of *H. eva*, the internal lamellæ occur in the penult whorl, as in typical *Holospira*, whereas in *H. dyeri* the palatal lamella is principally within the body whorl. Two other fossil species of *Holospira* are recognized in North America. *H. leidyi* Meek, from the Eocene of Wyoming, the type of which is apparently lost, has never been figured and comparison with *H. dyeri* is, therefore, impossible. *H. grangeri* Cockerell, a Paleocene species from New Mexico, is smaller and apparently more sculptured than *H. dyeri*; its internal characters are not known.

The shell features of this species strongly suggest *Holospira,* of which it is the oldest known representative. The occurrence of the lamellæ within the body whorl of *H. dyeri* is anomalous, for typically in this genus the lamellæ are in the penult whorl. However, some variation is shown in the position of the armature in living species, for example *H. cyclostoma* Pilsbry, in which it may extend into the first part of the body whorl (Pilsbry, 1953, p. 149). The position of the lamellæ in *H. dyeri,* therefore, probably does not affect the validity of its reference to *Holospira.* The definite possession and the position of the palatal cord, together with the probable axial and parietal lamellæ suggest strongly the armature of *Holospira* s.s., which is typically quadrilamellate, but no sign of a basal lamella that would complete the correspondence of the armature of *H. dyeri* and that of the living species has been seen.

Pilsbry (1953, p. 140) considers *Holospira* s.s. the parent stock of the prolific group, referred to several subgenera, known in the recent fauna, and the occurrence of this species in the Upper Cretaceous tends to confirm this theory.

Occurrence. St. Mary River formation.

Family, ENDODONTIDAE

Genus, *Anguispira* Morse

Anguispira russelli sp. nov.

Plate VIII, figures 10a-10c

Material. Holotype, G.S.C. No. 10186, Paskapoo formation, locality 16.

Dimensions. Specimen 10186: altitude 7·0; width 14·0; number of whorls, 5.

Description. Shell of medium size, depressed, umbilicate. Whorls 5, increasing in size slowly and regularly, rather convex above with a moderately impressed suture. Body whorl with rounded periphery, apparently descending in front in the last 3 mm. Aperture lunate; labral profile retractive, inclined at about 30 degrees to the axis; outer lip thin, simple above, becoming reflected but not thickened at the columellar insertion. Umbilicus with rounded basal margin, width about one-third that of shell. First whorl apparently smooth, sculpture of succeeding whorls consists of sharp, regular, slightly curved, retractive costulæ, about 8 to the mm. on the second whorl, 4 to the mm. on the body whorl, becoming less conspicuous on the basal surface.

Remarks. In general appearance this species resembles *Oreohelix ? obtusata* (Whiteaves), of the St. Mary River formation, but it is larger, has a less angular basal margin of the umbilicus, more prominent and regular sculpture, and a more retractive labral profile.

The regular sculpture and thin lip of this species suggest the *Endodontidae,* and it is provisionally placed in *Anguispira.*

This species is named for Dr. L. S. Russell, Director of the Zoology section, National Museum of Canada.

Occurrence. Paskapoo formation. At the type locality *A. russelli* is known from a single specimen. In the collections of the University of Alberta some specimens from locality 2 are apparently referable to this species.

Genus, *Discus* Fitzinger

Discus sandersoni (Russell)

Plate VIII, figure 2

1929. *Gonyodiscus sandersoni* Russell, Roy. Soc., Canada, Trans., ser. 3, vol. 23, sec. 4, p. 86, Pl. 1, figs. 16-18.

Material. Holotype, University of Alberta collections, No. Ct 388, Paskapoo formation, locality 13.

Dimensions. Specimen Ct 388: altitude 2·4; width 7·5; number of whorls, 5.

Remarks. Pilsbry (1948, p. 601) places this species in *Discus. Gonyodiscus* Fitzinger is regarded as a subgenus of *Discus* by that author, the differences between the two lying essentially in the nature of the soft parts. Living species of *Discus,* however, have a rib-sculptured base, whereas in *Gonyodiscus* the sculpture is usually erased below the periphery. In this respect *D. sandersoni* agrees with *Discus* s.s., as well defined costulæ are present on the base.

Occurrence. Paskapoo formation. At present this species is known only from the type locality.

Family, PUPILLIDAE

Genus, *Pupilla* Leach

Pupilla inermis Russell

1931. *Pupilla inermis* Russell, Roy. Soc., Canada, Trans., ser. 3, vol. 25, sec. 4, p. 15, Pl. 2, figs. 12, 13.

Occurrence. Paskapoo formation.

Genus, *Albertanella* Russell

Albertanella minuta Russell

1931. *Albertanella minuta* Russell, Roy. Soc., Canada, Trans., ser. 3, vol. 25, sec. 4, p. 16, Pl. 2, figs. 14-15.

Occurrence. Paskapoo formation.

Family, unknown

Genus, *Pseudocolumna* Wenz

Pseudocolumna haydeniana (Cockerell)

Plate IX, figures 4a, 4b, 5

1857. *Bulimus ? teres* Meek and Hayden (*non Bulimus teres* Olivier, 1807); Phil. Acad. Nat. Sci., Proc., vol. 8, p. 117.

1876. *Columna teres* (Meek and Hayden); Meek, U.S. Geol. Surv. Terr., Rept., vol. 9, p. 555, Pl. 44, figs. 11a, 11b.

1906. *Columna haydeniana* Cockerell, Amer. Mus. Nat. Hist., Bull., vol. 22, art. 27, p. 459.

1920. *Pseudocolumna haydeniana* (Cockerell); Wenz, Senckenbergiana, vol. 2, p. 17.

1929. *Pseudocolumna vermicula* (Meek and Hayden); Russell, Roy. Soc., Canada, Trans., ser. 3, vol. 23, sec. 4, p. 88.

[?] 1857. *Bulimus ? vermiculus* Meek and Hayden; Phil. Acad. Nat. Sci., Proc., vol. 8, p. 118.

[?] 1876. *Columna vermicula* (Meek and Hayden); Meek, U.S. Geol. Surv. Terr., Rept., vol. 9, p. 556. Pl. 44, figs. 12a, 12b.

[?] 1876. *Columna vermicula* var. *contraria* Meek; ibid., p. 557.

Material. Hypotypes, G.S.C. No. 10148, Paskapoo formation, locality 31; University of Alberta collections, No. Pa 32, Paskapoo formation, locality 31.

Dimensions. Specimen Pa 32: altitude 10·5; width 2·4; number of whorls 9 (10); specimen 10148: altitude 11·0; width 3·0; number of whorls, last $3\frac{1}{2}$.

Remarks. *Pseudocolumna haydeniana* (Cockerell), *P. vermicula* (Meek and Hayden), and *P. vermicula* var. *contraria* (Meek) were all described from one locality and are based on rather poorly preserved material. The first two are based on sinistral shells and the last was founded on dextral material. All these shells are characterized by being extremely closely coiled; an estimate derived from fragmentary shells from Alberta giving 12 or 13 whorls for an altitude of 18·7 mm. Russell has recorded that both sinistral and dextral varieties of both *P. haydeniana* and *P. vermicula* occur in Alberta and he considered that this feature did not have taxanomic significance for he placed *P. vermicula* var. *contraria* in synonymy with *P. vermicula* s.s. This probably is the case but with data presently available the Canadian shells cannot be divided specifically; probably the three categories recognized by Meek are inseparable. The Canadian shells are referred to *P. haydeniana,* because this species, designated the type of *Pseudocolumna* by Wenz, is most likely to survive if the synonymy of these forms can be established.

Occurrence. Originally described from the typical Fort Union group. Paskapoo formation, Willow Creek formation (upper part).

Pseudocolumna spitzia sp. nov.

Plate IX, figures 1-3

Material. Holotype, G.S.C. No. 10284, a fragmentary, immature shell, Edmonton formation (Disturbed belt), locality 7; paratype, G.S.C. No. 10285, a fragmentary immature shell, Edmonton formation (Disturbed belt), locality 7; paratype, G.S.C. No. 10286, a crushed adult shell, Willow Creek formation (lower part), locality 11.

Dimensions.

Specimen	Altitude	Width	Height of body whorl	Number of whorls
10284	18·5	4·3	8·1	9 ?
10285	19·7	4·5	....	last 8
10286	31·0	....	13·5	11 ?

Description. Shell sinistral, acute, elongate with a pointed apex. Whorls 10 or 11, increasing in size rapidly, sides flat, suture unimpressed. Aperture elongate, angular behind and, probably, in front. Columella twisted, with a fold. Surface markings consist of rather obscure, almost straight growth lines, traversing the whorls at right angles to the suture.

Remarks. This species is known only from an abundance of very poorly preserved specimens. Suggestions of a columellar fold are present, but the parietal wall and the anterior part of the aperture are unknown.

P. spitzia is probably congeneric with *P. haydeniana* (Cockerell), which is smaller, more closely coiled, and less ventricose in the body whorl than the new species.

Wenz (1923b, p. 876) placed *Pseudocolumna* in the terrestrial *Ruminidae,* but the shells occurring with the present species suggest an aquatic mode of life. *P. spitzia* occurs in abundance, and at many localities, associated with *Viviparus, Physa,* and other aquatic genera. Probably this species, and perhaps the type, represent an extinct group of *Lymnaeidae* or *Physidae.* For the present the relationships of *Pseudocolumna* are best considered undetermined.

Occurrence. Edmonton formation (Disturbed belt), Willow Creek formation (lower part).

INDEX TO LOCALITY NUMBERS[1]

St. Mary River Formation

1. North side of irrigation ditch, south of Barons, NE. ¼ sec. 4, tp. 12, rge. 23, W. 4th mer. (22401)
2. Railway cut, Nobleford, SE. ¼ sec. 3, tp. 12, rge. 23, W. 4th mer. Coll. W. S. Dyer, 1925 (8651). (22430)
3. Oldman River, north side, NE. ¼ sec. 25, tp. 10, rge. 24, W. 4th mer. Coll. C. M. Sternberg, 1946. (13842)
4. Oldman River, north side, west side of small gully entering the river in NE. ¼ sec. 25, tp. 10, rge. 25, W. 4th mer. (22431)
5. Oldman River, north side, east side of small gully entering the river in NE. ¼ sec. 25, tp. 10, rge. 25, W. 4th mer. (22394)
6. St. Mary River, south side, at southeast end of dam spillway, SW. ¼ sec. 12, tp. 5, rge. 24, W. 4th mer. (22398)
7. St. Mary River, south side, north side of dam spillway, SW. ¼ sec. 12, tp. 5, rge. 24, W. 4th mer. (22396)
8. St. Mary River, locality as No. 7, fossils from horizon 10 feet above No. 7. (22397)
9. St. Mary River, south side, NE. ¼ sec. 28, tp. 4, rge. 24, W. 4th mer. (22400)
10. St. Mary River, 300 yards upstream from boundary of sec. 27, tp. 5, rge. 23, W. 4th mer. Coll. M. Y. Williams. (8636)
11. Oldman River, south side, l.s. 11, sec. 6, tp. 10, rge. 1, W. 5th mer. Fossils from unio coquina 39 feet below top of formation. (22472)
12. Oldman River, south side, l.s. 11, sec. 6, tp. 10, rge. 1, W. 5th mer. Fossils from grey shale within "blocky sandstone member". (22471)
13. Oldman River, north side, l.s. 11, sec. 6, tp. 10, rge. 1, W. 5th mer. Fossils from grey shale 60 feet below top of formation. (22470)
14. Castle River, right side, l.s. 5, sec. 35, tp. 6, rge. 1, W. 5th mer. Fossils from green shale 470 feet below top of formation. (22461)
15. Castle River, right side, l.s. 5, sec. 35, tp. 6, rge. 1, W. 5th mer. (Fossils from green shale 490 feet below top of formation. (22460)
16. Castle River, right side, l.s. 5, sec. 35, tp. 6, rge. 1, W. 5th mer. Fossils from green silty shale 650 feet below top of formation. (22423)
17. Castle River, right side, l.s. 5, sec. 35, tp. 6, rge. 1, W. 5th mer. Fossils from green shale 735 feet below top of formation. (22424)
18. Pincher Creek, right side, l.s. 16, sec. 16, tp. 6, rge. 30, W. 4th mer. Fossils from sandstone talus. (22761)
19. Pincher Creek, right side, l.s. 5, sec. 22, tp. 6, rge. 30, W. 4th mer. Fossils from grey argillaceous limestone 108 feet below top of formation. (22760)
20. Pincher Creek, right side, l.s. 4, sec. 22, tp. 6, rge. 30, W. 4th mer. Fossils from dark grey calcareous shale 331 feet below top of formation. (Apparently this is the horizon from which R. G. McConnell and T. C. Weston obtained material in 1881 and 1883 respectively.) (22433)
21. Pincher Creek, right side, l.s. 1, sec. 21, tp. 6, rge. 30, W. 4th mer. Fossils from grey shale 544 feet below top of formation. (22429)
22. Pincher Creek, left side, l.s. 1, sec. 21, tp. 6, rge. 30, W. 4th mer. Fossils from grey shale 661 feet below top of formation. (22389)

[1] Collections not otherwise indicated were made by the writer during the field seasons 1949-51. Numbers in parentheses refer to the permanent catalogue numbers of the Geological Survey collections.

23. Pincher Creek, right side, l.s. 16, sec. 16, tp. 6, rge. 30, W. 4th mer. Fossils from calcareous sandstone ("ironstone") 833 feet below top of formation. (22427)
24. Pincher Creek, right side, l.s. 15, sec. 16, tp. 6, rge. 30, W. 4th mer. Fossils from grey silty shale 986 feet below top of formation. (22428)
25. Pincher Creek, left side, l.s. 2, sec. 21, tp. 6, rge. 30, W. 4th mer. Fossils from grey shale 1,014 feet below top of formation. (22425)
26. Pincher Creek, right side, l.s. 14, sec. 16, tp. 6, rge. 30, W. 4th mer. Fossils from grey shale 1,241 feet below top of formation. (22422)
27. Pincher Creek, right side, l.s. 14, sec. 16, tp. 6, rge. 30, W. 4th mer. Fossils from green silty shale 1,272 feet below top of formation. (22426)
28. Pincher Creek, right side, l.s. 13, sec. 15, tp. 6, rge. 30, W. 4th mer. Fossils from argillaceous sandstone 1,956 feet below top of formation. (22390)
29. Indianfarm Creek, left side, l.s. 11, sec. 34, tp. 5, rge. 29, W. 4th mer. Fossils from unio coquina in green sandstone. (22385)
30. Waterton River, right side, l.s. 6, sec. 13, tp. 5, rge. 28, W. 4th mer. Fossils from lenticular coquina of shells in green sandstone, 40 feet below top of formation. (20956)
31. Waterton River, right side, l.s. 4, sec. 13, tp. 5, rge. 28, W. 4th mer. Fossils from green sandstone 215 feet below top of formation. (20952)
32. Waterton River, right side, l.s. 13, sec. 36, tp. 4, rge. 28, W. 4th mer. Fossils from irregularly indurated green sandstone, within about 300 feet of base of formation. (21511)
33. Waterton River, left side, northeast limb of syncline in NE. ¼ sec. 2, tp. 5, rge. 28, W. 4th mer. Fossils from grey shale 89 feet below top of formation. (22387)
34. Locality and section as 33. Fossils from grey shale 142 feet below top of formation. (22386)
35. Locality and section as 33. Fossils from grey shale 153 feet below top of formation. (22380)
36. Locality and section as 33. Fossils from green shale 160 feet below top of formation. (22381)
37. Locality and section as 33. Fossils from grey silty shale 352 feet below top of formation. (22382)
38. Locality and section as 33. Fossils from grey shale 388 feet below top of formation. (22376)
39. Locality and section as 33. Fossils from grey shale 699 feet below top of formation. (22375)
40. Locality and section as 33. Fossils from grey silty shale 881 feet below top of formation. (20987)
41. Locality and section as 33. Fossils from "ironstone" bed low in the formation. (22474)
42. Locality and section as 33. Fossils from unio coquina 10 feet below 41. (22473)
43. Locality and section as 33. Fossils from grey shale near base of exposed section. (20990)
44. Belly River, right side, SW. ¼ sec. 3, tp. 4, rge. 27, W. 4th mer. Fossils from grey shale 122 feet above base of formation. (22402)
45. Belly River, right side, SW. ¼ sec. 3, tp. 4, rge. 27, W. 4th mer. Fossils from green sandstone about 160 feet above base of formation. (22403)
46. Belly River, right side, SW. ¼ sec. 3, tp. 4, rge. 27, W. 4th mer. Fossils from grey silty shale about 170 feet above base of formation. (22404)

Edmonton Formation

1. Kneehills Creek, south side, NW. ¼ sec. 11, tp. 29, rge. 22, W. 4th mer. Fossils from irregularly indurated sandstone, about 15 feet above level of railway grade. (20998)

2. Locality as 1. Fossils from unio coquina 35 feet above level of railway grade. (20997)
3. Kneehills Creek, north side, NE. ¼ sec. 12, tp. 29, rge. 22, W. 4th mer. Fossils from unio coquina about 75 feet above river level. (20996)
4. Kneehills Creek, north side, NE. ¼ sec. 12, tp. 29, rge. 22, W. 4th mer. Fossils from "ironstone" beds near horizon of locality 3. (21504)
5. Kneehills Creek, north side, NW. ¼ sec. 7, tp. 29, rge. 21, W. 4th mer. Fossils from lenticular shell coquina in "ironstone" bed about 70 feet above river level. (22370)
6. Red Deer River, west side, sec. 14, tp. 33, rge. 22, W. 4th mer. (22373)
7. Bow River, north side, SW. ¼ sec. 9, tp. 21, rge. 22, W. 4th mer. Fossils from "ironstone" bed about 25 feet above river level. Coll. W. S. Dyer, 1926. (8673) Coll. E. T. Tozer, 1951. (20992)
8. Bow River, south side. Fossils from "ironstone" beds at small gully immediately upstream from coulée in sec. 5, tp. 21, rge. 22, W. 4th mer. (21000, 21501, 21502)
9. Bow River, south side, 100 yards upstream from coulée in sec. 5, tp. 21, rge. 22, W. 4th mer. Fossils from lenticular coquina of shells in "ironstone" bed of large slumped outcrop. Fossil bed is now about 40 feet above river level. (20993)
10. Bow River, south side, sec. 10, tp. 21, rge. 23, W. 4th mer. Fossils from unio bed 18 feet above Drumheller member. (20994)
11. Coulée running north from Jumping Buffalo Hill, sec. 29, tp. 20, rge. 19, W. 4th mer. Fossils from abundant blocks of "ironstone" on east side of coulée. (22454)
12. Coal mine in NE. ¼ sec. 33, tp. 15, rge. 23, W. 4th mer. Fossils from unio coquina 1 foot above coal seam. (21505)
13. Little Bow River, left side, boundary between NW. and NE. quarters of sec. 10, tp. 14, rge. 23, W. 4th mer. Fossils from sandstone about 60 feet above river level. (22372)
14. Little Bow River, locality as 12. Fossils from horizon 10 feet below horizon of 12. (22371)
15. Little Bow River, left side, SW. ¼ sec. 5, tp. 14, rge. 23, W. 4th mer. Fossils from green shale immediately below 10-foot massive, buff weathering sandstone, about 70 feet above river level. (21503)
16. Little Bow River, left side, SW. ¼ sec. 5, tp. 14, rge. 23, W. 4th mer. Fossils from rubbly, fine-grained sandstone, about 10 feet above river level. (20999)

Edmonton Formation (Disturbed belt)

Lower fauna

1. Highwood River, south side, l.s. 2, sec. 10, tp. 18, rge. 2, W. 5th mer. Fossils from unio coquina 1,560 feet below top of formation. (22469)
2. Locality as 1. Fossils from unio coquina in buff weathering sandstone, 1,360 feet below top of formation. (22393)
3. Locality as 1. Fossils from green shale 1,348 feet below top of formation. (22446)
4. Bow River, north side, l.s. 8, sec. 13, tp. 26, rge. 4, W. 5th mer. Fossils from unio coquina at mouth of Grand Valley Creek (*See* Rutherford, 1927, p. 40; Russell, 1932c, p. 143).
5. Little Red Deer River, left side, l.s. 4, sec. 1, tp. 29, rge. 6, W. 5th mer. Fossils from unio coquina (*See* Russell, 1932c, p. 143). (22450)

Upper fauna

6. Highwood River, north side, l.s. 16, sec. 10, tp. 18, rge. 2, W. 5th mer. Fossils from buff weathering sandstone 635 feet below top of formation. (22468)

7. Highwood River, north side, l.s. 12, sec. 11, tp. 18, rge. 2, W. 5th mer. Fossils from thin argillaceous limestone 410 feet below top of formation. (22467)
8. Jumpingpound Creek, left side, at boundary of l.s. 3 and 4, sec. 29, tp. 25, rge. 4, W. 5th mer. Fossils from fissile grey shale horizons between 20 and 58 feet above 30-foot sandstone with scattered pebbles at base. (22451, 22452, 22453)
9. Bow River, north side, l.s. 4, sec. 18, tp. 26, rge. 4, W. 5th mer. Fossils from unio bed exposed in railway cut (*See* Rutherford, 1927, p. 40; Russell, 1932c, p. 144). (22449)

Willow Creek Formation (lower part)

1. Rice Creek, right side, l.s. 16, sec. 10, tp. 14, rge. 2, W. 5th mer. Fossils from horizon in lower part of member "D". (22412)
2. Oldman River, north side, l.s. 12, sec. 5, tp. 10, rge. 1, W. 5th mer. Fossils from grey shale about 50 feet below base of member "C". (21538)
3. Oldman River, south side, l.s. 9, sec. 6, tp. 10, rge. 1, W. 5th mer. Fossils from grey shale about 600 feet above base of formation (member "B"). (21543)
4. Oldman River, north side, boundary of l.s. 9 and 10, sec. 6, tp. 10, rge. 1, W. 5th mer. Fossils from grey shale about 400 feet above base of formation (member "A"). (21539, 21548)
5. Oldman River, south side, boundary of l.s. 9 and 10, sec. 6, tp. 10, rge. 1, W. 5th mer. Fossils from unio bed in member "A", 409 feet above base of formation. (21542)
6. Oldman River, south side, l.s. 11, sec. 6, tp. 10, rge. 1, W. 5th mer. Fossils from grey shale about 140 feet above base of formation (member "A"). (21537)
7. Oldman River, south side, l.s. 11, sec. 6, tp. 10, rge. 1, W. 5th mer. Fossils from basal unio coquina of formation (member "A"). (20981)
8. Oldman River, north side, l.s. 11, sec. 6, tp. 10, rge. 1, W. 5th mer. Fossils from irregularly indurated zone at top of basal sandstone of formation (member "A"). (21541)
9. Castle River, right side, l.s. 9, sec. 2, tp. 7, rge. 1, W. 5th mer. Fossils from greenish grey shale, 1,895 feet above base of formation (member "D"). (21534)
10. Castle River, left side, l.s. 11, sec. 2, tp. 7, rge. 1, W. 5th mer. Fossils from grey shale 1,400 feet above base of formation (member "D"). (20973)
11. Castle River, left side, l.s. 13, sec. 35, tp. 6, rge. 1, W. 5th mer. Fossils from grey shale 290 feet above base of formation (member "B"). (22419, 22420)
12. Pincher Creek, left side, l.s. 10, sec. 22, tp. 6, rge. 30, W. 4th mer. Fossils from grey shale 850 feet above base of formation (member "D"). (22408)
13. Pincher Creek, left side, l.s. 10, sec. 22, tp. 6, rge. 30, W. 4th mer. Fossils from grey shale 817 feet above base of formation (member "B"). (22405)
14. Pincher Creek, left side, l.s. 11, sec. 22, tp. 6, rge. 30, W. 4th mer. Fossils from grey shale 603 feet above base of formation (member "B"). (22407)
15. Pincher Creek, right side, l.s. 11, sec. 22, tp. 6, rge. 30, W. 4th mer. Fossils from grey shale 515 feet above base of formation (member "B"). (22410)
16. Pincher Creek, right side, l.s. 11, sec. 22, tp. 6, rge. 30, W. 4th mer. Fossils from grey shale 509 feet above base of formation (member "B"). (22409)
17. Pincher Creek, left side, l.s. 5, sec. 22, tp. 6, rge. 30, W. 4th mer. Fossils from grey shale about 293 feet above base of formation (member "B"). (22411)
18. Pincher Creek, left side, l.s. 5, sec. 22, tp. 6, rge. 30, W. 4th mer. Fossils from grey shale 107 feet above base of formation (member "B"). (20955)
19. Pincher Creek, left side, l.s. 5, sec. 22, tp. 6, rge. 30, W. 4th mer. Fossils from mottled maroon-green shale 78 feet above base of formation (member "B"). (22406)
20. Pincher Creek, left side, l.s. 5, sec. 22, tp. 6, rge. 30, W. 4th mer. Fossils from lenticular unio coquina at base of 3-foot sandstone 69 feet above base of formation (member "B"). (22421)
21. Waterton River, right side, l.s. 14, sec. 18, tp. 5, rge. 27, W. 4th mer. Fossils from grey shale 1,155 feet above base of formation (member "D" ?). (20948)

22. Waterton River, right side, l.s. 14, sec. 18, tp. 5, rge. 27, W. 4th mer. Fossils from grey shale 1,100 feet above base of formation (member "D" ?). (22417)
23. Waterton River, right side, l.s. 7, sec. 13, tp. 5, rge. 28, W. 4th mer. Fossils from mottled maroon-green shale 43 feet above base of formation (member "B" ?). (22416)

Willow Creek Formation (upper part)

1. Willow Creek, east side, NW. ¼ sec. 6, tp. 11, rge. 26, W. 4th mer. Fossils from 0·5-foot bed of grey limestone. (21560)
2. Willow Creek, east side, NE. ¼ sec. 12, tp. 11, rge. 27, W. 4th mer. Fossils from black clay shale, 15 feet above river level. (21544)
3. Willow Creek, west side, l.s. 2, sec. 12, tp. 11, rge. 27, W. 4th mer. (21571)
4. Willow Creek, east side, l.s. 11, sec. 24, tp. 10, rge. 27, W. 4th mer. Fossils from unio coquina about 20 feet above river level. (21572)
5. Willow Creek, west side, NE. ¼ sec. 22, tp. 11, rge. 27, W. 4th mer. (21573)
6. Oldman River, north side, l.s. 10, sec. 35, tp. 7, rge. 1, W. 5th mer. Fossils from grey shale 3,485 feet above base of formation (member "E"). (21567)
7. Oldman River, north side, l.s. 10, sec. 35, tp. 7, rge. 1, W. 5th mer. Fossils from coquina of gastropod shells 3,425 feet above base of formation.
8. Castle River, right side, l.s. 2, sec. 24, tp. 7, rge. 1, W. 5th mer. Fossils from grey shale 4,135 feet above base of formation (member "E"). (20974)
9. Castle River, right side, l.s. 14, sec. 13, tp. 7, rge. 1, W. 5th mer. Fossils from irregularly indurated, green, silty shale, 3,805 feet above base of formation (member "E"). (21545)
10. Castle River, left side, l.s. 9, sec. 14, tp. 7, rge. 1, W. 5th mer. Fossils from lenticular coquina of shells in grey argillaceous limestone, 3,470 feet above base of formation (member "E"). (21552)
11. Castle River, right side, l.s. 4, sec. 13, tp. 7, rge. 1, W. 5th mer. Fossils from grey shale 3,430 feet above base of formation (member "E"). (21568)
12. Castle River, right side, l.s. 13, sec. 12, tp. 7, rge. 1, W. 5th mer. Fossils from grey shale 3,260 feet above base of formation (member "E"). (21562)
13. South side tributary to Castle River, l.s. 14, sec. 11, tp. 7, rge. 1, W. 5th mer. Fossils from grey shale 2,490 feet above base of formation (member "E"). (21546)
14. South side, tributary to Castle River, l.s. 14, sec. 11, tp. 7, rge. 1, W. 5th mer. Fossils from grey shale 2,385 feet above base of formation (member "E"). (20971, 20972)
15. Crowlodge Creek, east side, l.s. 14, sec. 19, tp. 6, rge. 28, W. 4th mer. Fossils from grey shale. (20977)
16. Crowlodge Creek, east side, l.s. 14, sec. 19, tp. 6, rge. 28, W. 4th mer. Fossils from fine-grained green sandstone. (21575)
17. Waterton River, left side, l.s. 12, sec. 31, tp. 5, rge. 26, W. 4th mer. Fossils from black shale about 2 feet above river level. (21570, 21574)
18. Waterton River, right side, l.s. 16, sec. 21, tp. 5, rge. 27, W. 4th mer. Fossils from black shale 15 feet above river level. (21559)
19. Waterton River, left side, l.s. 2, sec. 28, tp. 5, rge. 27, W. 4th mer. (21556)
20. Waterton River, left side, l.s. 2, sec. 28, tp. 5, rge. 27, W. 4th mer. Fossils from fine-grained green sandstone, near river level. (21555)
21. Waterton River, left side, l.s. 2, sec. 28, tp. 5, rge. 27, W. 4th mer. Fossils from black clay shale near river level. (21554)
22. Waterton River, right side, l.s. 10, sec. 19, tp. 5, rge. 27, W. 4th mer. Fossils from grey shale about 1,500 feet above base of formation. (21550)
23. Waterton River, right side, l.s. 10, sec. 19, tp. 5, rge. 27, W. 4th mer. Fossils from grey shale, 5 feet below prominent 12-foot, buff weathering sandstone, 1,460 feet above base of formation. (21549)

Porcupine Hills Formation

1. Oldman River, north side, l.s. 7, sec. 36, tp. 7, rge. 1, W. 5th mer. Fossils from grey silty shale 180 feet above base of formation. (21561)

Paskapoo Formation

The following list incorporates a number of published localities for the Paskapoo fauna. Most of the material from these localities was collected by the late Dr. R. L. Rutherford, Dr. P. S. Warren, and Dr. L. S. Russell, and is housed at the University of Alberta. The writer has had an opportunity to examine some of these collections; some revision has been made, consequently, in some cases the faunules listed in Table VI, page 34, differ from the original published lists. The writer may, therefore, be considered responsible for the identification of material from these localities as they now stand.

1. Wallace Mountain, west slope; east fork Bruce River, Swan Hills district, Alberta. Coll. J. A. Allan, 1918 (Russell, 1926b, p. 212). (6233)
2. McLeod River, left side, l.s. 4, sec. 8, tp. 52, rge. 18, W. 5th mer. (Locality 19-44, Warren in Rutherford, 1926, p. 12).
3. McLeod River, west side, l.s. 1, sec. 6, tp. 51, rge. 22, W. 5th mer. (Russell, 1931a, pp. 15, 16).
4. McLeod River, sec. 36, tp. 52, rge. 20, W. 5th mer. (Russell, 1929b, p. 88).
5. McLeod River, sec. 3, tp. 52, rge. 22, W. 5th mer. (Russell, 1929b, p. 86).
6. McLeod River, l.s. 12, sec. 28, tp. 54, rge. 15, W. 5th mer. (Locality 50-26, Warren in Rutherford, 1928, p. 22).
7. McLeod River, l.s. 13, sec. 28, tp. 53, rge. 7, W. 5th mer. (Locality 56-26, Warren in Rutherford, 1928, p. 22).
8. Pembina River, l.s. 12, sec. 5, tp. 53, rge. 7, W. 5th mer. (Locality 60-26, Warren in Rutherford, 1928, p. 22).
9. Pembina River, right side, NW. ¼ sec. 20, tp. 53, rge. 7, W. 5th mer. Fossils from loose blocks of "ironstone" at water level, immediately upstream from highway bridge. (21513)
10. North Saskatchewan River, near mouth of Ram River (University of Alberta).
11. Alexo map-area, on south side North Saskatchewan River, 5,200 feet down river from mouth of Dizzy Creek. Coll. O. A. Erdman, 1944. (12345)
12. Saunders map-area, 1,190 feet east of Slippery Creek, on Canadian National Railway. Coll. O. A. Erdman, 1944. (12347)
13. North Saskatchewan River, left side, sec. 28, tp. 39, rge. 10, W. 5th mer. (Russell, 1929b, pp. 86-87).
14. Bucklake Creek, near Berrymoor, Alberta (University of Alberta).
15. Battle River, near Ponoka, Alberta (Russell, 1926b, p. 212).
16. Red Deer River, south side, l.s. 4, sec. 4, tp. 39, rge. 26, W. 4th mer. Fossils from green silty shale about 30 feet below the top of the "canyon". (21518)
17. Blindman River, right side, SW. ¼ sec. 10, tp. 40, rge. 1, W. 5th mer. Fossils from large talus blocks of grey argillaceous limestone. (20964)
18. Red Deer River, at mouth of Blindman River. (The material described from this locality by Whiteaves (1885, p. 17) is listed under this locality in Table VI.)
19. Red Deer River, north side, l.s. 4, sec. 24, tp. 38, rge. 26, W. 4th mer. Fossils from fissile carbonaceous shale. (20967)
20. Sec. 13, tp. 38, rge. 26, W. 4th mer. Fossils from small outcrop on west side of road leading to highway bridge across Red Deer River. (21516)
21. James River, l.s. 15, sec. 4, tp. 34, rge. 7, W. 5th mer. Fossils from base of massive sandstone. Coll. H. H. Beach, 1940. (16684)

22. Red Deer River, east side, l.s. 14, sec. 16, tp. 32, rge. 6, W. 5th mer. Fossils from base of massive sandstone. Coll. H. H. Beach, 1940. (16685)
23. Fallentimber Creek, south side, l.s. 5, sec. 31, tp. 30, rge. 5, W. 5th mer. (Russell, 1931a, pp. 15, 17).
24. Silver Creek, north side, l.s. 9, sec. 30, tp. 29, rge. 6, W. 5th mer. (22479)
25. Little Red Deer River, north side, l.s. 1, sec. 30, tp. 29, rge. 5, W. 5th mer. Fossils from horizon about 75 feet below 100-foot massive sandstone. (21509)
26. Little Red Deer River, south side, l.s. 15, sec. 29, tp. 29, rge. 5, W. 5th mer. Fossils from "ironstone" bed. (21508)
27. Little Red Deer River, south side, l.s. 15, sec. 29, tp. 29, rge. 5, W. 5th mer. Fossils from green shale about 15 feet above locality 24. (22477)
28. Little Red Deer River, NW. ¼ sec. 31, tp. 32, rge. 3, W. 5th mer. Coll. G. S. Hume, 1929. (22482)
29. Bow River, north side, l.s. 2, sec. 18, tp. 26, rge. 4, W. 5th mer. (Locality 2, Warren in Rutherford, 1927, p. 40).
30. Jumpingpound Creek, right side, l.s. 10, sec. 28, tp. 25, rge. 4, W. 5th mer. (21507)
31. Calgary and vicinity (Russell, 1926b, pp. 208, 209).
32. Elbow River, right side, NE. ¼ sec. 33, tp. 23, rge. 1, W. 5th mer. Fossils from shell bed about 75 feet above river level. (21506)
33. Bow River, left side, NW. ¼ sec. 32, tp. 22, rge. 29, W. 4th mer. Fossils from shell beds about 50 feet above river level. (22478)
34. Bow River, left side, NW. ¼ sec. 27, tp. 21, rge. 26, W. 4th mer. Fossils from lenticular argillaceous limestone about 40 feet above river level.
35. Pekisko Creek, south side, l.s. 14, sec. 26, tp. 17, rge. 2, W. 5th mer. Fossils from grey shale 4 feet below hard buff weathering sandstone. (21517)
36. Highwood River, right side, just below mouth of Sheep River, l.s. 11, sec. 32, tp. 20, rge. 28, W. 4th mer. (*See* Russell, 1931a, pp. 11-13). (21515)
37. Mosquito Creek, north side, SW. ¼ sec. 7, tp. 15, rge. 25, W. 4th mer. (22475)
38. Mosquito Creek, north side, NE. ¼ sec. 11, tp. 15, rge. 26, W. 4th mer. Fossils from black silty shale 4 feet above river level. (22476)
39. Mosquito Creek, north side, NE. ¼ sec. 24, tp. 15, rge. 27, W. 4th mer. (20982)
40. Mosquito Creek, middle of south side of sec. 33, tp. 15, rge. 27, W. 4th mer. Coll. W. S. Dyer, 1925. (8662)

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(1946b): Eocene nonmarine Gastropods from Hot Spring County, Wyoming; Jour. of Pal., vol. 20, No. 5, pp. 495-500, 11 text figs.
(1948): Paleocene fresh-water mollusks from Southern Montana; U.S. Geol. Surv., Prof. Pap. 214-C, pp. 35-50, Pl. 10.
(1951): Fresh-water Mollusks of Cretaceous age from Montana and Wyoming; U.S. Geol. Surv., Prof. Pap. 233-A, pp. 1-20, Pls. 1-2.
(1953): Designation of a genotype for *Reesidella* Yen; Jour. of Pal., vol. 27, No. 1, pp. 157-158.

PLATE I

(All figures natural sizes)

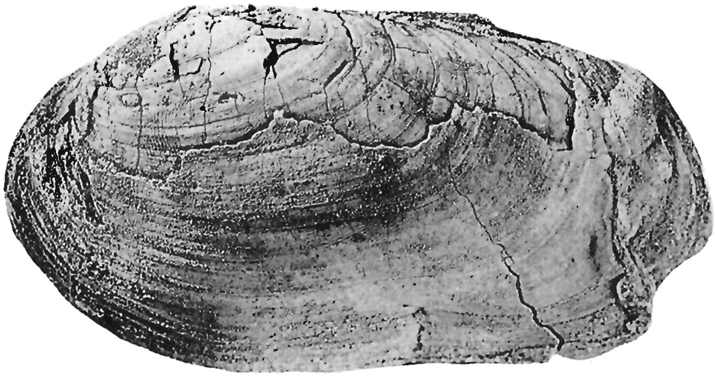
Figure 1. *Unio stantoni* White. Left valve of hypotype, G.S.C. No. 10314, Edmonton formation (lower part). (Page 37.)

Figure 2. *Unio stantoni* White. Left valve of hypotype, G.S.C. No. 10315, Edmonton formation (lower part). (Page 37.)

Figure 3. *Plesielliptio brachyopisthus* (White). Left valve of hypotype, G.S.C. No. 10320, Edmonton formation (Disturbed belt). (Page 39.)

Figure 4. *Plesielliptio brachyopisthus* (White). Left valve of hypotype, G.S.C. No. 10321, Edmonton formation (Disturbed belt). (Page 39.)

Figure 5. *Unio sandersoni* Warren. Left valve of hypotype, G.S.C. No. 10317, Edmonton formation (lower part). (Page 37.)



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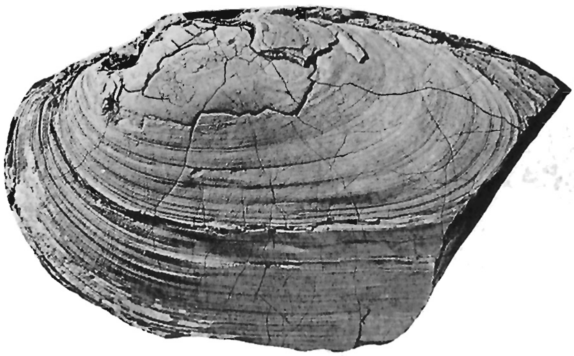

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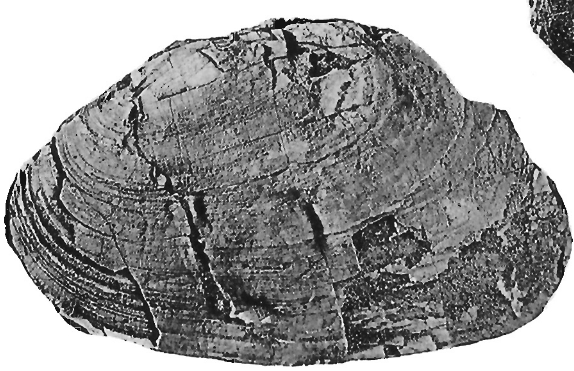

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Plate II

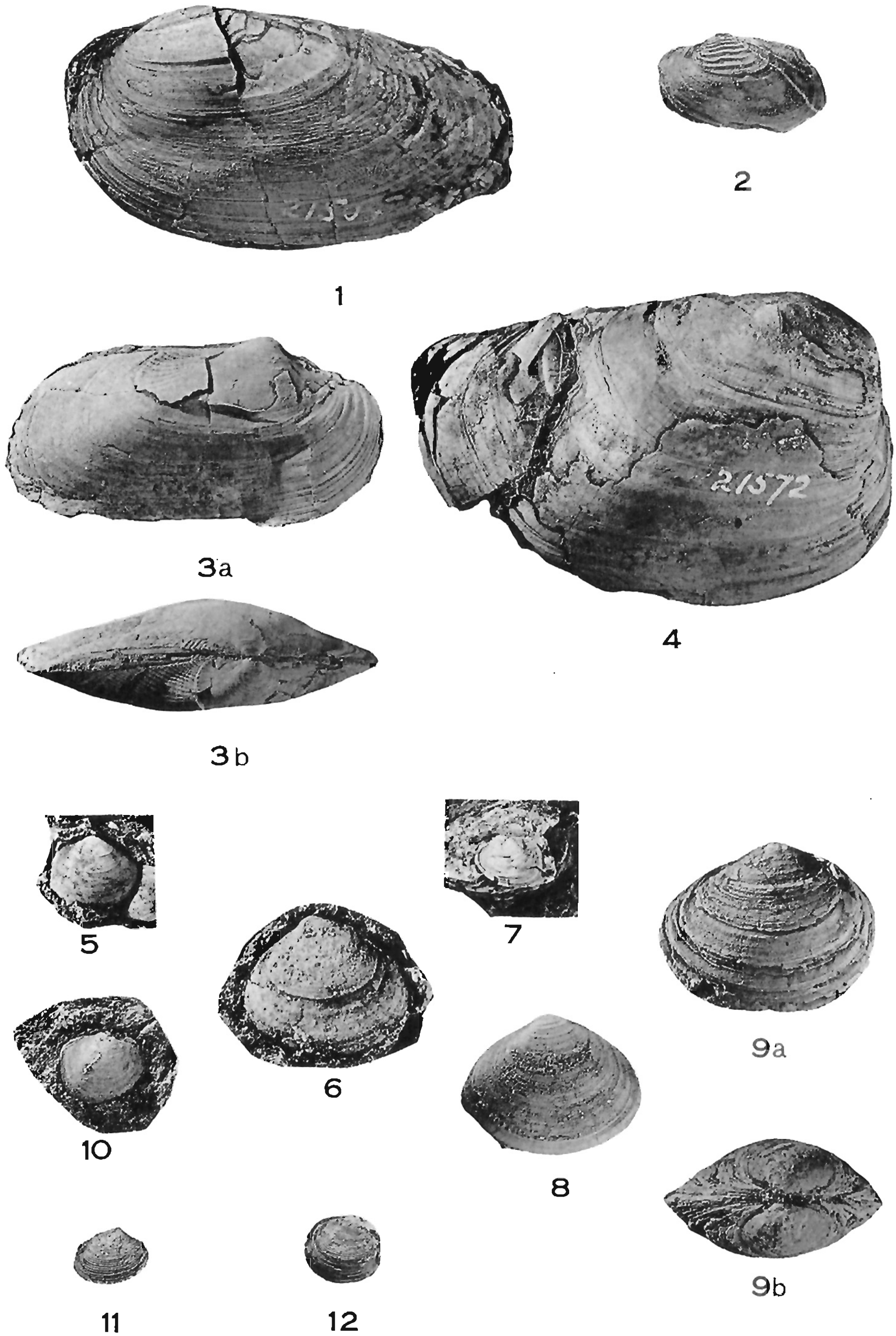

PLATE II

(Figures natural size unless otherwise stated)

Figure 1. *Plesielliptio priscus* (Meek and Hayden). Left valve of hypotype, G.S.C. No. 10319, Paskapoo formation. (Page 40.)

Figure 2. *Plesielliptio priscus* (Meek and Hayden). Left valve of immature individual, hypotype, G.S.C. No. 10318, Ravenscrag formation (Saskatchewan). (Page 40.)

Figures 3a, 3b. *Rhabdotophorus senectus* (White). Right lateral and dorsal views of hypotype, University of Alberta collections No. Pa. 96, Paskapoo formation. (Page 41.)

Figure 4. *Unio* sp. cf. *U. proavitus* White. Left valve of G.S.C. No. 10316, Willow Creek formation (upper part). (Page 38.)

Figure 5. *Sphaerium aequale* Russell. Left valve of topotype, G.S.C. No. 10324, Paskapoo formation. (x2) (Page 42.)

Figure 6. *Sphaerium fowleri* Russell. Left valve of topotype, G.S.C. No. 10325, Paskapoo formation. (x2) (Page 43.)

Figure 7. *Sphaerium formosum* (Meek and Hayden). Left valve of hypotype, G.S.C. No. 10128, Willow Creek formation (upper part). (x2) (Page 43.)

Figure 8. *Sphaerium heskethense* Warren. Left valve of hypotype, G.S.C. No. 10323, Edmonton formation (lower part). (x2) (Page 44.)

Figures 9a, 9b. *Sphaerium heskethense* Warren. Left lateral and dorsal views of hypotype, G.S.C. No. 10322, Edmonton formation (lower part). (x2) (Page 44.)

Figure 10. *Sphaerium gietzi* sp. nov. Right valve, paratype, G.S.C. No. 10197, St. Mary River formation. (x2) (Page 43.)

Figure 11. *Sphaerium gietzi* sp. nov. Right valve, paratype, G.S.C. No. 10196, St. Mary River formation. (x2) (Page 43.)

Figure 12. *Sphaerium gietzi* sp. nov. Right valve, holotype, G.S.C. No. 10195, St. Mary River formation. (x2) (Page 43.)

PLATE III

(Figures natural size unless otherwise stated)

Figure 1. *Viviparus westoni* sp. nov. Dorsal view of holotype, G.S.C. No. 10122, St. Mary River formation. (Page 58.)

Figure 2. *Viviparus westoni* sp. nov. Dorsal view of paratype, G.S.C. No. 10124, St. Mary River formation. (Page 58.)

Figure 3. *Viviparus westoni* sp. nov. Ventral view of paratype, G.S.C. No. 10126, St. Mary River formation. (Page 58.)

Figure 4. *Viviparus westoni* sp. nov. Lateral view of paratype, G.S.C. No. 10123, St. Mary River formation. (Page 58.)

Figure 5. *Viviparus westoni* sp. nov. Apex of shell showing sculpture, paratype, G.S.C. No. 10127, St. Mary River formation. (x2) (Page 58.)

Figure 6. *Viviparus westoni* sp. nov. Ventral view of paratype, G.S.C. No. 10125, Edmonton formation (lower part). (Page 58.)

Figure 7. *Viviparus prudentius prudentius* White. Dorsal view of hypotype, G.S.C. No. 10288, St. Mary River formation. (Page 54.)

Figures 8a, 8b. *Viviparus prudentius prudentius* White. Dorsal and ventral views of hypotype, G.S.C. No. 10287, St. Mary River formation. (Page 54.)

Figure 9. *Viviparus prudentius prudentius* White. Apical view of hypotype, G.S.C. No. 10289, St. Mary River formation. (Page 54.)

Figures 10a, 10b. *Viviparus prudentius willovensis* subsp. nov. Dorsal and ventral views of holotype, G.S.C. No. 10129, Edmonton formation (Disturbed belt). (Page 55.)

Figure 11. *Viviparus prudentius willovensis* subsp. nov. Apical view of crushed shell showing sculpture, paratype, G.S.C. No. 10130, Willow Creek formation (lower part). (Page 55.)

Figure 12. *Viviparus prudentius willovensis* subsp. nov. Apical view of two crushed specimens, specimen on left is paratype, G.S.C. No. 10131, Edmonton formation (Disturbed belt). (Page 55.)

Figures 13a, 13b. *Viviparus mokowanensis* sp. nov. Dorsal and ventral views of holotype, G.S.C. No. 10298, St. Mary River formation (basal member). (Page 52.)

Figure 14. *Viviparus mokowanensis* sp. nov. Ventral view of paratype, G.S.C. No. 10299, St. Mary River formation (basal member). (Page 52.)

PLATE III

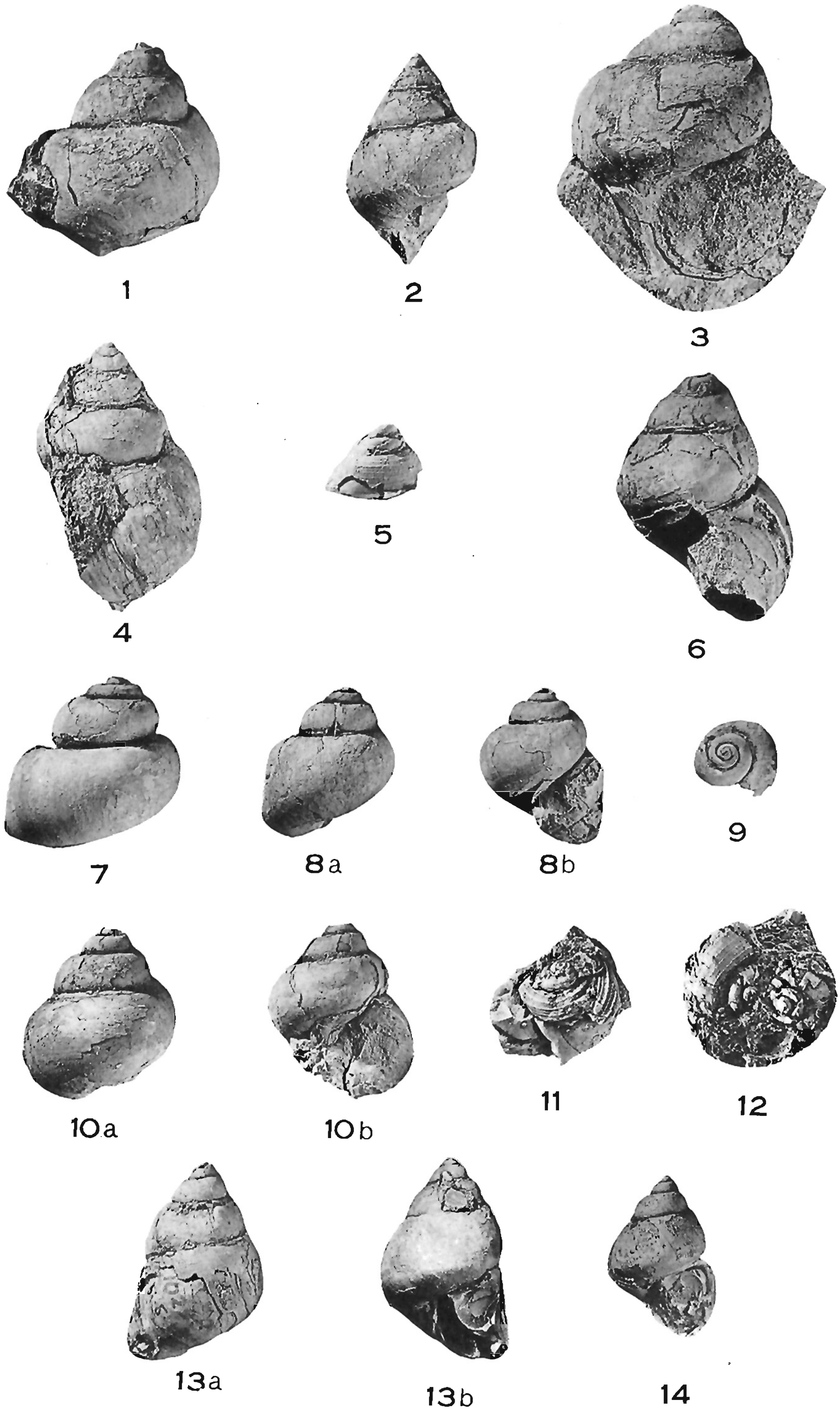

Plate IV

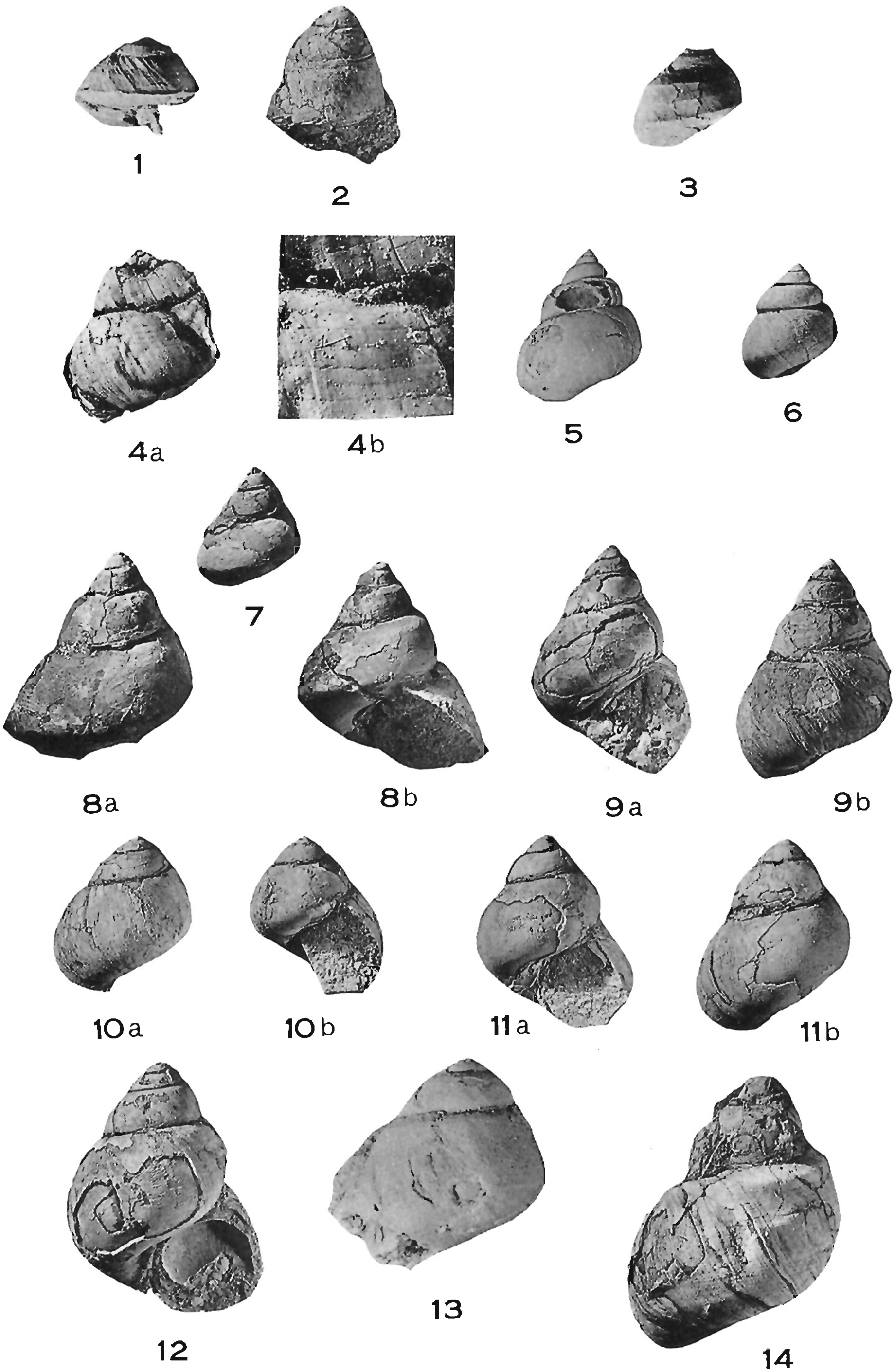

PLATE IV

(Figures natural size unless otherwise stated)

Figure 1. *Viviparus retusus* (Meek and Hayden). Dorsal view of fragmentary shell showing rounded apex and sculpture, hypotype, G.S.C. No. 10137, Paskapoo formation. (Page 56.)

Figure 2. *Viviparus retusus* (Meek and Hayden). Dorsal view of hypotype, G.S.C. No. 10136, Paskapoo formation. (Page 56.)

Figure 3. *Viviparus trochiformis* (Meek and Hayden). Fragmentary shell showing sculpture, hypotype, G.S.C. No. 10138, Paskapoo formation. (Page 58.)

Figures 4a, 4b. *Viviparus leai* (Meek and Hayden). Dorsal view of crushed shell showing sculpture with (4b) part of surface enlarged x4, hypotype, G.S.C. No. 10134, Paskapoo formation. (Page 51.)

Figure 5. *Viviparus leai* (Meek and Hayden). Dorsal view of hypotype, University of Alberta collections No. Pa 101, Paskapoo formation. (Page 51.)

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Figures 8a, 8b. *Viviparus planolatere* Russell. Dorsal and ventral views of hypotype, G.S.C. No. 10132, Paskapoo formation. (Page 53.)

Figures 9a, 9b. *Viviparus raynoldsanus* Meek and Hayden. Ventral and dorsal views of hypotype, G.S.C. No. 10135, Paskapoo formation. (Page 55.)

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Figures 11a, 11b. *Viviparus tasgina* Dyer. Ventral and dorsal views of hypotype, G.S.C. No. 10293, Edmonton formation (lower part). (Page 57.)

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Figure 14. *Viviparus tasgina* Dyer. Dorsal view of slightly distorted shell, hypotype, G.S.C. No. 10291, Edmonton formation (lower part). (Page 57.)

PLATE V

(Figures natural size unless otherwise stated)

Figure 1. *Valvata filosa* Whiteaves. Apical view of hypotype, G.S.C. No. 10301, St. Mary River formation. (x4) (Page 70.)

Figure 2. *Valvata filosa* Whiteaves. Apical view of hypotype, G.S.C. No. 10302, Willow Creek formation (lower part). (x4) (Page 70.)

Figure 3. *Valvata* sp. cf. *V. subumbilicata* (Meek and Hayden). Apical view of G.S.C. No. 10303, Paskapoo formation. (x4) (Page 71.)

Figure 4a. *Valvata bicincta* Whiteaves. Apical view of hypotype, G.S.C. No. 10305, Paskapoo formation. (x4) (Page 70.)

Figure 4b. *Valvata bicincta* Whiteaves. Ventral view of hypotype, G.S.C. No. 10304, Paskapoo formation. (x4) (Page 70.)

Figure 5. *Reesidella* sp. cf. *R. protea* (Yen). Ventral view of G.S.C. No. 10279, St. Mary River formation. (x2) (Page 69.)

Figure 6. *Reesidella* sp. cf. *R. protea* (Yen). Ventral view of G.S.C. No. 10280, St. Mary River formation. (x2) (Page 69.)

Figure 7. *Reesidella* sp. cf. *R. protea* (Yen). Ventral view of crushed immature shell preserving impression of operculum in the aperture, G.S.C. No. 10772, St. Mary River formation. (x4) (Page 69.)

Figures 8a, 8b. *Reesidella* sp. cf. *R. protea* (Yen). Outer and inner views of operculum, G.S.C. No. 10770, St. Mary River formation. (x4) (Page 69.)

Figures 9a, 9b. *Reesidella* sp. cf. *R. protea* (Yen). Outer and inner views of operculum, G.S.C. No. 10771, Willow Creek formation (lower part). (x4) (Page 69.)

Figure 10. *Campeloma nebrascensis whitei* Russell. Ventral view of hypotype, G.S.C. No. 10142, Paskapoo formation. (Page 61.)

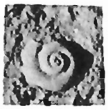
Figures 11a, 11b. *Campeloma nebrascensis nebrascensis* (Meek and Hayden). Dorsal and ventral views of holotype, G.S.C. No. 10139, Edmonton formation (lower part). (Page 61.)

Figures 12a, 12b. *Campeloma edmontonensis* sp. nov. Ventral and dorsal views of holotype, G.S.C. No. 10139, Edmonton formation (lower part). (Page 60.)

Figure 13. *Campeloma edmontonensis* sp. nov. Dorsal view of fragmentary shell, paratype, G.S.C. No. 10140, Edmonton formation (lower part). (Page 60.)

Figure 14. *Campeloma edmontonensis* sp. nov. Dorsal view of paratype, G.S.C. No. 10141, Edmonton formation (lower part). (Page 60.)

PLATE V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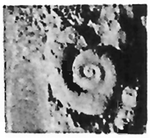
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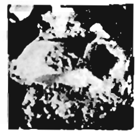
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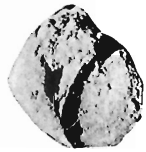
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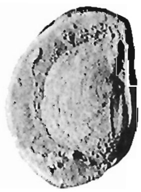
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PLATE VI

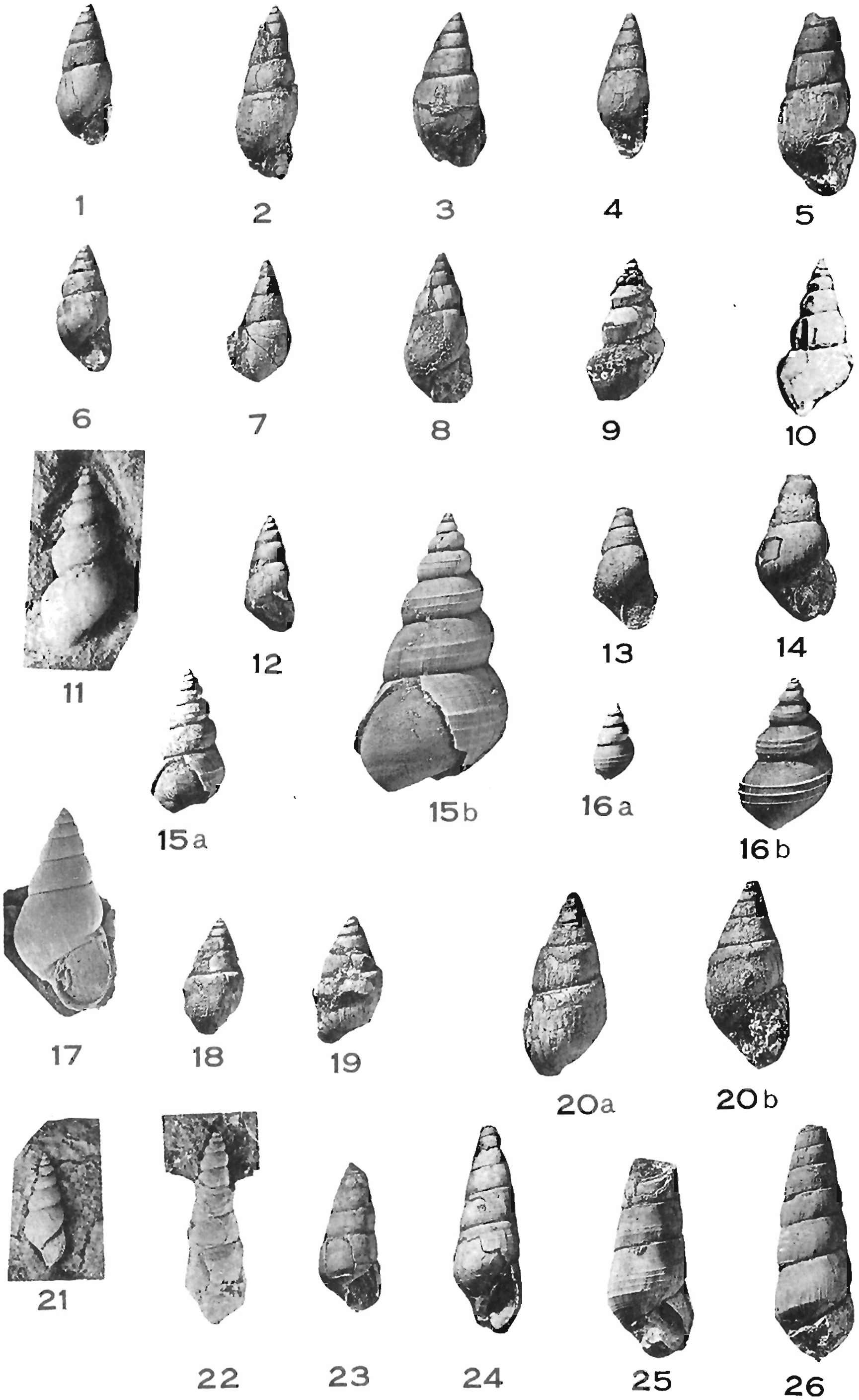
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Plate VI

(Figures natural size unless otherwise stated)

Figure 1. *Lioplacodes limnaeformis* (Meek and Hayden). Ventral view of hypotype G.S.C. No. 10154, Paskapoo formation. (Page 62.)

Figure 2. *Lioplacodes limnaeformis* (Meek and Hayden). Ventral view of hypotype, G.S.C. No. 10153, Paskapoo formation. (Page 62.)

Figure 3. *Lioplacodes limnaeformis* (Meek and Hayden). Ventral view of hypotype, G.S.C. No. 10152, Paskapoo formation. (Page 62.)

Figure 4. *Lioplacodes limnaeformis* (Meek and Hayden). Ventral view of hypotype, G.S.C. No. 10156, Paskapoo formation. (Page 62.)

Figure 5. *Lioplacodes limnaeformis* (Meek and Hayden). Ventral view of fragmentary shell, hypotype, G.S.C. No. 10155, Paskapoo formation. (Page 62.)

Figure 6. *Lioplacodes limnaeformis* (Meek and Hayden). Ventral view of hypotype, G.S.C. No. 10149, Edmonton formation (lower part). (Page 62.)

Figure 7. *Lioplacodes limnaeformis* (Meek and Hayden). Dorsal view of hypotype, G.S.C. No. 10151, St. Mary River formation. (Page 62.)

Figure 8. *Lioplacodes limnaeformis* (Meek and Hayden). Ventral view of hypotype, G.S.C. No. 10150, St. Mary River formation. (Page 62.)

Figure 9. *Lioplacodes whiteavsi* (Russell). Dorsal view of holotype of "*Goniobasis*" *whittakeri* Dyer, G.S.C. No. 6683, St. Mary River formation. (Page 67.)

Figure 10. *Lioplacodes whiteavsi* (Russell). Dorsal view of holotype, University of Alberta, collections No. Ct 377, St. Mary River formation (reprint from Russell, 1929b, Pl. I, fig. 7, reduced to natural size). (Page 67.)

Figure 11. *Lioplacodes sanctamariensis* (Russell). Dorsal view of hypotype, G.S.C. No. 10146, Edmonton formation (lower part). (Page 65.)

Figure 12. *Lioplacodes sanctamariensis* (Russell). Ventral view of hypotype, G.S.C. No. 10145, St. Mary River formation. (Page 65.)

Figure 13. *Lioplacodes sanctamariensis* (Russell). Ventral view of hypotype, G.S.C. No. 10144, St. Mary River formation. (Page 65.)

Figure 14. *Lioplacodes sanctamariensis* (Russell). Ventral view of hypotype, G.S.C. No. 10143, St. Mary River formation. (Page 65.)

Figures 15a, 15b. *Lioplacodes tenuicarinata* (Meek and Hayden). Dorsal views, 15b x2, of hypotype, University of Alberta collections No. Pa 103, Paskapoo formation. (Page 66.)

Figures 16a, 16b. *Lioplacodes tenuicarinata* (Meek and Hayden). Dorsal views, 16b x2, of hypotype, University of Alberta collections No. Pa 102, Paskapoo formation. (Page 66.)

Figure 17. *Lioplacodes nebrascensis nebrascensis* (Meek and Hayden). Ventral view of hypotype, University of Alberta collections No. Pa 102, Paskapoo formation. (Page 63).

Figure 18. *Lioplacodes nebrascensis nebrascensis* (Meek and Hayden). Dorsal view of hypotype, G.S.C. No. 10157, Paskapoo formation. (Page 63.)

Figure 19. *Lioplacodes nebrascensis nebrascensis* (Meek and Hayden). Dorsal view of hypotype, G.S.C. No. 10158, Paskapoo formation. (Page 63.)

Figures 20a, 20b. *Lioplacodes nebrascensis producta* (White). Dorsal and ventral views of hypotype, G.S.C. No. 10159, Paskapoo formation. (Page 64.)

Figure 21. *Goniobasis eulimoides* (Meek). Ventral view of hypotype, G.S.C. No. 10282, Paskapoo formation. (Page 71.)

Figure 22. *Goniobasis eulimoides* (Meek). Dorsal view of hypotype, G.S.C. No. 10283, Paskapoo formation. (Page 71.)

Figure 23. *Goniobasis webbi* Dyer. Ventral view of posterior whorls showing weak sculpture, hypotype, G.S.C. No. 10161, Edmonton formation (lower part). (Page 72.)

Figure 24. *Goniobasis webbi* Dyer. Ventral view of hypotype, G.S.C. No. 10163, Edmonton formation (lower part). (Page 72.)

Figure 25. *Goniobasis webbi* Dyer. Anterior whorls of example showing prominent sculpture, hypotype, G.S.C. No. 10162, Edmonton formation (lower part). (Page 72.)

Figure 26. *Goniobasis webbi* Dyer. Dorsal view of hypotype, G.S.C. No. 10160, Edmonton formation (lower part). (Page 72.)

Plate VII

(All figures x2)

On the line drawings accompanying the photographs palatal and parietal lamellæ are represented in solid black.

Figure 1. *Grangerella mcleodensis* (Russell). Dorsal view of hypotype, G.S.C. No. 10193, Paskapoo formation. (Page 50.)

Figure 2. *Grangerella mcleodensis* (Russell). Dorsal view of specimen showing impression of upper palatal lamella, hypotype, G.S.C. No. 10191, Willow Creek formation (upper part). (Page 50.)

Figure 3. *Grangerella mcleodensis* (Russell). Basal view of specimen showing impression of basal palatal lamella, hypotype, G.S.C. No. 10192, Willow Creek formation (upper part). (Page 50.)

Figure 4. *Grangerella mcleodensis* (Russell). Ventral view of damaged shell showing aperture with basal and upper palatal lamellæ, hypotype, G.S.C. No. 10194, Porcupine Hills formation. (Page 50.)

Figures 5a-c. *Dimorphoptychia mokowanensis* sp. nov. Apical, ventral, and basal views of holotype, G.S.C. No. 10182, St. Mary River formation. (Page 47.)

Figure 6. *Dimorphoptychia mokowanensis* sp. nov. Apical view of paratype, G.S.C. No. 10183, St. Mary River formation. (Page 47.)

Figures 7a, 7b. *Dimorphoptychia mokowanensis* sp. nov. Lateral and apical views of paratype, G.S.C. No. 10199, showing impression of palatal lamella, St. Mary River formation. (Page 47.)

Figure 8. *Dimorphoptychia rutherfordi* (Russell). Apical view of slightly crushed shell showing impression of upper palatal lamella, hypotype, G.S.C. No. 10297, Paskapoo formation. (Page 48.)

Figures 9a, 9b. *Dimorphoptychia rutherfordi* (Russell). Basal and apical views of specimen showing reflected lip and impression of upper palatal lamella, hypotype, G.S.C. No. 10179, Paskapoo formation. (Page 48.)

Figures 10a, 10b. *Dimorphoptychia rutherfordi* (Russell). Apical and lateral views of hypotype, G.S.C. No. 10178, Paskapoo formation. (Page 48.)

Figure 11. *Dimorphoptychia rutherfordi* (Russell). Basal view of crushed shell showing one parietal lamella, hypotype, G.S.C. No. 10180, Paskapoo formation. (Page 48.)

Figure 12. *Dimorphoptychia* sp. cf. *D. rutherfordi* (Russell). Apical view of G.S.C. No. 10184, St. Mary River formation. (Page 48.)

Figure 13. *Dimorphoptychia rutherfordi* (Russell). Basal view of largely exfoliated shell showing two parietal lamellæ (structure in centre represents remains of Columellar insertion of lip) hypotype, University of Alberta collections No. Pa 105, Paskapoo formation. (Page 48.)

Figure 14. *Dimorphoptychia douglasi* sp. nov. Apical view of specimen showing impression of upper palatal lamella, paratype, G.S.C. No. 10308, Paskapoo formation. (Page 46.)

Figure 15. *Dimorphoptychia douglasi* sp. nov. Apical view of paratype showing reflected lip, G.S.C. No. 10176, Paskapoo formation. (Page 46.)

Figure 16. *Dimorphoptychia douglasi* sp. nov. Apical view of specimen showing well-developed spiral sculpture, paratype, G.S.C. No. 10175, Paskapoo formation. (Page 46.)

Figure 17. *Dimorphoptychia douglasi* sp. nov. Basal view of specimen showing convex face of lip, paratype, G.S.C. No. 10177, Paskapoo formation. (Page 46.)

Figure 18. *Dimorphoptychia douglasi* sp. nov. Lateral view of specimen showing reflected lip and retractive labral profile, paratype, G.S.C. No. 10198, Paskapoo formation. (Page 46.)

Figures 19a, 19b. *Dimorphoptychia douglasi* sp. nov. Apical and basal views of specimen showing impressions of lower and middle palatal lamellæ, holotype, G.S.C. No. 10310, Willow Creek formation (upper part). (Page 46.)

Figure 20. *Dimorphoptychia douglasi* sp. nov. Lateral view of specimen showing upper and middle palatal lamellæ, paratype, G.S.C. No. 10309, Willow Creek formation (upper part). (Page 46.)

PLATE VII

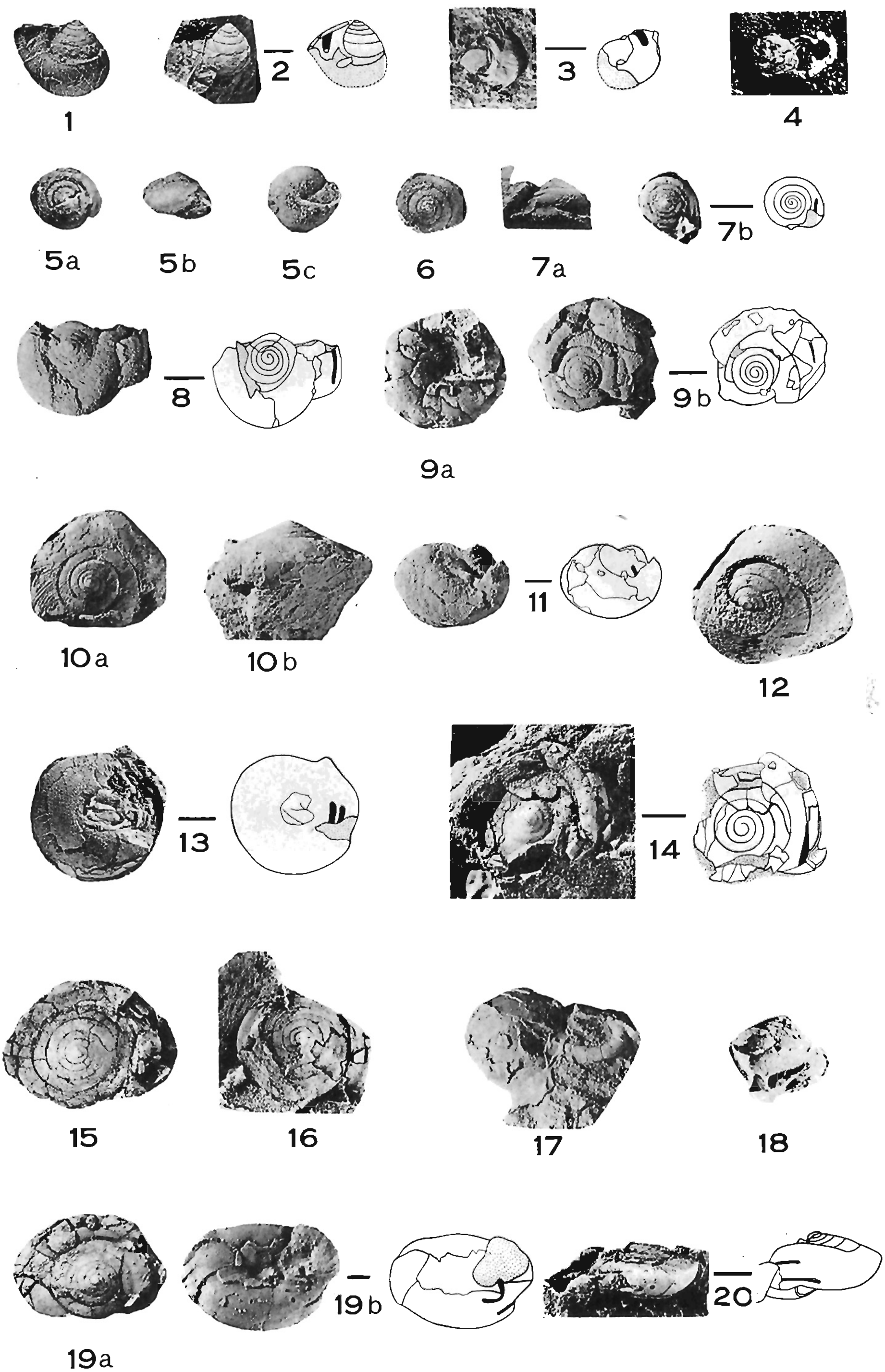
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PLATE VIII

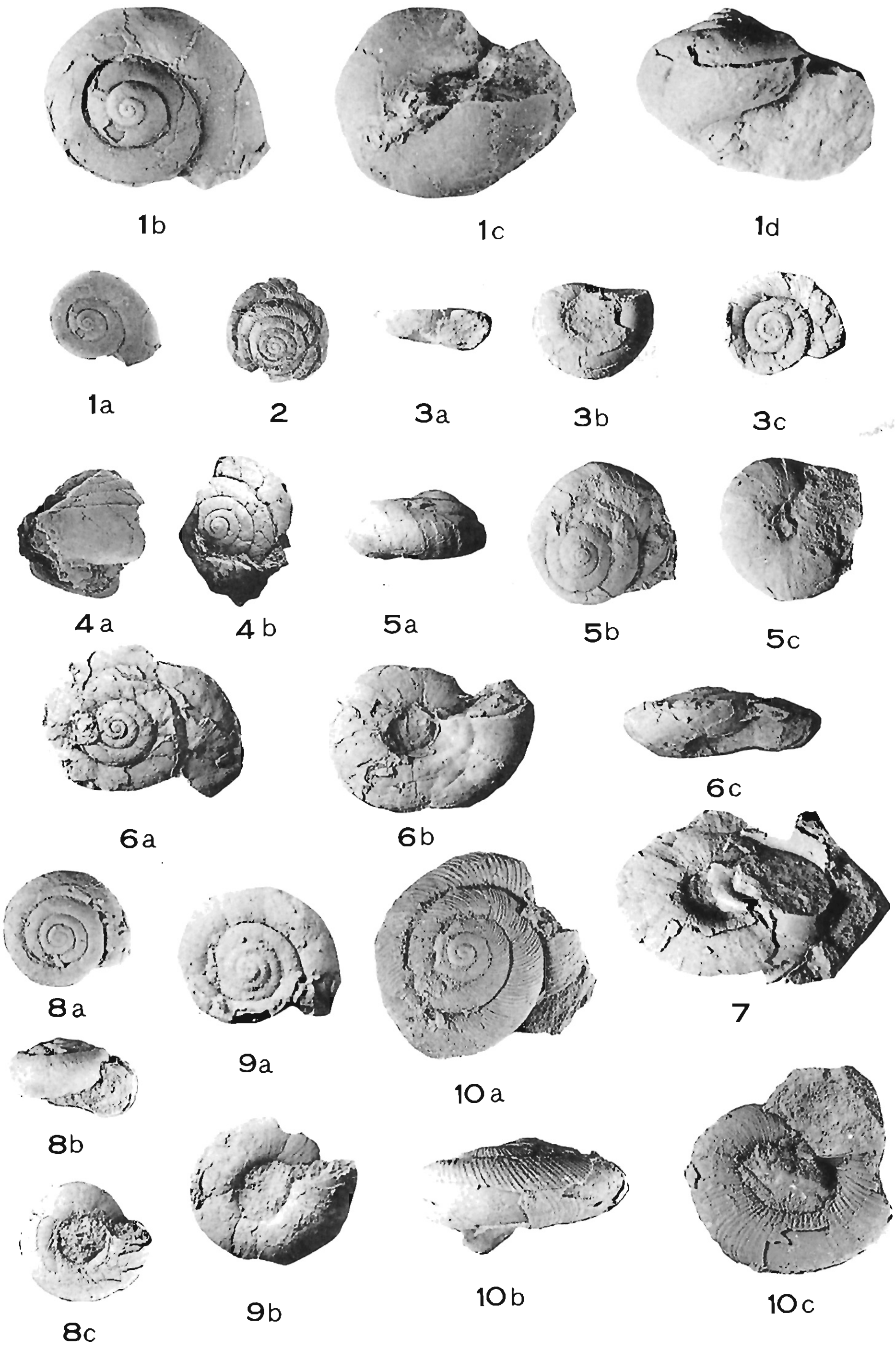
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PLATE VIII

(Figures natural size unless otherwise stated)

Figures 1a–1d. *Glypterpes rotundata* (Russell). 1a, apical view (x1),1 b–1d, apical, basal, and ventral views (x2) of hypotype, G.S.C. No. 10164, Paskapoo formation. (Page 77.)

Figure 2. *Discus sandersoni* (Russell). Apical view of holotype, University of Alberta collections No. Ct 388. (x2) (Page 85.)

Figures 3a–3c. *Oreohelix angulifera* (Whiteaves). Ventral, basal, and apical views of hypotype, G.S.C. No. 10165, St. Mary River formation. (x2) (Page 78.)

Figures 4a, 4b. *Oreohelix thurstoni* (Russell). Lateral and apical views of hypotype, G.S.C. No. 10167, Willow Creek formation (upper part). (Page 79.)

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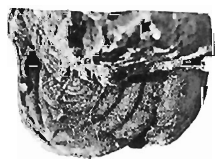
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