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GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

PAPER 64-33

SUB-FAIRHOLME DEVONIAN ROCKS OF THE EASTERN FRONT RANGES, SOUTHERN ROCKY MOUNTAINS, ALBERTA

(parts of) 82 NW, 82 NE and 83 SW, 83 SE

(Report, appendix and 10 figures)

J. D. Aitken

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ABSTRACT

The type section of Walcott's Ghost River Formation embraces the upper, dolomite half of the Middle Cambrian Pika Formation, the Middle or Upper Cambrian Arctomys Formation, the Upper Cambrian Lynx Formation, and only five feet of basal Devonian beds. Thick plant-bearing Devonian red beds occupying a nearby channel were not described by Walcott. Because the name Ghost River (as a Cambrian Formation) is redundant, and because of the confusion surrounding it, further use of the name is not recommended.

The name Yahatinda Formation is proposed for basal Devonian, partly red, continental to marine-littoral beds which overlie irregular topography developed on a profound regional unconformity. Evidence of age from fossil plants conflicts with that from fossil fishes, but a Middle Devonian age appears probable.

Several lines of evidence suggest that the upper contact of the Yahatinda Formation with the overlying solution-breccia-bearing basal member of the Fairholme Group is disconformable.

SUB-FAIRHOLME DEVONIAN ROCKS OF THE EASTERN FRONT RANGES, SOUTHERN ROCKY MOUNTAINS, ALBERTA

INTRODUCTION

THE "GHOST RIVER PROBLEM"

The name "Ghost River Formation" was given by Walcott (1921)[1] to "285 feet (86.8 m.) of thin-bedded and shaly, buff-coloured magnesian limestones lying conformably between the Middle Cambrian limestones beneath (Cathedral Formation) and the superjacent Devonian beds ..." (Walcott, 1923, p. 464). He did not assign a definite age to the Ghost River Formation, and his writings contain partly contradictory suggestions as to its age. On the one hand, in both 1923 and 1928 he treated the Ghost River Formation under the major heading "Devonian", but nowhere in the text repeated the apparent assignment to the Devonian. On the other hand, his statement that "... (the Ghost River Formation is) ... the only representative of 23,960 feet (7,303.0 m.) of strata that occurs in the Kicking Horse Pass section ..... between the Cathedral[2] limestones and the Devonian" (ibid.) implies a pre-Devonian, largely Cambrian age for the formation. Again, Walcott was clearly in doubt about the stratigraphic age and relationships of his Ghost River Formation when he wrote (ibid.): "The interval between the Cambrian and Devonian along the line of the present Rocky Mountains front was largely one of non-deposition, as the evidence of erosion along the several miles of exposure of the contact between the magnesian limestones of the Ghost River Formation and the Cambrian beneath <u>and the Devonian above</u> on Ghost River is almost negligible" (author's italics). Finally, in his last, posthumously published work on the subject, Walcott (1928, p. 259), writing of the stratigraphic section at Ghost River, says: "Between the Devonian and the Cambrian, the thin Ghost River formation ..... (occurs). No traces of the Ozarkian (Mons) were observed and there is no evidence of it having been removed by erosion. It is barely possible that the magnesian limestones of the Ghost River formation were deposited in Upper Cambrian time, but as stated previously, there is no

---

[1] Names and/or dates in parentheses refer to publications listed in the References.

[2] This quotation and those that follow should be read in the context that Walcott had failed to recognize at Ghost River the Middle Cambrian Eldon Formation, erected by him some years earlier (Eldon and Pika of this paper). In fact the Eldon Formation is present in typical lithofacies, and in a thickness only moderately reduced from that of the type section, as recognized by Fitzgerald (1962b), but Walcott miscorrelated it with the pre-Eldon, Middle Cambrian Cathedral Formation.

proof for this view. The outstanding stratigraphic feature of this area is the absence of Silurian, Ordovician, Ozarkian, and some Upper and Middle Cambrian formations that are so well developed in the Sawback Range and the western side of the Rocky Mountains generally."

No complete and detailed regional study of the strata lying between the long-recognized thick Middle Cambrian carbonates and the much-studied Upper Devonian Fairholme bituminous, fossiliferous carbonates has ever been made in the Front Ranges. A literature of local observations on the Ghost River Formation has accumulated, some authors placing the formation in the Devonian and others placing it in the Cambrian. DeWit (1956b) stated that the type "Ghost River" embraced strata of Cambrian age in its lower part and strata of Devonian age in its upper part, these being separated by a major unconformity which Walcott did not recognize. This important conclusion has not received the attention it deserved, and references to the Ghost River Formation have continued to appear without qualification, as if it were a valid and uncontroversial formation as defined by Walcott.

The history of stratigraphic and nomenclatural confusion with regard to the problem of the Ghost River Formation is partly summarized in Figure 2. The sources of this confusion may be listed as follows:

(a) Walcott's failure to recognize at Ghost River, on grounds of lithology and sequence of lithologic units, greatly thinned equivalents of the Cambrian formations which he had previously established in the Main Ranges.

(b) Walcott's failure to describe clearly and in detail the location of the type section and the strata to be found there.

(c) Widespread paraconformity[1] between Devonian and pre-Devonian strata.

(d) Paucity of fossils in basal Devonian strata, and near absence of fossils in Upper Cambrian strata along much of the Mountain Front[2].

(e) Lack of familiarity (on the part of several of the authors on this subject) with pre-Devonian stratigraphy of the region.

---

[1] Paraconformity is defined as the relationship in which an unconformity is represented only by a bedding plane (Dunbar and Rodgers, 1957, p. 119).

[2] The term "Mountain Front" is here used in referring to the eastern limit of the Rocky Mountain Front Ranges.

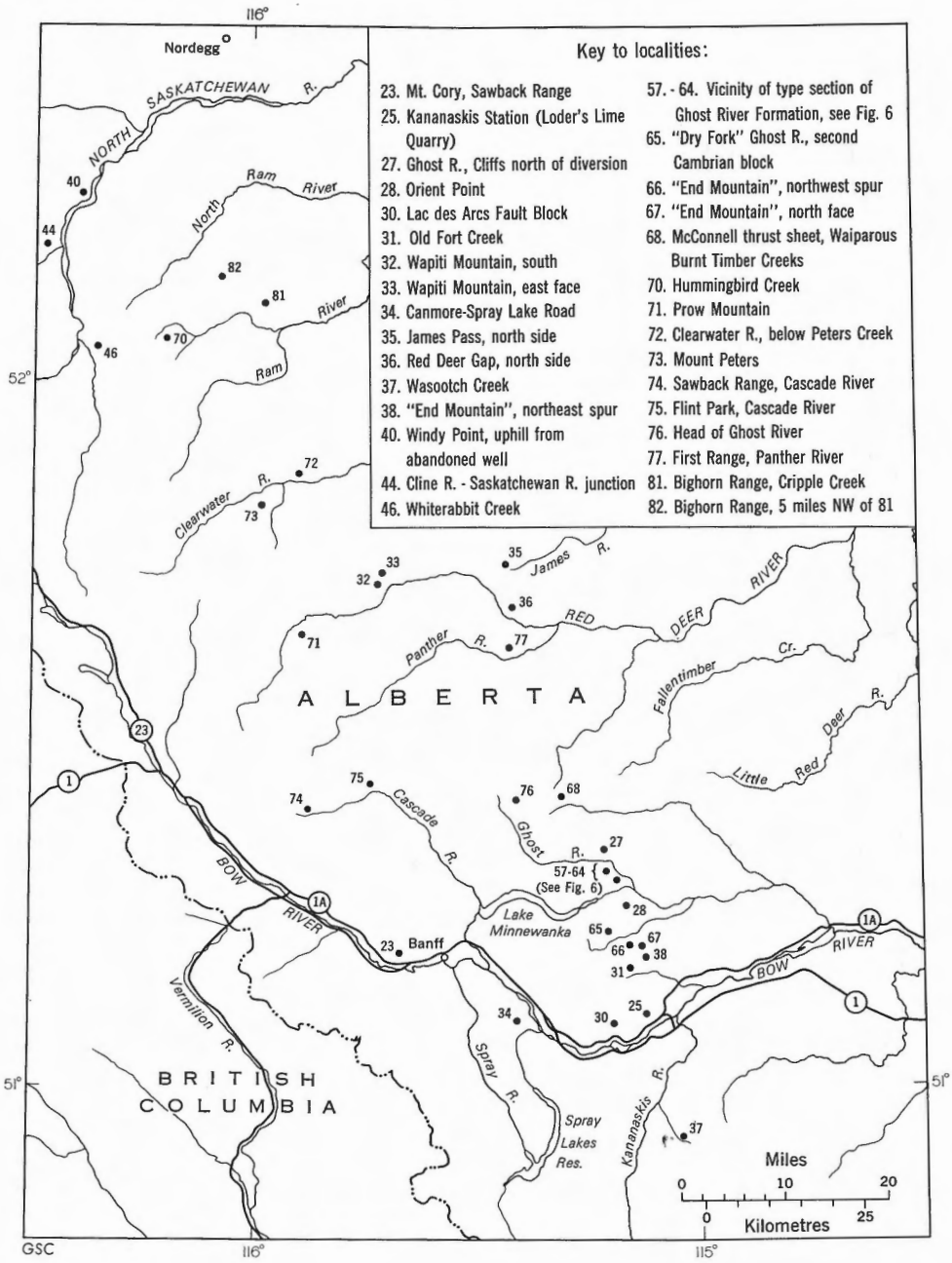

Figure 1. Localities at which basal Devonian and subjacent strata were examined

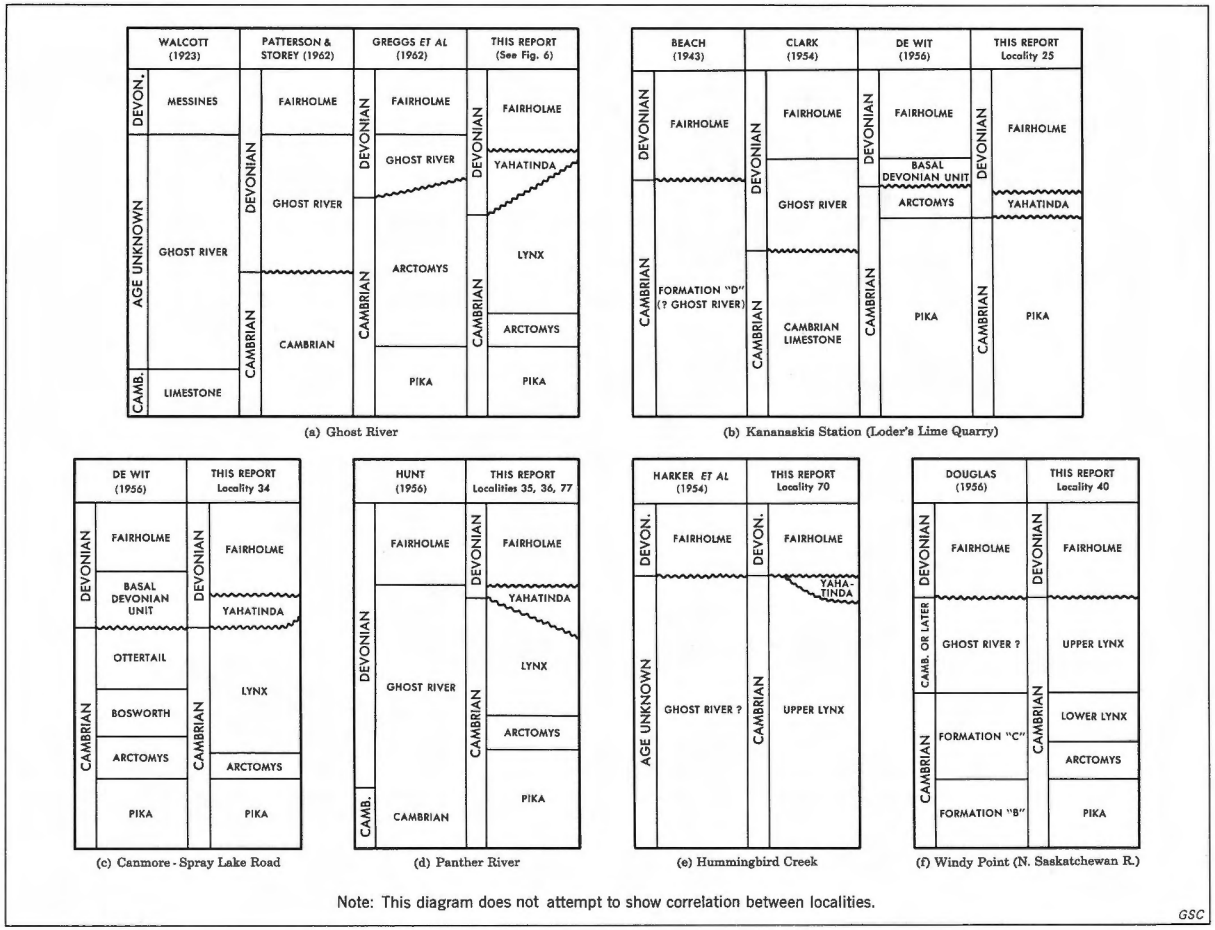

Figure 2. Nomenclature and stratigraphic concepts of various authors at selected localities

(f) Acceptance by some authors of geometric relationships suggestive of angular unconformity as conclusive evidence of unconformity, and as adequate criteria for identifying the base of the Devonian.

(g) Lack of re-study of the type section of the Ghost River Formation and nearby outcrops, and failure of several authors to attempt to relate their observations of the Ghost River to the type section.

(h) A paucity of detailed descriptions of strata assigned to the Ghost River Formation at different localities.

As part of a regional study of pre-Devonian strata, the writer has examined beds immediately above and below the sub-Devonian unconformity at a large number of localities in the Front Ranges, from Little Elbow River in the south to North Saskatchewan River in the north (see Fig. 1). This study has confirmed that the type section of the Ghost River Formation is, except for a few feet of poorly exposed Devonian rocks at the top, which Walcott may not have seen, a section of Cambrian rocks readily correlated with formations named and much more fully developed in the Main Ranges. At other localities, the name "Ghost River" has been applied to intervals entirely Devonian, entirely Cambrian, or both Devonian and Cambrian. The name is accordingly discarded. Nomenclature relating to the Main Ranges is applied to Cambrian rocks in the Front Ranges, and a new name, "Yahatinda Formation", is applied to pre-Fairholme rocks of Devonian age.

FIELD WORK

Pertinent field work was carried out during three weeks of each of the 1961 and 1962 field seasons, the remainder of these seasons having been devoted to the study of Cambrian and Ordovician sections in the Main and Front Ranges. Localities at which the basal Devonian and underlying strata have been examined are indicated on the index map, Figure 1.

ACKNOWLEDGMENTS

The writer acknowledges the able field assistance of R.D. Ferguson, G.E. Benson, G.F. Marlborough, A.K. Kuhme and A. Djalil Nasution. Thanks are due also to J.R. Patterson, T.P. Storey, R.G. Greggs, and E.L. Fitzgerald, for their willingness to share information and discuss problems of mutual interest. Fossil identifications were an important contribution to this report; they were made by David Dineley of the University of Ottawa (fishes) and B.S. Norford and D.C. McGregor of the Geological Survey (invertebrates and spores).

STRATIGRAPHY

SUB-DEVONIAN STRATA

Unfossiliferous rocks underlie and overlie the sub-Devonian unconformity throughout much of the area studied, and the unconformity appears only as a bedding plane in a great many exposures. Under these circumstances, correlation is based entirely on the recognition of rock units. Because the basal Devonian strata are of variable lithology, complete familiarity with both basal Devonian and pre-Devonian formations is essential in order to identify the base of the Devonian at many localities. It is therefore necessary to describe, at least briefly, those pre-Devonian formations of the region which are anywhere in depositional contact with the Devonian.

The nomenclature employed relates to formations defined in the Main Ranges. Despite the pronounced eastward thinning of the Cambrian and Ordovician successions, correlation of rock units in the Front Ranges with rock units in the Main Ranges has proved to be remarkably straightforward. However, detailed demonstration of the writer's correlations with the Main Ranges, which differ in minor respects from those of DeWit (1956b), Usher (1959), and Fitzgerald (1962a, b, c), must await presentation in a further publication.

Discussion of the ages of the pre-Devonian formations is omitted. Following Greggs (1962), the Middle Cambrian-Upper Cambrian boundary is placed within the lower division of the Lynx Formation, and the Cambrian-Ordovician boundary is placed at the base of the Mons-Sarbach (restricted).

Except in the immediate vicinity of faults and local closed folds, pre-Devonian strata in the Front Ranges have suffered no post-diagenetic alterations other than mild recrystallization, dolomitization, and local, minor silicification, as confirmed by study of a large number of systematically collected specimens under the binocular microscope. These alterations are comparable in kind and degree with those suffered by overlying Devonian strata in the same region. The specimens which are not intensely dolomitized display such features as well-preserved oolitic and pelletoid fabrics and well-preserved, delicate trilobite fragments; aphanitic (micritic) limestones form a large part of the section. The Cambrian strata therefore cannot be said to be "severely metamorphosed", as reported by Patterson and Storey (1960, p. 150), except locally, where they are dynamically metamorphosed by shearing related to Laramide deformation.

TABLE OF FORMATIONS

Era	Period or epoch	Formation and thickness (feet)	Lithology
Palaeozoic	Upper Devonian	Fairholme Group 1,000-1,400	Mainly fossiliferous limestone and dolomite; greenish grey and black shale.
	Disconformity		
	Middle Devonian	Yahatinda Formation (new name) 0-120	Dolarenite[1], dolsiltite[1], dolomite conglomerate and breccia, argillaceous dolomite, minor siltstone and sandstone; largely red beds.
	Regional Unconformity		
	Ordovician	Mons and Sarbach Formations, undifferentiated 0-1200	Limestone, dolomite, putty-coloured shale, much limestone conglomerate.
	Upper Cambrian	Lynx Formation 0-1700	Dolomite, silty and sandy dolomite, shale, limestone, minor siltstone and chert.
	Middle Cambrian	Arctomys Formation 0-210	Siltstone, silty dolomite, shale; shallow-water, evaporitic environment.
		Pika Formation 0-320	Limestone, oolitic and conglomeratic dolomite, minor shale.
		Eldon Formation 750-780	Limestone and dolomite.

[1]Dolarenite and dolsiltite here refer to clastic sedimentary rocks mainly composed of sand- and silt-sized detrital grains of dolomite.

Pika Formation

The Middle Cambrian Pika Formation (Deiss, 1939) is a moderately recessive unit of thin-bedded, argillaceous, dolomite-mottled dense limestone, overlain by dolomite, which lies between the Eldon Formation and recessive shales and yellow-weathering siltstones and silty dolomites of the Arctomys Formation. The Pika is important to the present study because (a) it is a lithologically distinctive formation of remarkably constant thickness (300-320 feet) in the Front Ranges, and (b) in most sections at the Mountain Front it contains the highest occurrence of pre-Devonian fossils.

All Pika sections in the Front Ranges display the following diagnostic characteristics:

(a) Two thin intervals of grey shale occur in the basal third of the formation. Thin beds of limestone within these shale intervals contain trilobites[1] in nearly every section examined.

(b) An upward change from thin-bedded limestone to very fine crystalline[2] dolomite of identical bedding style takes place at about the middle of the formation. In detail, the limestone-dolomite contact crosses the bedding and is demonstrably the result of post-depositional dolomitization.

(c) An upper, tan-weathering member of thin- and medium-bedded dolomite containing beds of oolite and flat-pebble conglomerate is present.

The Pika Formation corresponds roughly to Formation "D" of Beach (1943), and Formation "B" of Douglas (1956). The upper, dolomite half of the Pika in the Ghost River area was assigned to the Ghost River Formation by Walcott (1921, 1923, 1928), Clark (1954), Hunt (1956), Patterson and Storey (1960, 1962), and Fitzgerald (1962a, b, c).

---

[1] Collections from the Pika studied by B.S. Norford (GSC Localities No. 52569 to 52577 inclusive) are characterized by the presence of ? Parehmania sp. and/or ? Ithyektyphus sp. Both of these forms were identified by Norford in a collection from the type section of the Pika.

[2] See scale of crystallinity given as footnote on first page of Stratigraphic Sections.

Arctomys Formation

The Middle Cambrian Arctomys Formation (Walcott, 1920)[1] in the Front Ranges is a recessive interval of shales, siltstones, and silty dolomites. The shales are largely grey and very dark grey, displaying only to a minor extent the bright red and green coloration typical of the formation in the Main Ranges. The distinctive yellow- and orange-weathering siltstones and silty dolomites are yellow, laminated and platy, and commonly display mud-cracks, ripple-marks, and "salt hoppers" (casts of salt-crystal impressions). The formation is unfossiliferous. The Arctomys thickens northwestward from 60 feet at Ghost River to 210 feet at North Saskatchewan River.

The Arctomys Formation corresponds to the lower shaly part of Douglas' (1956) Formation "C". In the Ghost River area, it was included in the Ghost River Formation by Walcott (1921, 1923, 1928), Clark (1954), Hunt (1956), Patterson and Storey (1960, 1962), and Fitzgerald (1962b, c). DeWit (1956b) placed the base of the Arctomys at the same level as the writer, but extended the formation higher in the section. In two sections, Loder's Lime Kiln and Grotto Mountain Thrust Block, DeWit assigned to the Arctomys Formation red beds which the writer assigns, on lithologic grounds, to the basal Devonian Yahatinda Formation.

Lynx Formation

The Middle and Upper Cambrian Lynx Formation (Walcott, 1913), as restricted by Mountjoy (1962), includes all strata intervening between the top of the Arctomys Formation and the base of the Mons-Sarbach (restricted) of this report[2]. Although the name is here applied to an area remote from the type section near Mount Robson, correlation of the Lynx and the overlying and underlying formations is straightforward, by virtue of

---

[1] In this report the name is applied only to the lowermost 750 feet (866 feet by Walcott's measurement) of the type section, following the usage of Deiss (1939), Mountjoy (1962), and others.

[2] The Lynx Formation is overlain by the Chushina Formation in the vicinity of the type locality (Burling, 1955; Mountjoy, 1962). The base of the Chushina Formation is here correlated on straightforward faunal and lithological grounds with the base of the Mons-Sarbach (restricted) of this report. Greggs (1962, p. 81) makes the same correlation. Mons-Sarbach is here preferred to Chushina because of relative proximity to the type section of the Mons and Sarbach Formations, near Glacier Lake. Furthermore, the Sarbach probably embraces beds younger than any in the type Chushina.

persistence of lithologic character and stratigraphic position, and furthermore, no other published name applies to the entire interval occupied by the formation. In parts of the Main Ranges the stratigraphic interval correlative with the Lynx Formation is readily divisible into five formations by distinguishing recessive, shaly rock-units from cliff-forming, limestone rock-units (Walcott, 1928; Greggs, 1962). At the Mountain Front, the lower two of these formations, Greggs' Waterfowl and Corona, are recognizable but are too thin to be mapped individually. Together, they are here informally designated the lower division of the Lynx Formation. The remainder of the Lynx Formation, equivalent to Greggs' Mount Synge, Bison Creek, and Mistaya Formations, cannot at present be subdivided at the Mountain Front, and is here informally designated the upper division of the Lynx Formation, or upper Lynx.

Lower division

The lower Lynx consists of a lower, cliff-forming member, and an upper, recessive member. The lower member, 50 to 93 feet thick at the Mountain Front, consists of dolomitic siltstones and silty and minor sandy dolomites. A 1- to 2-foot shale bed, 10 to 12 feet above the base of the unit is a useful marker horizon in the Ghost River region. The uppermost 12 to 15 feet of the unit contains light-coloured masses of chert which commonly preserve the pelletoid, calcarenitic, and locally oolitic fabric of the replaced limestone; this cherty zone is an unmistakable marker horizon from Ghost River northwestward to James Pass.

The upper, recessive member is 23 to 270 feet thick at the Mountain Front and is mainly grey and greenish grey shale, interrupted in the southeast by thin beds of dolomite, and in the northwest by very thick beds of calcarenitic and oolitic limestone, locally dolomitized. Large bun-shaped stromatolites are a prominent feature of the recessive member in the thicker sections.

The limestones of the upper, recessive member of the lower Lynx have yielded the only post-Pika, pre-Devonian fossils found along the Mountain Front within the area studied. Erdman (1946) and McLaren (reported in Douglas, 1956) collected Upper Cambrian trilobites from beds apparently correlative with the upper member of the lower Lynx, at localities not visited by the writer. Collections from three different beds in the Windy Point section (No. 40) were examined by B.S. Norford, who reports the presence of the following fauna, indicative of the early Upper Cambrian *Cedaria* zone:

Arapahoia aff. *A. snowiensis* Howell and Duncan
Arapahoia cf. *A. aspinosa* Lochman
Kormagnostus simplex Resser

Cedarina cf. C. cordillerae (Howell and Duncan)
Clavagnostus sp.
? Coosella sp.

The fauna thus substantiates the rock-unit correlation, because Greggs' (1962) Corona Formation also falls within the Cedaria zone (see above).

Upper division

The upper Lynx consists, in the area of study, of a thick, very monotonous, cliff-forming succession of unfossiliferous dolomite beds, generally grey in colour, with some pink, red, and purple tints, either as overall colours or mottling especially in the upper parts of the unit. Crystallinity varies from (rarely) aphanitic to (rarely) medium crystalline[1]. Silty to very silty dolomites occur in most sections in the lower part of the unit, and siltstones are prominent near the base along the Mountain Front. One or more beds or zones of sandy dolomite and/or dolomitic sandstone occur in many sections of the upper Lynx, but are not consistent as to stratigraphic position. Oolitic dolomite occurs in a number of sections; its marker value is at best only locally applicable. Small chert masses and thin chert beds appear in most sections of the upper Lynx; their distribution apparently is independent of stratigraphic position. Argillaceous, aphanitic dolomite, commonly purple or purple-mottled, occurs in a number of sections but is inconsistent as to stratigraphic position within the upper Lynx.

The upper division of the Lynx Formation has been removed by erosion in the easternmost ranges at Bow River and southward. Northwestward along the Mountain Front it is overlain unconformably by Devonian rocks (Figs. 3, 4). Farther west, it is overlain conformably by Ordovician Mons-Sarbach, undifferentiated. At Mount Cory in the Sawback Range (Locality 23), where the three-part subdivision of the Main Ranges is evident, equivalents of the upper Lynx total 1,370 feet. The interval thins rapidly eastward (Fig. 3); the maximum thickness observed along the Mountain Front in the area studied is 280 feet, at Windy Point (Section 40).

The Lynx Formation in the Ghost River area has been included in the Ghost River Formation by Walcott (1921, 1928), Clark (1954), Hunt (1956), Patterson and Storey (1960, 1962), and Fitzgerald (1962a, c). The beds described as "Ghost River?" by Harker et al. (1954) at Hummingbird Creek and Cripple Creek, and by Douglas (1956) at Windy Point, are here assigned to the upper division of the Lynx Formation. DeWit (1956b) used the names Bosworth and Ottertail Formations for beds in the Canmore-Spray Lakes road section here referred to the Lynx Formation (upper and lower divisions).

[1] See scale of crystallinity given in footnote on first page of Stratigraphic Sections.

Recognition of the Lynx Formation, especially its upper division, is very necessary for a correct interpretation of the pre-Fairholme history of the Front Ranges, inasmuch as beds so designated in this report have been repeatedly assigned to the Ghost River Formation of uncertain, possibly Devonian age. Correlation of the upper Lynx from the Main Ranges eastward to the Mountain Front is based on lithologic similarity and stratigraphic sequence. In the western Front Ranges, a thick, monotonous, unfossiliferous cliff-forming dolomite unit, the upper Lynx, underlies the distinctive, fossiliferous, Ordovician Mons-Sarbach. At the Mountain Front, where the Mons-Sarbach is missing by erosion at the sub-Devonian unconformity (Fig. 3), a thick, monotonous, unfossiliferous, cliff-forming sequence subjacent to the Fairholme Group and superjacent to the lower Lynx must be assigned to the upper Lynx, unless a similar unit of Devonian age is known to exist, which is not the case. Elsewhere in this report it is shown that the demonstrably Devonian, pre-Fairholme Yahatinda Formation not only is lithologically distinct from the upper division of the Lynx Formation, but also lacks the regional persistence and uniformity of lithologic character of the upper Lynx.

Mons and Sarbach Formations, Undifferentiated

The Ordovician Mons and Sarbach Formations (Walcott, 1920) are here treated as a single rock unit because of the very gradual transition between them which prevents the delineation of an objective contact. The base of the unit as considered here is of necessity raised to the base of Walcott's (1928) unit 1a of the type section, a widely recognizable greenish-grey-weathering shale, because the Lynx Formation includes at its top a thick limestone unit, Walcott's unit 1b, which was included in the type Mons. This restriction of the Mons-Sarbach results in the base being raised from a horizon not identifiable in the eastern Front Ranges to one of the most easily recognized and widespread lithologic contacts in the southern Rocky Mountains, which is the base of the Mons sensu North and Henderson (1954).

The Mons-Sarbach, undifferentiated, consists in the Front Ranges of a thin basal unit of putty-coloured calcareous shales with thin beds of grey limestone (locally dolomite) and an abundance of beds of flat-pebble limestone conglomerate ("Mons" part), overlain gradationally by a thick unit of thin-bedded limestone with subordinate shale interbeds and an abundance of limestone conglomerates and stromatolites ("Sarbach" part). Fragments, chiefly large genal spines, of large smooth asaphid trilobites[1] are found in the Mons-Sarbach at a number of localities.

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[1] GSC Localities Nos. 51995, 51996, 51997, 52000, identified by B.S. Norford.

"Ghost River Formation" (Obsolete)

Type Section

Walcott made only one explicit reference to the location of the type section of his Ghost River Formation (1923, p. 463): "(The type locality is) ..... in the first small canyon south of Ghost River canyon and opening on Ghost River as the river bends to the south." Unfortunately, contradictory implicit references to the location of the type section, embodied in captions of illustrations published posthumously in 1928, have created confusion.

On the one hand, Plate 27 (1928) is a photograph of the locality designated in 1923 as the type section of the formation but it is not identified by caption as illustrating the "type section". The fact that a stratigraphic section was indeed measured at the locality shown in Plate 27 is confirmed by the caption of Walcott's sketched section for the Ghost River area, Figure 24, which states that "(Fig. 24) ..... is based on the measured section up to the Devonian, illustrated in ..... plate 27".

On the other hand, another photograph, Plate 28, showing a nearby locality topographically similar to that illustrated in Plate 27, and by implication doubtless also intended to illustrate this same locality, is clearly misidentified. Whereas the caption states, in part: "The stratigraphic section was measured on the right side of the small stream flowing into the river from the west", the stream actually shown in Plate 28 is in the second, not the first canyon opening on Ghost River as it bends to the south (see above), and the type locality specifically designated in 1923 does not appear in the photograph. This conclusion can be verified by examination of the outcrops along both of the streams in question. The right side of the stream in Plate 28, being a wooded slope almost devoid of outcrop at the level of the Ghost River Formation, is an unlikely choice for a type section. Furthermore, if Walcott had measured the good outcrops in the bed of this stream, he would have seen and noted a 7- to 12-foot-thick boulder conglomerate with red mudstone matrix at the base of the Devonian. Moreover, the exposures (Section 62, Fig. 6) on the right side of the stream[1] designated in 1923, which appear in the centre of Plate 27 (1928), correspond in thickness and general lithology to Walcott's extremely generalized description of the type section (1923, p. 464)[2].

---

[1] The exposures along a vertical line pass through Walcott's symbol "G" (Plate 27, 1928).

[2] To compound the confusion, his most complete description (1928, p. 261) of the formation is not, apparently, a description of the type section, but of another section overlooking Devil's Gap.

These exposures provide virtually the only sub-Fairholme section, among the six reasonably well exposed sections in the drainage basins of the two streams in question, which Walcott could have examined without seeing red beds (Devonian Yahatinda Formation), which he does not mention. It is therefore concluded that the type section is the section shown in Walcott's Plate 27 (1928).

Fitzgerald (1962b) re-described the section identified above as the type section of the Ghost River, but being misled by the erroneous caption of Plate 28 (1928), concluded that his section was not the type section.

Strata Included in Type Section

The type section of the Ghost River Formation includes strata readily assignable, on the basis of lithology and sequence of lithologic units, to the upper, dolomite part of the Pika Formation, the Arctomys Formation, and the lower and incomplete upper divisions of the Lynx Formation (Figs. 3 and 4). The recognition of these rock units is confirmed by (a) the trilobites occurring in the Pika Formation, a short distance below the base of the type Ghost River, (b) the presence of abundant "salt hoppers" in the Arctomys, and (c) the correlation, via intervening sections, of the upper, shaly member of the Lower Lynx with a similar unit containing Upper Cambrian trilobites, in a similar sequence above fossiliferous Pika beds at North Saskatchewan River; to this correlation there exists no reasonable alternative (Fig. 4).

The Lynx Formation is overlain, in the type section of the Ghost River, by only 5 feet of grey, purple-mottled argillaceous dolomite of Devonian age (Yahatinda Formation), which neither Walcott nor Fitzgerald described. The type Ghost River Formation, therefore, is composed of Cambrian strata for which, with the exception of Pika, previously published formation names have priority.

The application ("restriction") (by Greggs et al., 1962) of the name "Ghost River" to channel-filling Devonian red beds (Yahatinda of this report) which outcrop 300 yards south of the type section (Fig. 6) is improper, because Walcott did not include these beds in his type section. It is inconceivable that he would have failed to describe these plant-bearing, partly conglomeratic red beds, if he had intended to include them in his type Ghost River. Indeed, there is no suggestion that he knew of their existence.

DEVONIAN STRATA

Yahatinda Formation

Origin of Name and Type Section

The formation is named in reference to Ya-Ha-Tinda[1] Ranch, which occupies the north side of the valley of Red Deer River east of the eastern boundary of Banff National Park. The type section of the formation is visible from the vicinity of the ranch buildings.

The type section of the Yahatinda is hereby designated as the conspicuous, lens-like section (No. 33 of this report, see Appendix) of mainly red, channel-filling beds on the east face of Wapiti Mountain, lat. 51°44', long. 115°43 1/2', just above timber-line. The channel occupied by the Yahatinda beds is 118 feet deep and 300 to 400 yards wide; it was eroded in the upper division of the Cambrian Lynx Formation and is a fine demonstration of the sub-Devonian unconformity.

The less well exposed, but more accessible section (No. 61 of this report) of the Yahatinda Formation, found about 300 yards south of the type section of the Ghost River Formation, in NE 1/4, sec. 16, tp. 27, rge. 9, 5th mer., is hereby designated a supplementary reference section.

Distribution and Thickness

The Yahatinda Formation is present more or less continuously along the Mountain Front from Bow River in the south to James Pass in the north (Fig. 4). Throughout much of the corresponding interval in the Second Range, it is missing, except for isolated channel-fillings such as the type section. On Bow River, the formation is present in widely separated exposures as far west as Canmore. The area in which the Yahatinda is more or less continuously distributed thus appears as a vaguely defined belt oriented north-south through the eastern end of Lake Minnewanka (Fig. 5). Fish-bearing red beds at Mount Joffre, 38 miles south of Locality 30 (Fig. 1), reported by D.R. Wilson (quoted in Patterson and Storey, 1960, p. 152), may belong to the Yahatinda Formation[2]. If so, the Mount Joffre occurrence represents a further extension along the trend of the above-mentioned belt. On either side of the main area of occurrence, the

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[1] This means "mountain prairie" in the Stoney tongue. The spelling has been changed in the formation name because of the awkwardness of hyphenated geological proper nouns.

[2] This locality was examined by the writer in 1963. The red beds are assigned, on the basis of lithology, position, and the contained fish remains, to the Yahatinda Formation.

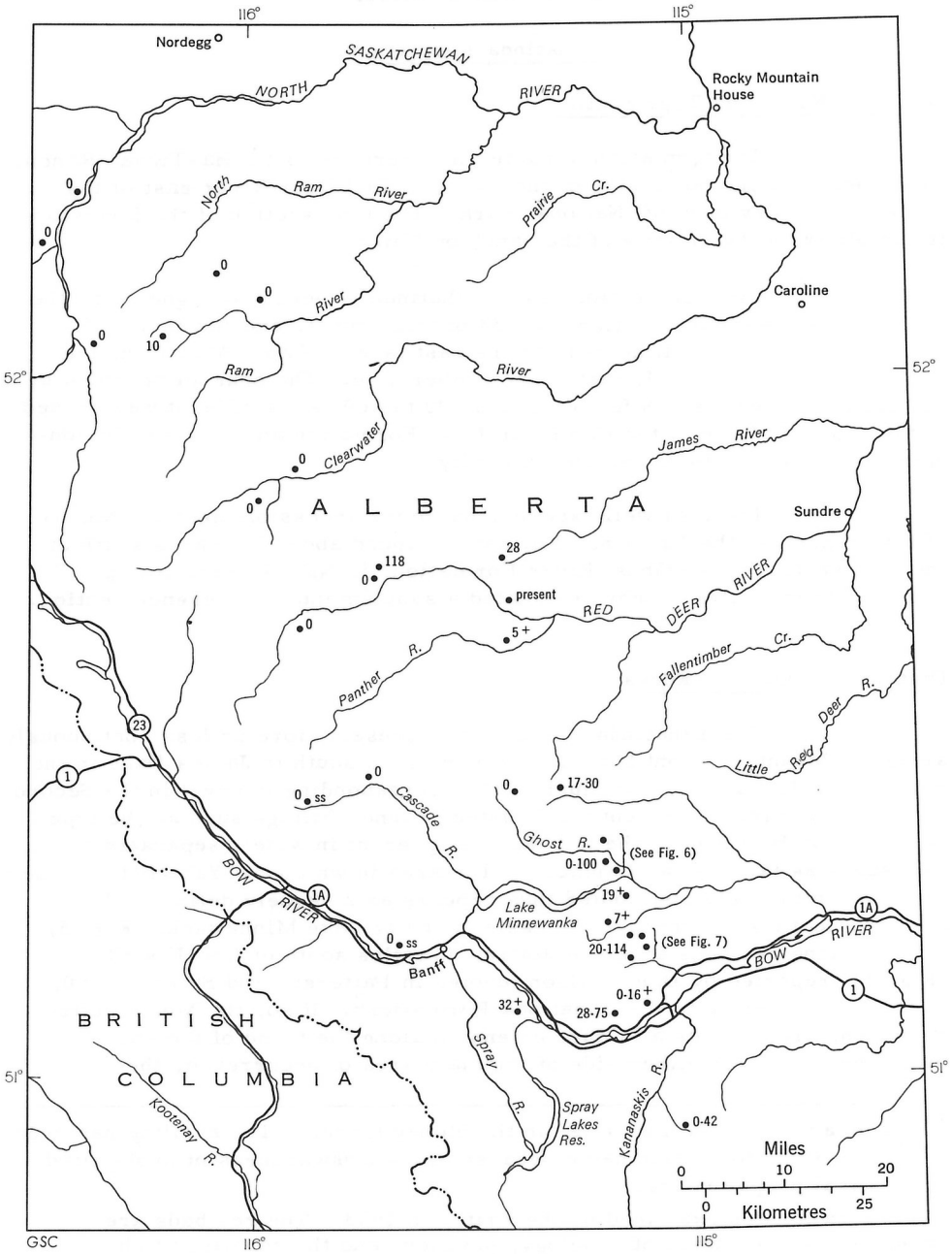

Figure 5. Measured thicknesses of Yahatinda Formation. "SS" denotes presence of sandstone and/or sandy carbonates at the base of Fairholme Group

formation is found only in local, widely separated bodies, most or possibly all of which are the fillings of erosional channels in the sub-Devonian surface. To discover all of these isolated occurrences would require detailed mapping of the base of the Devonian throughout the area of study, a task beyond the limits of practicability for present purposes.

Overlying as it does an erosional surface of appreciable local relief, the Yahatinda varies rapidly in thickness (Figs. 6, 7, 8, 9). The maximum measured thickness, 118 feet, is in the axis of the channel at the type section; the formation thins to disappearance within a few hundred yards north and south of the type section.

Lithology

The varied lithology of the Yahatinda Formation is described, for the sake of clarity, in terms of two lithologic facies, the "channel" and "non-channel" facies, which tend to be laterally and vertically distinct from one another, although linked by a transition which is gradual in some instances and abrupt in others.

"Channel" Facies. The "channel" facies occupies the deeper parts of the more pronounced of the sub-Devonian channels. Its characteristic lithology is dolarenite[1] and dolsiltite[1], normally purple-red to pink in colour, but also light grey, white, greenish white, and mottled. Abundant evidence (bleaching of red along fractures, embayed remnants of red in a white field) shows that the light-coloured strata mostly are bleached red strata. The dolarenites and dolsiltites are almost invariably argillaceous, generally silty, and locally sandy. The presence or absence of quartz silt and sand can in most instances be related to the presence or absence of these particles in the underlying Cambrian rocks. Rare grains of glauconite are present in many specimens. Some dolarenites are pebbly, and intergrade with the conglomerates and breccias described below. Occurrences of fish fragments and of hematite-replaced woody plant remains known to the writer are almost entirely limited to dolarenites of the "channel" facies. At one section only (No. 27), a bed of dolarenite with brachiopod or molluscan fragments is present.

Conglomerates and breccias occur in most outcrops of the "channel" facies. The rounded to angular, pebble- to boulder-sized clasts consist almost entirely of dolomites relatable to the underlying Cambrian beds, although clasts derived from the Yahatinda Formation itself are also locally present. The matrix is dolarenite. Clasts of chert and quartzite

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[1] These uncommon rocks (see footnote to Table of Formations) were identified by binocular-microscope examination, and the identification was confirmed in thin sections cut from representative specimens.

(silicified siltstone) are present in significant amount only where these materials are present in the vertically or laterally adjacent Cambrian beds. Purple-red, argillaceous, dolomitic siltstone occurs in most "channel" sections, and is an important constituent of several. Grey and yellow-grey dolomitic siltstone containing layers of reed-like plant impressions (Greggs et al., 1962, Fig. 1b; Patterson and Storey, 1962, Fig. 2) was observed only at the type section and Section 61 of this report. Sandstone, light grey and yellow-grey, fine- and very fine-grained, dolomitic, grading to sandy dolomite, was observed in important amount only at the type section. The "channel" facies characteristically occurs in lenticular thin and medium beds; crossbedding and scour-and-fill structures are prominent. Mud-cracks are present in some places.

"Non-channel" Facies. The "non-channel" facies of the Yahatinda Formation is characteristic of the thinner, laterally persistent sections of the formation which bear no obvious relationship to the abrupt sub-Devonian channels, and of the upper parts of channel-filling sections. Red and purple beds, and beds mottled by these colours, are present in the "non-channel" facies, but olive-green, greenish grey, and grey are generally more prominent. Dolarenite, dolsiltite, and siltstone similar to those of the "channel" facies are commonly present, either as red or as non-red beds. Conglomerate and breccia normally occur only at the base of "non-channel" sections. Prominent in these sections are thick massive beds of dolomite, grey and green-grey, yellow-weathering, very fine crystalline, argillaceous, commonly silty[1]. These beds are at least partly dolsiltites. The more argillaceous representatives intergrade with soft, crumbly dolomitic mudstones in medium and thick beds. Weakly developed, roughly hemispherical stromatolites, 1 foot and less in plan diameter, occur here and there in the argillaceous dolomites of the "non-channel" facies. Stromatolites composed of grey aphanitic limestone, which occur in Section 66, are the only limestones assigned to the Yahatinda Formation.

The "non-channel" facies is generally medium- to thick-bedded and massive. Thin-bedded, flaggy to shaly beds occur locally. Mud-cracks are present in a number of sections.

Contact Relations

Basal Contact. The Yahatinda Formation overlies an obviously weathered and eroded surface at most sections in which its base is

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[1] Certain individual beds of the grey Yahatinda dolomites are indistinguishable by routine examination from certain Cambrian Lynx dolomites. These, fortunately, generally occur interbedded with strata characteristic of the Yahatinda.

exposed. At the Canmore-Spray Lake Road section (Section 34), for instance, the lowest, conglomeratic beds of the Yahatinda in part terminate against, and in part drape across a 6-foot erosional "scarp". Solution-enlarged joints in subjacent upper Lynx dolomite lead to solution pockets; both joints and pockets are filled with light green earthy argillaceous dolomite.

At Old Fort Creek (Section 31), a 3-foot-thick lower Lynx dolomite bed resistant to weathering gradually disappears over a distance of about 200 feet at the slightly channelled, locally conglomeratic base of the Yahatinda. The next-underlying bed is brecciated and locally stained red. Solution cavities, locally filled with purple-red claystone, are present in this bed; the overlying, resistant bed has sagged upon partial collapse of the cavities.

In the general vicinity of the type section of the Ghost River Formation (Fig. 6), the beds beneath the Yahatinda are riddled with fissures filled with red and green dolomitic mudstone continuous with the basal bed of the Yahatinda. Certain of the subjacent Lynx dolomites are stained red or orange, but others have resisted staining. Shales of the Lynx Formation, normally grey, are purple-red wherever in proximity to the base of the Yahatinda[1]; this is interpreted as a weathering effect at the unconformity.

At James Pass (Locality 35), red-stained small solution-openings extend downward to a maximum of 20 feet below the base of the Yahatinda. The crystalline fabric of the underlying dolomite has been loosened, and green clay locally has been introduced into the intercrystalline voids, producing a fabric nowhere displayed by Lynx dolomites stratigraphically remote from the sub-Devonian unconformity. Vaguely defined "pipes" of green- and orange-stained dolomite collapse-breccia extend downward from the unconformity. At the contact, a locally red-stained, 3-foot bed of dolomite, which here is the highest Cambrian bed, terminates abruptly in a 3-foot "scarp" buried by the Yahatinda. Dolomite boulders lie at the toe of the "scarp".

The regional structural relationship of the base of the Yahatinda to underlying strata is summarized in Figures 3 and 4, which illustrate the regional truncation of pre-Devonian strata by the base of the Devonian, hitherto described by Harker et al. (1954), and DeWit (1956b). This relationship was investigated in detail at several localities (Figs. 6, 7, 8, 9).

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[1] See Figure 6, where the colours of the shaly intervals are indicated.

For the purposes of the studies at Ghost River (Fig. 6)[1] and End Mountain (Fig. 7), a subdivision of the Lynx Formation into thin lithologic units of remarkable persistence was effected[2].

Stratification in the Cambrian is nearly parallel to stratification in the Devonian (vertical exaggeration of 21 times in the cited figures causes only a modest apparent angularity); the thickness of the Yahatinda, and the position of its base with respect to the Cambrian formations, is primarily governed by the palaeotopography of the sub-Devonian surface[3]. Failure to appreciate this relationship is presumably the cause of a recently published gross mis-correlation (Fig. 10a).

At the type section of the Yahatinda Formation the relationship of the formation to palaeotopography may be directly observed (Fig. 8). At Wasootch Creek (Fig. 9) the interval between the top of the Eldon and the base of the Cairn consists in one place of 58 feet of Cambrian Pika beds and 6 feet of Yahatinda; two tenths of a mile distant, the corresponding interval is occupied by 41 feet of Yahatinda and no Pika[4].

In summary, the Yahatinda Formation was deposited upon the deeply weathered surface of a plain interrupted, at wide intervals, by narrow stream valleys. Although regional truncation of a great thickness of older rocks underlying this plain is demonstrable by comparison of widely spaced stratigraphic sections, the discordance in attitude is, with very rare exceptions, so slight as to be imperceptible in extensive outcrops.

Fairholme-Yahatinda Contact. The demarcation of a consistent contact between the Yahatinda Formation and the overlying Fairholme Group is complicated by the extreme rarity of well-exposed

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[1] The trace of the sub-Devonian unconformity in this figure is not a true cross-section of the palaeotopography, and gives a false impression of an intensely dissected surface. This is because the stratigraphic sections are randomly situated, and intersect the walls of a deep, sub-Devonian channel. The line of section crosses the channel only once, between Sections 62 and 64.

[2] A description of these lithologic units is given in the Appendix.

[3] Note also that Belyea (1959, p. 7) suggests that the thickness of the Middle Devonian Elk Point Group in southern Alberta is partly controlled by sub-Devonian topography.

[4] This relationship, which demonstrates that the red beds are a lenticular deposit unconformable upon the Pika, confirms that the "Ghost River Formation" of Scott (1959) is not, as he concluded, the Cambrian Arctomys Formation, but a Devonian Formation, the Yahatinda.

sections across this contact, the lithologic variability of the juxtaposed formations, and the presence, in both formations, of grey dolomites which are, on the basis of routine examination, identical. Nevertheless, a contact can be drawn so as to restrict certain lithologies to one or other of the juxtaposed formations; the contact so drawn appears on detailed cross-sections to be a consistent horizon, and is taken to be the top of the Yahatinda. Lithologies confined to the Yahatinda are: (a) rocks wholly or partly red, purple, or green (some greenish grey dolomites are present in the basal Fairholme); (b) dolarenites and dolsiltites; and (c) rocks containing more than a trace of quartz silt. Lithologies confined to the Fairholme are: (a) limèstones and limestone breccias (with the single exception of stromatolites of limestone in Section 66); (b) brown crystalline dolomites; and (c) beds containing Amphipora or stromatoporoids (not usually present at the very base of the Fairholme).

Evidence suggestive of disconformity between the Fairholme and the Yahatinda is discussed elsewhere.

Origin

During the early stages of accumulation of the Yahatinda Formation, deposition took place only in the lower parts of erosional channels and valleys. In view of the detrital nature of these early sediments, absence of marine fauna, indications of shallow water, and the delimitation of areas of deposition by topography, this early deposition must have been either alluvial or marine to brackish deltaic. In at least the "channel" facies of the formation, the alternately coarse and fine texture of the sediments and the abundance of scour-and-fill structures strongly suggest fluviatile deposition. If this is the case, the rare but widespread pellets of glauconite occurring in the clastic sediments must be regarded as detrital grains derived from the underlying Cambrian strata. This tentative conclusion is reinforced by the occurrence of large fragile fish-plates, up to 10 centimeters in breadth, of which D. L. Dineley (personal communication, 1963) says, "These fossils are to all intents and purposes non-marine forms, occurring almost invariably in red-bed facies of lacustrine and fluviatile origin." These fossils are not likely to have withstood any appreciable amount of river transport (i. e. into a marine environment). Further confirmation is provided by the discovery of large delicate fragments of terrestrial plants[1] reported by Greggs et al. (1962). The authors conclude that "It is improbable that such an apparently delicate fragment could have withstood water transport for any great distance. The sedimentary environment appears to have been quiet. near-shore, shallow, and marine to brackish." In the

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[1] Similar plant fragments, none so large or so complete as those figured by Greggs et al. (1962) are present in the type section of the Yahatinda Formation.

opinion of the present writer, however, the fact that the associated "dolomites" are mainly of detrital origin makes it unnecessary to postulate any marine influences in the depositional environment of the plant-bearing beds.

The "non-channel" facies of the Yahatinda is in general finer grained and more regularly bedded than the "channel" facies, and furthermore lacks the crossbedding and scour-and-fill structures of the latter. Mud-cracks testify to temporary emergence of the surface of sedimentation. The presence of stromatolites strongly suggests a saline environment (Ginsburg, 1960). In the absence of evidence for vulcanism, glaciation, and tectonism, it is extremely unlikely that saline lakes would be created subsequent to a period of river-valley excavation and alluviation. The "non-channel" facies, i.e. the stratigraphically higher and younger Yahatinda strata, is therefore considered to have been deposited in a littoral marine environment. The history of the Yahatinda Formation thus began when dissection of emerged land was halted by a rising sea-level. Alluviation of the valleys of lowland streams was a first consequence of lowered stream-gradients; subsequently the rising sea inundated the lowland over a wide area.

Age and Correlation

Physical relationships alone (Figs. 3, 4, 6 to 9), show very clearly that the Yahatinda Formation is younger than, and unrelated to, the great depositional cycle whose record in the Main Ranges is one of almost continuous deposition from Early Cambrian to Early Silurian times (Walcott, 1928). Physical relationships also suggest that Yahatinda deposition was a local, atypical, early manifestation of Devonian sedimentation.

Palaeontological evidence of three kinds bears upon the question of the age of the Yahatinda: fish fossils, plant megafossils, and fossil spores.

Two large fish fragments sufficiently intact to permit partial identification were collected from a single locality, the broad channel filled with Yahatinda beds on the north flank of "End Mountain"[1] (Section 67, Fig. 7). These specimens were examined by D.L. Dineley, University of Ottawa, who reports them to be pteraspidiform medial discs, whose size, shape, and ornamentation suggest affinities with the later pteraspidomorphs. One specimen shows certain affinities with Pteraspis species, and its ornamentation is similar in some respects to that of the Beartooth Butte (Cyrtaspis) Protaspis. According to Dr. Dineley, both specimens strongly suggest a late Lower Devonian age, however, in view of the evidence from fossil plants and spores, and the fact that pteraspid-like fishes are now known to occur in Spitsbergen in beds assigned to the Middle Devonian,

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[1] See footnote to description of Section 38.

he is prepared to consider a Middle Devonian age as possible (personal communication, 1963).

Greggs et al. (1962) report on plant megafossils recovered from "the type section of the Ghost River Formation" (Section 61 of this report). These fossils ".... appear to have close relationships to species of a flora described by Høeg from the uppermost Middle Devonian (or possibly lowermost Upper Devonian) of Spitsbergen, and also to species described by Kräusel and Weyland from the upper Middle Devonian of Germany."

McGregor (1963 and in press) has enlarged upon the original report in Greggs et al. (1962) of spores recovered from the above locality. He reports the presence of ten genera of spores in an assemblage which, compared with data from Western Canada, New York, and Spitsbergen ".... reinforces the conclusion (based on the plant megafossils) that they are late Givetian or perhaps Frasnian", i.e. late Middle Devonian or earliest Upper Devonian. McGregor (ms. and personal communication) has identified in samples from the type locality of the Yahatinda Formation, seven genera of spores. Of these seven genera, five are present in the material from Ghost River (Section 61), and both of the spores identifiable as to species are present also in material from Section 61.

From the foregoing, it might appear that the Yahatinda Formation could include beds as old as late Lower Devonian and as young as early Upper Devonian; however, the physical relationships between fish-bearing and plant-bearing strata suggest that, on the contrary, it is unlikely that the formation encompasses so great a span of time.

Although the fossil plants and fishes reported on to date nowhere occur in the same outcrop section, stratigraphic relationships between beds bearing these fossils are clear. The fish fragments occur in a red dolarenite - siltstone - conglomerate - breccia unit which is present at the base of all known thick sections of the Yahatinda Formation, the higher of the two identified specimens being found in the uppermost foot of this unit at "End Mountain". The lowest fossilized plant material occurs only 5 feet (Ghost River) and 15 feet (Wapiti Mountain) above the top of the red basal unit. Furthermore, the lateral extent of the plant-bearing beds and the underlying red, locally fish-bearing unit is in each instance limited by the walls of channels cut into pre-Devonian beds. In view of these relationships, acceptance of the conclusion that the plant-bearing beds are significantly younger than the fish-bearing beds would require an explanation for the preservation of the channel walls and the red fish-bearing beds in the bottom of the channels for a long period of time prior to deposition of the plant-bearing beds. Several sequences of events could be postulated to account for such preservation, but all are highly improbable and unsupported by stratigraphic evidence. For these reasons, it is concluded that the fish-bearing and plant-bearing strata are of nearly the same age.

McGregor (personal communication, 1963) is emphatic that the fossil flora of the Yahatinda is definitely not of Lower Devonian age. On the other hand, an Upper Devonian age appears to be excluded, not only by the fossil fishes, but also by the evidence of an important stratigraphic break between the plant-bearing beds and the latest Middle, or early Upper Devonian, basal beds of the Fairholme Group. On the basis of available evidence, therefore, the Yahatinda Formation is of Middle Devonian age.

Sandberg (1961) has suggested a correlation between the "upper part of the Ghost River Formation" (Yahatinda Formation) and the Lower Devonian Beartooth Butte Formation of Wyoming and Montana. The similarities between the two formations in lithology, fossil content, and stratigraphic relationships are indeed striking; however, McGregor (1963) denies the correlation on the basis of the distinctly older aspect of the Beartooth Butte megaflora.

The available palaeontological evidence for the age of the Yahatinda ("Ghost River Formation") confirms the correlation with some part of the Middle Devonian Elk Point Group of the subsurface of the Western Plains, as earlier suggested by Webb (1954), Andrichuk (1954), and Harker et al. (1954). The two formations are, however, lithologically distinct, and may not have been in physical continuity when deposited; compare Figure 5 of this report with Figure 1 of Belyea (1959).

Fairholme Group (Basal Part)

Throughout most of the area studied, the basal part of the Fairholme Group is represented by the Cairn Formation; only at Windy Point (Section 40) and Cline River (Section 46) is the Flume Formation present (see McLaren, 1955, Fig. 1). Wherever practicable, measured sections were continued upward to include massive chert- and stromatoporoid-bearing beds of brown crystalline dolomite or dolomitic limestone, characteristic of the Cairn and Flume. These and the overlying beds of the Fairholme are fully dealt with by McLaren (1955) and Belyea and McLaren (1956). Only the basal beds of the Fairholme Group and their relationship with underlying formations will be dealt with here.

Lithology

Limestone Breccia. In many places, the basal 100 feet of the Fairholme Group contains, in addition to beds typical of the Cairn and Flume Formations, remarkable limestone breccias which have received little attention in the literature. At all of the localities studied, these breccias are limited to positions in the section lower than the lowest stromatoporoid-bearing bed. The breccias are composed almost entirely of limestone,

mainly white or near-white, but also grey, light brown, and pink, uniformly microcrystalline and very pure except for the presence of minute prisms of authigenic quartz. The limestone blocks and slabs, 1/2 to 2 inches thick and up to 12 inches long, are generally angular and bounded on two sides by bedding planes. Much of the breccia is of a porous and permeable open type, cemented only at points of contact between fragments. The voids of this type of breccia are coated with an orange-coloured, earthy substance. Elsewhere, the fragments are embedded in a matrix of similar limestone. In a few localities, breccias of brown, very fine crystalline dolomite fragments occur in the basal Cairn; they are presumed to be related in origin to the limestone breccias. The breccias weather readily. Their presence accounts, in many places, for the persistent covered interval at the base of the Fairholme.

The limestone breccias are closely associated with thin- and medium-bedded unfossiliferous limestone identical with the limestone of the breccia fragments. Intervals of breccia commonly are crossed by intervals or single thin beds of limestone, these typically being buckled and fractured. In several exposures, bedded limestone passes laterally into brecciated limestone and then into typical breccia.

Sandstone, shale, and boulders were nowhere found interbedded with the limestone breccias, as reported by DeWit (1956b, p. 102). These materials are limited to the underlying Yahatinda Formation, in which they are associated with detrital dolomite breccias.

DeWit doubted that the limestone breccias could be completely accounted for by collapse attendant upon leaching of evaporites, and invoked slumping into palaeotopographic "lows" to account for them. The Fairholme was, however, deposited upon an even surface (see below); slumping could not have taken place to any important extent. On the other hand, the consistent involvement of a peculiar type of limestone in the breccias demonstrates that the breccias are related in some way to a specific depositional environment. Furthermore, the sagging of overlying beds into the "open" type of breccia demonstrates that collapse took place, in some instances at least, subsequent to deposition of the overlying beds. Only an origin by collapse attendant upon leaching of evaporites interbedded with limestone can account for these observations.

Sandstone. Clean, white, well-sorted sandstone is present at the base of the Cairn Formation in the Bourgeau Range (Usher, 1959, Plate 111), the Sawback Range, Mount Wilson, Cirrus Mountain (Norford, 1961), and Sunwapta Pass. The writer has determined that this sandstone is conformable and in places interbedded with the overlying Devonian, and regionally truncates the underlying Ordovician and Silurian formations; this tends to support Norford's (1961) assignment of the sandstone to the Cairn Formation.

Contact Relations

Although the contact between the Fairholme Group and Cambrian or Ordovician formations is an important unconformity, it appears conformable and planar in nearly all exposures. The only exception known to the writer is the local, distinctly angular unconformity exposed in an outcrop just above timber-line north of Cascade River, at the sharp westward bend of the river 15 miles above Lake Minnewanka (Locality 75). The angle of truncation here is about 30 degrees, and the overlying argillaceous dolomite of the Cairn is in knife-sharp "welded" contact with Lynx beds. A few angular fragments of Lynx dolomite are incorporated in the basal inch of the Cairn. In nearby outcrops, bedding in the Cambrian is essentially parallel to bedding in the Devonian; the angular relationship exists only in a small area in which bedding in the Cambrian is warped out of the prevailing attitude. The relationships suggest that the truncated structure is either a monoclinal flexure or a fault with attendant drag. Exposures are not extensive enough to permit confirmation of either of these possibilities.

Although most exposures of the contact between the Fairholme and the Yahatinda are conformable in appearance, whether sharp and obvious or arbitrary and apparently gradational, the two formations are probably in disconformable contact, for reasons summarized in the following paragraphs.

At the Canmore-Spray Lake road, one exposure of the base of the Cairn, here limestone breccia, reveals a distinctly erosional contact with the underlying green-grey silty dolomite of the Yahatinda.

At James Pass, 54 feet of brown and grey crystalline dolomite assigned to the Cairn Formation intervenes between the top of the Yahatinda and the base of a thick section of limestone breccia. However, at the type locality of the Yahatinda, at Wapiti Mountain, the breccia is in contact with the Yahatinda (Fig. 3, D-F). Unless the breccia is a lateral equivalent of the crystalline dolomite, which appears unlikely in the absence of evidence to this effect, the breccia must lie across the depositional edge of the crystalline dolomite in an overstep relationship, to overlie the Yahatinda disconformably at Wapiti Mountain. Suggestive evidence tending to confirm the disconformity is the fact that the Cairn-Lynx contact at Wapiti Mountain forms a continuous plane with the contact between the Cairn and the Yahatinda (Fig. 8). This relationship is coincidental and improbable unless both pre-Cairn formations are bevelled by a common plane of erosion.

Evidence has been given on foregoing pages to show that the Yahatinda Formation overlies a chemically weathered surface of appreciable relief. The Fairholme Group, on the other hand, overlies unweathered rocks forming a nearly plane surface, probably a plane of marine erosion. These facts suggest a period of non-deposition between the accumulation of the Yahatinda and deposition of the basal Fairholme beds, during which time

marine erosion bevelled the region and removed the accumulated products of pre-Yahatinda weathering. This reconstruction of events, if correct, bears upon the age of the Yahatinda Formation, because the base of the Fairholme Group is generally agreed to be of latest Middle or early Upper Devonian age (Belyea and McLaren, 1957; Taylor, 1957; Crickmay, 1961).

With the exception of its occurrences near Banff, the basal Cairn sandstone is found only west of the area of Figure 1. The depositional trends of the basal Cairn sandstone and the Yahatinda Formation are thus strongly divergent. Throughout the area of study, occurrences of the basal Cairn sandstone are separated from Yahatinda occurrences by a belt in which neither formation occurs. These differences in trend and distribution, as well as the pronounced differences in lithology, probably reflect the occurrence of important diastrophic events between the times of deposition of the two formations.

The Sub-Devonian Unconformity

The data brought together in this report (e.g. Figs. 3, 4, 6, 7, 8, 9) provide additional documentation of the nature and magnitude of the sub-Devonian unconformity in southwestern Alberta, as hitherto described by Harker et al. (1954) and DeWit (1956b). Despite the great thickness of strata truncated by the base of the Devonian between the Continental Divide and the Mountain Front, the angle of truncation is almost everywhere imperceptible; "angular unconformity" appears only in stratigraphic cross-sections of greatly exaggerated vertical scale. In the words of Harker, Hutchinson, and McLaren (1954): "In few sections is any unconformity detectable by an obvious discordance in dip and the evidence is, in almost every case, entirely stratigraphic."

In contrast to the foregoing, angular unconformity[1] at the base of the Devonian has been reported by several authors (Clark, 1954; Gussow, 1960; Patterson and Storey, 1960). Each of these reported instances has been carefully checked, and found not to be supported by the evidence. A very local, distinctly angular unconformity at the base of the Devonian was, however, discovered at Cascade River, as previously mentioned.

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[1] The term "angular unconformity" is here restricted to that relationship in which angular discordance between strata in depositional contact is visible in outcrop. Regional truncation of strata, revealed only by stratigraphic studies, is here excluded from the concept of angular unconformity, following Billings (1942, p. 243).

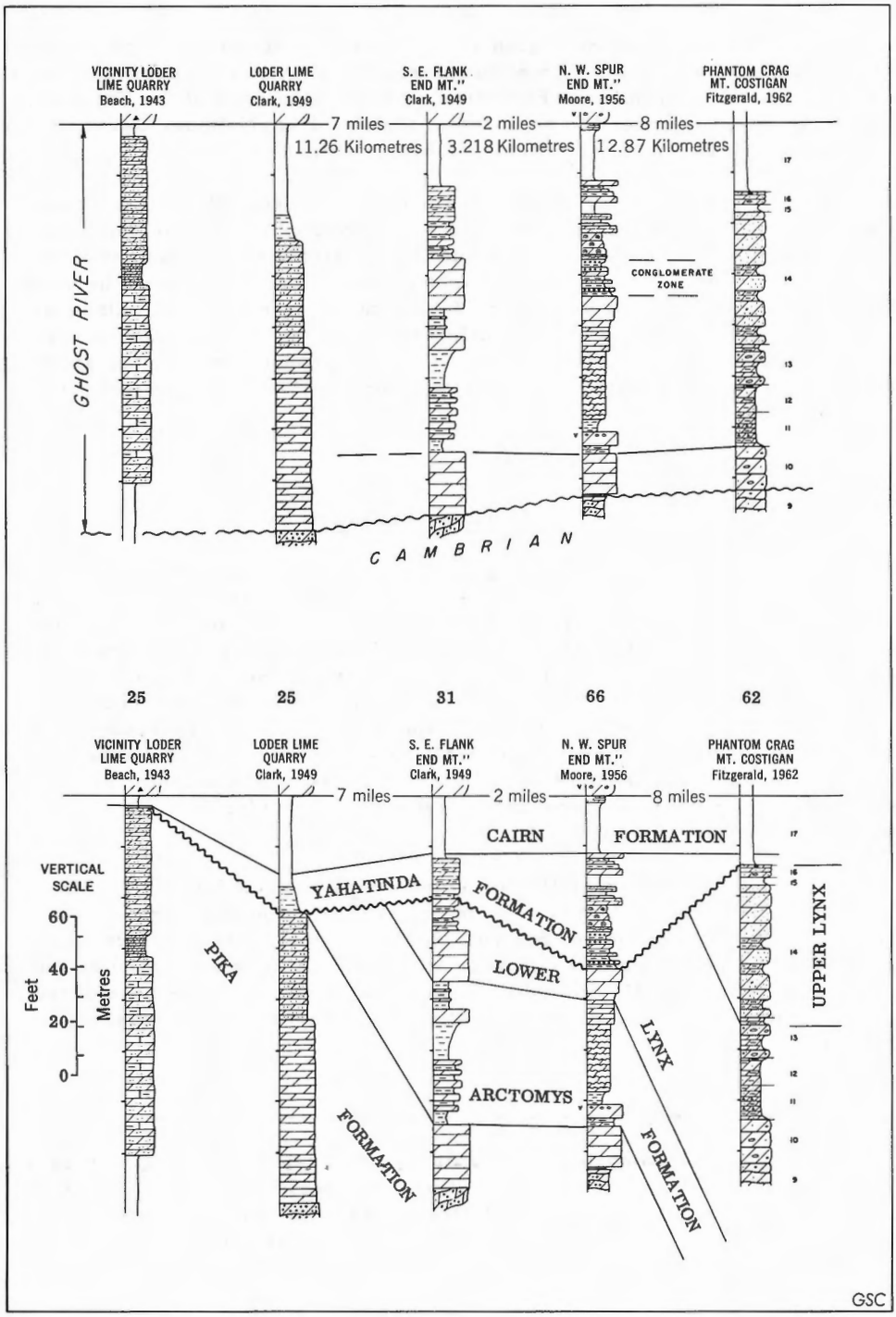

Figure 10. Correlation of basal Devonian and subjacent formations from Loder's lime quarry to Ghost River; (a) according to Patterson and Storey (1962); (b) this report. (Reproduced by permission from the Journal of Alberta Society of Petroleum Geologists)

The "angular unconformity" in the cliffs near Mount Yamnuska, reported by Gussow (1960), is an obvious angular relationship between different beds within the Middle Cambrian Eldon Formation. At this locality the top of the Eldon Formation and the Pika Formation lie undisturbed above the locus of the angular relationship and parallel with the overlying Fairholme beds. Trilobites are present in the Pika in these exposures. The angular relationship is caused, not by unconformity, but by structural disturbances in the Eldon Formation, which here immediately overlies the McConnell thrust fault. Similar relationships may be observed in the Kananaskis-Ghost River region in the hanging-walls of the McConnell and other thrusts, regardless of the age of the strata involved.

Photographs of the "angular unconformity" at "End Mountain", as seen in outcrops on strike with one another and 1 1/4 miles apart, have been published by Clark (1954, Fig. 2), and Patterson and Storey (1960, Fig. 1; 1962, Fig. 3). The claim, made by these authors, of angular unconformity at the base of the Devonian, is based entirely on views of mountainsides in which the outcrop traces of certain pre-Fairholme strata lie across ("truncate") the projected traces of other, more steeply dipping pre-Fairholme strata. The appearance of angular unconformity is indeed most convincing, but on close inspection, the angular relationship is found to occur well down within the Cambrian sequence. The unmistakable Arctomys and Lynx Formations lie undisturbed above the more steeply dipping beds, in structural concordance with the overlying Fairholme (Fig. 7). The pseudo-unconformity at "End Mountain" is, in fact, a minor thrust fault, subparallel to the McConnell Thrust, which here occupies a position within the upper part of the Pika Formation. This thrust fault, which is not folded to the same extent as the McConnell Thrust, can be readily identified on the southern, eastern, and northern flanks of End Mountain. Its nature is well displayed on the northeastern spur of End Mountain, where it brings high Pika beds over Yahatinda. In this instructive locality, the ascending sequence in the immediate hanging-wall of the McConnell Thrust is Pika - Arctomys - Lynx - Yahatinda (thin) - minor fault to Pika, whereas the sequence superimposed on the latter sequence by the minor thrust is Pika - Yahatinda (thick) - Fairholme, because the thrust sheet contains at this point a channel, 105 feet deep and filled with Yahatinda beds, which cuts out the Lynx and Arctomys (Fig. 7).

In summary, the gradual, regular, unidirectional regional truncation of pre-Devonian strata, which brings basal Devonian strata in contact with successively older formations in an eastward direction, is a consequence of pre-Middle Devonian epeirogenic (essentially vertical) movements. The occurrence of an exceptional, very local angular unconformity, mentioned above, is logically attributed to small-scale vertical structural adjustments accompanying regional broad uplift and/or tilting. Published reports of important angular unconformities cannot be substantiated nor can the claim of regional metamorphism in Cambrian rocks of the Front Ranges. For these reasons, it is concluded that claims of the effects

of "Caledonian orogeny" in the Front Ranges (Patterson and Storey, 1960; Gussow, 1960) are without foundation.

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STRATIGRAPHIC SECTIONS[1]

1. MOUNT CORY (SECTION 23[2])
(Lat. 51°11'N, Long. 115°42 1/2'W)

The following section was measured about 1,200 yards south of the summit of Mount Cory, on a narrow spur, outlined by the 8,000-foot contour, which extends almost due south from the summit. The base of the Devonian is covered almost everywhere on the mountain, but at this point it is completely exposed.

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
	Fairholme Group (Cairn Formation)		
	The units described below are moderately resistant.		
9	Dolomite, brown, bituminous, fine and very fine equicrystalline[3], very slightly argillaceous; at the top, traces of brachiopods and the lowest occurrence of Amphipora	18	75

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[1] Measurements were made with staff and compass; and except where otherwise stated, samples were collected at intervals of 10 feet for laboratory examination.

[2] Numbers assigned to measured stratigraphic sections in text and illustrations are permanent numbers, prefixed by the letters AC, which identify the writer's work in the files of the Geological Survey. Lithological and palaeontological collections are also keyed to this system. Future publications referring to other parts of the same measured sections will use the same permanent reference numbers.

[3] An arbitrary scale of crystallinity was employed, as follows:
Coarse crystalline - average diameter of crystals greater than 1 mm
Medium crystalline - 1/4 to 1 mm
Fine crystalline - 1/16 to 1/4 mm
Very fine crystalline - 1/32 to 1/16 mm
Microcrystalline - 1/64 to 1/32 mm
Aphanitic - less than 1/64 mm

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
8	Breccia; angular blocks, commonly exceeding 5 feet in greatest dimension, of dolomite as unit 9, tightly packed, with a sparse cement of white calcite	19	57
7	Breccia; slightly rounded, heterogeneous clasts (10 inches maximum dimension) of brown, very fine crystalline dolomite, grey aphanitic dolomite, and khaki mudstone, in a matrix of limestone, buff, very fine grained, argillaceous, silty	2	38
6	Limestone, brownish grey, aphanitic and microcrystalline, slightly argillaceous, with laminae of micro-breccia, in 3/4-inch to 3-inch beds; each foot or so, several inches of sandstone, white, fine- to coarse-grained, calcareous, or sandy limestone; near the top, two beds of khaki shale, 2 inches and 1 inch thick respectively ...	12	36
5	Mudstone, khaki-coloured, calcareous, slightly sandy	1 1/2	24
4	Limestone, as unit 6, in 1/2-inch and 1-inch beds	1	22 1/2
3	Sandstone, calcareous, greenish yellow (argillaceous) to white, fine-grained, poorly to well sorted	3	21 1/2
2	Shale, khaki-coloured, silty, slightly calcareous, with sandy laminae, slaty cleavage ..	1 1/2	18 1/2
1	Quartzite, dark grey, pepper-and-salt, fine-grained, grading upward through sandstone, white, medium-grained, calcareous, to 1 foot of siltstone, grey, at the top (thickness variable)	7	17
	Unit 1 rests upon a channelled erosional surface with 3 feet of local relief; the beds above and below the contact are parallel.		
	Total thickness of Fairholme Group measured ...	65	

Unit		Thickness in Feet Unit	Total from Base
	Sarbach Formation		
2	Dolomite, white, very fine inequicrystalline	5	10
1	Limestone, light grey and pinkish grey, microcrystalline, with greenish argillaceous laminae, thin-bedded; minor dolomite	5	5
	Total thickness of Sarbach Formation described:	10	

Measurement of this section was completed downward to the Eldon Formation.

2. GHOST RIVER (SECTION 27)
(Lat. 51°20'N, Long. 115°12'W)

The following section (see No. 27, Fig. 6), was measured on exposures above the high cliffs of Middle Cambrian carbonates on the west side of the valley separating Black Rock Mountain from the mountains to the west. The line of section is about 3/4 mile north of Ghost River and 1 mile north of the type section of Walcott's "Ghost River Formation". The strata are well exposed.

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
	Fairholme Group (Cairn Formation)		
	The units described below are moderately recessive.		
5	Dolomite, brown, very fine crystalline, relict pelletoid fabric; massive; abundant partly silicified stromatoporoids	2	178
4	Poorly exposed. Limestone, light brown, aphanitic, pelletoid; partly massive, partly laminated	22 1/2	176
	The units described below are very recessive and poorly exposed.		
3	Limestone, white to grey, microcrystalline, abundant micro-vugs; also limestone, white and brown (argillaceous) interlaminated, microcrystalline; massive, weathers buff	11	153 1/2
2	Covered	5	142 1/2
1	Dolomite, grey, very fine equicrystalline, minor aphanitic, very pure; a few micro-vugs; mostly massive, buff-weathering	10 1/2	137 1/2
	Basal contact marked by an abrupt lithologic change.		
	Total thickness of Cairn Formation measured ...	51	

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
	Yahatinda Formation		
	The units described below are moderately recessive.		
2	Dolomite (mainly dolarenite and dolsiltite?) pink to rose, locally veined by greenish white, also mottled, fine- and very fine equicrystalline; insoluble residue generally slight to abundant red clay and trace of silt; massive; basal part of unit contains 5% glauconite and displays a well preserved skeletal dolarenite fabric (brachiopod fragments?)	35	127
1	Dolarenite, rose, fine equicrystalline, insoluble residue of abundant red clay and trace of silt, interbedded with siltstone, pink to white, dolomitic, argillaceous, in recessive flaggy beds	3	92
	Basal contact marked by a sharp lithologic change.		
	Total thickness of Yahatinda Formation	38	
	Lynx Formation (upper division)		
	The units described below support some prominent features, but do not form continuous cliffs.		
4	Siltstone, very dolomitic, varicolored, mostly grey streaked with red, grading to dolomite, very silty, very fine crystalline, laminated; several 1-foot beds of edgewise conglomerate (flat chips of siltstone in a matrix of silty dolomite); at top of the unit, complexly shaped bodies of pink siltstone in grey to white siltstone may be burrows; unit is massive, weathers orange-buff	14	89

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
3	Dolomite, white, grey, pink, very fine crystalline and microcrystalline, partly silty, and siltstone, very dolomitic, grey, pink, laminated, cross-laminated and contorted laminations; dolomite predominates in the lower half, siltstone in the upper; the unit is mainly massive and orange-buff weathering; 20 feet above the base, several low mounds suggest poorly developed stromatolites	66	75
2	Siltstone, pink, mostly dolomitic, partly quartzitic; thin-bedded, laminated and cross-laminated, massive	1 1/2	9
1	Dolomite, grey-brown, microcrystalline, silty, with particles of siltstone, pinkish grey, dolomitic; weathers yellow-buff; very minor shale, maroon, green at top	7 1/2	7 1/2
	Total thickness of upper Lynx	89	

Underlying beds - Lynx Formation (lower division)

Measurement was continued downward to the base of the Pika Formation.

3. OLD FORT CREEK (SECTION 31)
(Lat. 51°10'N, Long. 115°7 1/2'W)

The following section (see No 31, Fig. 7), was measured at a point just east of the axis of the End Mountain syncline, immediately north of Old Fort Creek[1], a locality photographed by Clark (1954, Fig. 2). The thin-bedded Pika Formation is intensely crumpled and broken by minor thrust faults in the immediate hanging-wall of the McConnell thrust; this deformation ends upwards at a bedding-plane thrust fault within the upper part of the Pika, giving the impression that an angular unconformity is present within the Cambrian succession. Some authors (Clark, 1954; Patterson and Storey, 1960, 1962) have placed the base of the Devonian at this pseudo-unconformity. The exposures are fair.

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
	Fairholme Group (Cairn Formation)		
	The upper of the units described below forms the basal part of a cliff; the lower units are recessive.		
6	Dolomite, light brown, very fine inequicrystalline, massive; abundant stromatoporoids, in part silicified	4 1/2	165 1/2
5	Dolomite, resin-brown, very fine equicrystalline, argillaceous to very argillaceous; rare pebbles; largely laminated and platy	13 1/2	161
4	Covered	11	147 1/2
3	Limestone, brown, aphanitic, partly pelletoid; partly dolomitized; laminated, platy	2	136 1/2
2	Limestone, off-white, microcrystalline, with micro-vugs; massive	1 1/2	134 1/2

[1] According to Map 82 O/3 East, scale 1:50,000, Surveys and Mapping Branch, Dept. of Mines and Technical Surveys, Ottawa, published 1959, this is the "Bowfort Creek" of Clark (1954) and others.

Unit		Thickness in Feet Unit	Total from Base
1	Covered	12 1/2	133
	Total thickness of Cairn Formation measured ..	36 1/2	

Yahatinda Formation

The units described below are moderately resistant, but much less so than the underlying Upper Cambrian beds.

2	Dolomite, light greenish grey to near-white, very fine crystalline, mostly silty, very argillaceous, and siltstone as unit 1; laminated, flaggy, also massive; weathers yellow	5 1/2	120 1/2
1	Dolomite, red to white, very fine crystalline, silty, very argillaceous, grading to siltstone, dolomitic, partly argillaceous, partly sandy; minor shale, maroon, silty, dolomitic; scattered small pebbles and granules; at the base, a lenticular conglomerate (pebbles of the underlying rocks in a matrix of green argillaceous dolomitic sandstone)- 8 inches in maximum thickness; the unit is partly platy, partly flaggy, partly massive, and weathers red and buff	15	115

Beds above and below the basal contact are structurally conformable, but the underlying beds are locally channelled to a maximum relief of 6 inches, and the basal beds locally have sagged into collapse of solution cavities in the beds below the unconformity.

Total thickness of Yahatinda Formation	20 1/2	

Unit		Thickness in Feet: Unit	Total from Base
	Lynx Formation (lower division)		
	The units described below form a 35-foot vertical cliff.		
3	Dolomite, light brownish grey to near-white, fine- and very fine crystalline, argillaceous, partly silty, uniform, monotonous; massive, weathers cream to buff; the uppermost 5 feet contains purple-stained, solution-enlarged fissures and small cavities, some of which contain purplish or orange silty argillaceous sediment introduced from above	15	100
2	Mainly siltstone, maroon, white, slightly dolomitic, platy, with partings of shale, maroon and green	3	85
1	Siltstone, purple, pink, white, very dolomitic, cross-laminated, grading to dolomite, silty, argillaceous, micro-crystalline; siltstone beds are 1 inch to 2 inches thick, dolomite beds are thick and massive	17	82
	Abrupt lithologic change.		
	Total thickness of lower Lynx.....	35	
	Arctomys Formation		
	The units described below are recessive.		
2	80% shale, brown, grey-brown, soft, micaceous, fissile to platy, with laminae of siltstone increasing upward; weathers yellow. 20% silt-stone, purple-grey, dolomitic, cross-laminated, minor edgewise conglomerate, grading to dolomite, silty and sandy	28	65

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
1	50% dolomite, grey, dark grey, very fine crystalline, argillaceous, silty, grading upward to siltstone, dolomitic, cross-laminated; beds are flaggy, 1 inch thick, and massive, 3 to 8 inches thick; weathers smooth orange-buff and pink-buff; 50% shale, brown, grey-brown, soft, micaceous, fissile (poorly exposed in basal half of unit)	27	37
	Basal contact not exposed.		
	Total thickness of Arctomys Formation	55	

Pika Formation

The formation forms a succession of small cliffs alternating with recessive intervals; a short distance below the top it becomes intensely deformed.

1	Dolomite, purple-brown, very fine crystalline and microcrystalline, in regular thin beds ...	10	10
	Total thickness of Pika Formation measured ..	10	

4. WAPITI MOUNTAIN (SECTION 32)
(Lat. 51°43'N, Long. 115°43'W)

The following section (see No. 32, Figs. 3, 4, 8) was measured in and near the canyon of a small stream, tributary to Red Deer River, which crosses the road a few hundred yards east of the eastern boundary of Banff National Park. The pre-Devonian strata were measured just above timber-line on the shoulder of the mountain east of the stream. The Devonian strata were measured on the west wall of the canyon. The rocks are well exposed.

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
	Fairholme Group (Cairn Formation)		
	The uppermost of the units described below is moderately cliff-forming, the remainder moderately recessive.		
14	Dolomite, light brown, patchily microcrystalline and fine-crystalline, massive; silicified stromatoporoids, rare brachiopod fragments	12	177
13	Limestone, grey-brown, calcisiltite, very dolomitic, laminated, platy	1 1/2	165
12	Limestone, grey, microcrystalline, partly argillaceous, massive, largely brecciated and porous; local very rare silicified *Amphipora*; two feet covered in middle of unit	10	163 1/2
11	Limestone, light grey, microcrystalline, very argillaceous, laminated; passes laterally into massive breccia	2	153 1/2
10	Limestone, brown, aphanitic, pelletoid, partly dolomitized, massive; rare small silicified stromatoporoids	2	151 1/2

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
9	Limestone, interlaminated brown, aphanitic, brown pelletoid, and near-white, microcrystalline; basal 1/2 foot is platy, rest is flaggy; scattered silicified Amphipora 1/2 to 1 foot above base	8	149 1/2
	The units described below are very recessive and are exposed only locally.		
8	Limestone, grey-brown, microcrystalline, also aphanitic, clotted; excellent microvug porosity, locally brecciated; basal foot is light brown, shaly; base of unit has sagged, presumably into underlying cavernous breccia	9 1/2	141 1/2
7	Covered—probably breccia	3	132
6	Limestone, brown, light brown-grey, aphanitic and very fine crystalline, pin-point porosity; locally brecciated; local blebs of chert	3	129
5	Covered	5 1/2	126
4	Limestone, light brown, grey, microcrystalline, faint trace silt; scattered pin-point vugs, massive, faintly laminated, locally brecciated	3	120 1/2
3	Breccia; as unit 1, but with a 1/2-foot bed of brecciated limestone locally present at the base	3	117 1/2
2	Limestone, light grey, microcrystalline, and dolomite, grey, fine equicrystalline, euhedral, argillaceous, passing laterally into breccia	4 1/2	114 1/2
1	Breccia; angular fragments up to 12 inches in maximum dimension of limestone, near-white, uniformly microcrystalline; part of the breccia has a matrix of the same		

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
	limestone, and part is cemented only at the contacts between fragments, hence is highly porous and permeable; vugs are present within, as well as between, fragments; the open breccia has a prominent orange earthy coating	8 1/2	110
	The contact with the underlying formation is marked by an abrupt lithologic change.		
	Total thickness of Cairn Formation measured ..	75 1/2	

Lynx Formation (upper division)

The units described below form prominent cliffs.

3	Dolomite, grey, brown-grey, yellow-grey, microcrystalline to fine equicrystalline, local trace of silt; partly laminated, partly clotted; beds with blebs of light grey chert 30 and 45 feet above base	56	101 1/2
2	Dolomite, brownish grey, very fine crystalline, trace of relict oolitic fabric, thin-bedded and cross-laminated; weathers light brown	5	45 1/2
1	Dolomite, brownish grey to near-white, very fine crystalline and microcrystalline, locally clotted, local trace of silt; laminated, massive; weathers cream-coloured; agate-like chert nodules in uppermost foot	40 1/2	40 1/2
	Total thickness of upper Lynx beds described	101 1/2	

Measurement was continued downward to the lowest beds exposed in structural continuity, 450 feet lower. 396 feet of upper Lynx beds are present.

5. WAPITI MOUNTAIN, EAST FACE (SECTION 33)
(Lat. 51°44'N, Long. 115°43 1/2'W)

Type Section of the Yahatinda Formation

The type section (see No. 33, Fig. 8), is on the east face of Wapiti Mountain, in the immediate hanging-wall of the unnamed major thrust fault, where a prominent lens of red- and buff-weathering sediments occupies a channel 118 feet deep and 300 to 400 yards wide, which has been cut into the pre-Devonian rocks by pre-Yahatinda erosion. The exposures are excellent.

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
	The overlying recessive, poorly exposed section of the basal Cairn Formation was examined and found to be similar in thickness and character to the nearby section 32. The contact is marked by a sharp lithologic change.		
	Yahatinda Formation		
	The units described below are moderately resistant. They occupy a channel cut in the pre-Devonian beds described in Section 32.		
17	Sandstone, very dolomitic, light yellow-grey, very fine grained, poorly sorted, grading to dolomite, sandy; massive and flaggy, weathers yellow; minor shale, dolomitic, greenish grey, partly sandy, platy	9	118
16	Sandstone, very dolomitic, light grey, fine-grained, argillaceous, platy to shaly	1 1/2	109
15	Covered	3 1/2	107 1/2
14	Dolomite, silty and sandy, as unit 11, with abundant sandy layers and two 8-inch-thick pebbly zones	3	104

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
13	Dolomite, silty and sandy, as unit 11, in nodular beds 3 to 12 inches thick, with several thin beds of shaly dolomitic siltstone containing fragmental plant remains	6	101
12	Conglomerate, poorly rounded pebbles of dolomite similar to underlying dolomites in a matrix of sandy dolomite, as unit 11	1	95
11	Dolomite, grey, microcrystalline, very silty and sandy, grading to dolomitic siltstone and dolomitic fine-grained sandstone; massive, weathers yellow; at base, burrows oriented perpendicular to bedding	4 1/2	94
10	Sandstone, buff, fine-grained, dolomitic, argillaceous, platy; sand grains are sub-rounded, well-sorted; abundant reed-like plant impressions	1 1/2	89 1/2
9	Mudstone, brownish grey, yellowish grey, very dolomitic, very sandy, grading to dolomitic argillaceous sandstone and sandy dolomite; beds 3 to 6 inches thick, massive; weathers brown; rare isolated pebbles; sand-filled burrows perpendicular to bedding	4	88
8	Siltstone, grey and pinkish grey, very dolomitic, with laminae of fine-grained sandstone; very minor shale, grey, very dolomitic, silty and sandy; pebbly layers common, rare isolated pebbles in the basal ten feet; macerated plant remains in some layers; unit is massive, weathers yellow, smooth	27	84
7	Sandstone, grey, fine-grained, poorly sorted, very dolomitic; with many pebbles of sandy and silty dolomite of 3/4-inch average diameter; many carbonaceous flakes	1 1/2	57

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
6	Siltstone, grey, very dolomitic, with lenses and pockets of fine-grained sandstone; massive; weathers yellow	6 1/2	55 1/2
5	Siltstone, red, ferruginous, grading upward to grey, partly sandy	4 3/4	49
4	Conglomerate; poorly rounded pebbles 1/2-inch average diameter, of dolomite, grey, fine-crystalline, in a matrix of sandstone, buff, dolomitic	3/4	44 1/4
3	Siltstone, brick-red, very dolomitic, ferruginous, partly sandy; massive, partly rubbly weathering	20	43 1/2
2	Breccia, intraformational; angular chips and slabs, average diameter 3/4 inch but reaching 6 inches at the base, of rocks mainly similar to the underlying beds but including rare fragments of pre-Devonian dolomite, in a matrix of sandstone, pink and white, very dolomitic; a single massive bed	4	23 1/2
1	Dolsiltite and dolarenite, brick-red, minor pink and buff, argillaceous, sandy, partly pebbly; numerous thin beds of sandstone, maroon to white, also greenish, fine- and medium-grained, dolomitic, argillaceous, partly conglomeratic; sand grains have high roundness and sphericity, but sorting is poor; lamination is general, channelling and crossbedding common; in the uppermost 13 feet, 1- to 3-inch beds of breccia similar to unit 2 are common	19 1/2	19 1/2

Sharp erosional contact with the beds forming the floor of the channel.

Unit	Thickness in Feet Unit	Total from Base
Total thickness of Yahatinda Formation	118	

Underlying beds—Lynx Formation (upper division)
(see description in Section 32)

6. CANMORE-SPRAY LAKE ROAD (SECTION 34)
(Lat. 51°05'N, Long. 115°25'W)

The following section (see No. 34, Fig. 3) was measured in a shallow gully which crosses the Canmore-Spray Lake road directly uphill from the pool below the upper generating station. Exposures are fair.

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
	Fairholme Group (Cairn Formation)		
	The units described below are weakly cliff-forming.		
12	Dolomite, light brown, fine inequicrystalline, massive, abundant, poorly preserved, silicified stromatoporoids	5	192
11	Dolomite, as below, but in 1- to 3-inch beds; rare brachiopods	1	187
10	Covered	6	186
9	Dolomite, brown, minor grey, fine- and very fine equicrystalline, bituminous, in massive 2- to 10-inch beds, brown-weathering; scattered brachiopods in some beds	7 1/2	180
8	Limestone, very light grey, microcrystalline, in irregular thin beds, partly brecciated; a few vugs	1 1/2	172 1/2
7	Very poorly exposed; dolomite, brown, fine-equicrystalline, very bituminous, porous, flaggy; in the middle, one foot of limestone, mottled buff, very fine crystalline, in 3/4-inch beds; partly highly porous, as by selective leaching	13	171
6	Dolomite, brown, very fine equicrystalline, porous, laminated, partly in 1-foot beds; minor gashes of white dolomite	10	158

Unit		Thickness in Feet Unit	Total from Base
5	Covered	15	148
4	Dolomite, grey-brown, also light grey with pink laminae, very fine equicrystalline, interbedded with limestone, dolomitic, grey; beds 4 to 6 inches; vuggy porosity in upper part	12	133
	The units described below are very recessive and rarely exposed.		
3	Poorly exposed. Breccia; angular fragments, in all sizes up to 2 inches by 8 inches, of limestone, grey and very light grey; microcrystalline, in part laminated, very pure; the breccia is cemented only at points of contact and is highly porous and permeable; the voids are coated with an orange, earthy substance	16	121
2	Dolomite, brown, very fine crystalline, laminated; a few calcite veinlets	1	105
1	Covered	8 1/2	104
	Total thickness of Cairn Formation measured ..	96 1/2	

Yahatinda Formation

	The units described below are recessive, but slightly less so than the overlying beds.		
7	Beds similar to unit 5, partly pinkish grey	3	95 1/2
6	Dolomite, conglomeratic; fragments (20%) of dolomite, light grey, microcrystalline, buff-weathering, are both angular and rounded, reach a maximum size of 3 inches by 1 inch; matrix is dolomite, grey, fine-crystalline, greenish weathering; a single massive bed	2	92 1/2

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
5	Dolomite, greenish grey, very fine inequicrystalline to microcrystalline; partly silty and argillaceous; in massive 2- to 6-inch beds; weathers buff and greenish; in part displays a poorly sorted clastic fabric	5 1/2	90 1/2
4	Covered	4	85
3	Dolomite, greenish grey, fine- and very fine equicrystalline, argillaceous, in 1/4- to 4-inch platy and flaggy beds; weathers greenish buff	8 1/2	81
2	Dolomite, dark brown, veined by white; very fine crystalline, slightly argillaceous; subcylindrical structures of organic origin	1	72 1/2
1	Dolarenite, greenish grey, poorly sorted, very fine grained, argillaceous, partly silty, mostly in 1- to 6-inch beds, buff-weathering; at the base becomes conglomeratic, with clasts of Upper Cambrian dolomite locally reaching a diameter of one foot	13 1/2	71 1/2
	Total thickness of Yahatinda Formation	37 1/2	

Beds above and below the contact have the same general attitude, but the lower beds of the Yahatinda Formation in part terminate against, and in part drape over a six-foot erosional scarp in the sub-Devonian surface.

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
	Lynx Formation (upper division)		
	The units described below form a bold cliff.		
4	Dolomite, light grey, fine-equicrystalline, relict fine calcarenitic(?) fabric. Also dolomite, grey, with minor red veins, fine- and very fine inequicrystalline, partly with a clotted appearance; massive, weathers to a smooth cream and grey surface; the top of the unit is fissured and stained by Devonian weathering	15	58
3	Dolomite, grey, rust-specked, fine-equicrystalline, massive; fine oolitic and calcarenitic relict fabric is visible only on the weathered surface	8	43
2	Dolomite, very massive; relict pisolites(?) of fine-crystalline grey dolomite in matrix of dolomite, white, fine- and medium-crystalline	18 1/2	35
1	Dolomite, grey, pink, fine- and very fine inequicrystalline, massive, weathers buff-grey; stromatolitic structure is locally present throughout, and distinct, laminated, cylindrical stromatolites extend upward 4 feet from the base of the unit	16 1/2	16 1/2
	Total thickness of upper Lynx	58	
	Lynx Formation (lower division)		
	This section was measured downward to the lowest beds exposed, which belong to the Pika Formation.		

7. JAMES PASS (SECTION 35)
(Lat. 51°44'N, Long. 115°26 1/2'W)

The following section (see No. 35, Fig. 3), was measured on the north side of James Pass, one-half mile east of Eagle Lake. The strata strike northwesterly and dip southwesterly. The section was measured more or less along the upper limit of talus cover. Exposures are excellent. A representative sample was collected from each five-foot interval (Devonian strata) or ten-foot interval (pre-Devonian strata), and subsequently examined in the laboratory.

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
	Fairholme Group (Cairn Formation)		
10	Limestone, very dolomitic, very light brown, very fine crystalline, massive; abundant silicified stromatoporoids	1	185 1/2
9	Limestone, brown, microcrystalline, faintly clotted, with dolomitic laminae	3/4	184 1/2
8	Limestone, very light grey, very fine crystalline, uniform; weathers dove-grey, smooth	3/4	183 3/4
	This bed is irregular in thickness, as it fills in the irregularities in the top of the underlying, slightly slumped bed, and has itself sagged slightly into the underlying brecciated limestone.		
	The units described below are generally recessive and talus-covered, but on the line of section they form steep cliffs.		
7	Limestone as unit 6, but locally brecciated and cavernous; bedded limestone passes laterally into coarse breccia with slabs up to 1 foot in greatest dimension	7	183

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
6	Limestone, brown to very light brown, aphanitic, clotted, with calcite "eyes" and veinlets, partly dolomitic, porous, and limestone, very light brownish grey, microcrystalline, uniform; all laminated; unit weathers grey	7	176
5	Mainly breccia; angular fragments, up to 1 foot in greatest dimension, of limestone, brown to very light brownish grey, also white and pink, microcrystalline and aphanitic with local clotted and fine calcarenite fabric, and minor dolomite, calcareous, brownish grey, very fine crystalline, euhedral, highly porous, with veins of white calcite. The breccia in part has a matrix of dense limestone like the fragments, and in part is cemented only at inter-fragment contacts, hence is highly porous and permeable. The fragments composing the breccia are homogeneous at a given level but change composition vertically. Minor intervals up to 3 feet thick of bedded, laminated, brecciated carbonates of the types occurring as breccia interrupt the massive breccia. At the base, a trace of primary breccia, with 1-centimeter clasts of limestone and green shale in a matrix of microcrystalline limestone. The unit is conspicuously orange-weathering	29	169
4	Limestone and breccia; 2- to 3-inch beds of limestone, dirty white, very fine crystalline, euhedral, trace clay, trace silt, with excellent inter-crystalline and micro-vug porosity, interbedded with 1-foot intervals of the same limestone occurring as a porous breccia	5 1/2	140

Unit		Thickness in Feet Unit	Total from Base
	The contact with the underlying beds is marked by an abrupt lithologic change across a bedding plane.		
	The units described below are moderately cliff-forming.		
3	Dolomite, brown to light brown, mottled by white, medium crystalline, with relict fine calcarenite fabric; massive; minor intervals of dolomite, brown, very fine crystalline, laminated, uniform	11 1/2	134 1/2
2	Dolomite, brown, microcrystalline and very fine crystalline, in regular 3-inch to 5-inch beds with 1/2-inch partings of shale, brown, dolomitic, with carbonaceous specks	5	123
1	Dolomite, brownish grey, greenish grey, fine- and very fine crystalline, in distinct 1-inch to 2-foot beds; a few dolomite-filled vugs; weathers grey; local pink coloration and surface stain at top	37 3/4	118
	The contact with the underlying formation is marked by an abrupt lithologic change.		
	Total thickness of Cairn Formation measured ..	105 1/4	

Yahatinda Formation

	The units described below are moderately recessive, becoming very recessive at the top (unit 4).		
4	Dolomite (60%) as unit 3, interbedded with shale (40%), very dolomitic, brown, slightly silty, fissile	4 3/4	80 1/2

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
3	Dolomite, brown, fine-crystalline, and dolomite, grey, microcrystalline, intermixed and wavily interlaminated, as by organic stirring; partly argillaceous and silty, with a few discontinuous shaly laminae; weathers yellow and grey, flaky	8 1/2	75 1/2
2	Dolomite, dirty greenish grey, very fine crystalline, slightly argillaceous; weathers yellow with nodular appearance	1	67
1	Dolomite (dolarenite?), brick-red, pink, lavender, mottled, patchily very fine to medium-crystalline; abundant residue of red clay and a trace of silt; indistinct 1-inch beds, partly laminated; weathers reddish purple; boulder conglomerate locally present at base	14	66
	The beds above and below the basal contact are parallel, but a 2 1/2-foot bed of the underlying dolomite terminates in a small erosional scarp buried by the Yahatinda beds.		
	Total thickness of Yahatinda Formation	28 1/2	

Lynx Formation (upper division)

The units described below form bold cliffs.

2	Dolomite, near-white, minor brownish grey, locally pink-mottled, medium crystalline below, becoming fine crystalline upward, with relict oolitic fabric at top; common large vugs filled with coarse dolomite and quartz; massive; lenticular thin beds (?) of grey and lavender dolomites consisting of sand- and pebble-sized dolomite		

Unit		Thickness in Feet Unit	from Base
	fragments in an argillaceous, very fine crystalline matrix; extensively stained and fissured by pre-Devonian weathering, with orange and green argillaceous sediments introduced along fissures	37	52
1	Dolomite, near-white, medium-crystalline, uniform, in massive 8-inch to 2-foot beds; weathers grey, granular	15	15
	Total thickness of pre-Devonian described	52	

Measurement was continued downward to the lowest structurally undisturbed strata at this locality, 295 feet below. The upper division of the Lynx Formation is 264 feet thick.

8. WASOOTCH CREEK (SECTIONS 37 A AND B)
(Lat. 50°55 1/2'N, Long. 115°03'W)

The two sections described below (see Fig. 9), are located as follows: 37 B was measured on the north bank of a gully, tributary to the east fork of Wasootch Creek, which reaches the creek 1/4 mile above the forks, or 4 1/4 miles upstream from the Kananaskis Forestry Road; 37 A was measured near the crest of a minor ridge, 1/5 mile northwest of 37 B, directly along the strike. The exposures are fair. The Yahatinda beds were sampled at 5-foot intervals for laboratory study. The Pika and Cairn beds are of typical and familiar facies and were not sampled.

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
	Section 37 A		
	Fairholme Group (Cairn Formation)		
	The units described below are recessive at the base, becoming resistant upward.		
6	Limestone as below, but thick-bedded, massive, with silicified stromatoporoids	not measured	
5	Limestone, brown, very fine crystalline, dolomitic to very dolomitic, laminated to 1-foot beds, weathers brown	10 1/2	87 1/2
4	Covered	5	77
3	Limestone, dolomitic, as unit 1	2	72
2	Limestone, pelletoid, with dolomitized matrix; massive, cream-weathering	1	70
1	Limestone, dark grey, dense, partly with clastic fabric, dolomitic; mainly laminated, platy, brown-weathering	5	69
	Contact concealed		
	Total thickness of Cairn Formation measured .	23 1/2	

Unit		Thickness in Feet Unit	Total from Base
	Yahatinda Formation		
3	Shale as unit 1, very recessive, poorly exposed	2	64
2	Covered	1 1/2	62
1	Shale, yellow, earthy, calcareous, soft laminated, platy	2 1/2	60 1/2
	Contact concealed		
	Total thickness of Yahatinda Formation	6	
	Pika Formation		
	The units described below are moderately recessive relative to the Eldon and Cairn formations.		
6	Poorly exposed. Shale grey, yellow-weathering, deeply weathered, with a few thin beds of limestone, grey, very fine grained. This interval yields slabs of limestone with abundant trilobite remains	9	58
5	Limestone, thin-bedded, as unit 1, but partly to completely altered to dolomite, grey, very fine crystalline, calcareous, orange-weathering	2 1/2	49
4	Mainly covered (shale as below?). In the middle, 3 inches of limestone flat-pebble conglomerate overlying 8 inches of thin-bedded limestone as below	6 1/2	46 1/2
3	Limestone, thin-bedded, as unit 1	5	40
2	Covered	5	35

Unit		Thickness in Feet Unit	Total from Base
1	Limestone, dark grey, fine-grained, with abundant argillaceous-dolomitic mottlings and partings; beds are 1 inch and less thick, flaggy	30	30
	Gradational contact		
	Total thickness of Pika Formation	58	

Eldon Formation

Limestone, very fine grained and microcrystalline, dolomitic, partly pellet-sparite, and dolomite, fine- and very fine crystalline, calcareous; mottling widespread; beds 1-inch thick at top, thickening down-section, but lacking the argillaceous partings of the Pika Formation.

Massive and resistant in comparison with the Pika ..... not measured

Section 37 B

Fairholme Group—Cairn Formation

Poorly exposed, not measured. Beds corresponding to Cairn Units 1 to 6 of Section 37 A.

Yahatinda Formation

The units described below are recessive, but less so than the basal Cairn beds.

5	Breccia; angular fragments of clay, soft, yellow, porous, typically as semi-aligned prisms 2 inches x 1 inch, and smaller, in a matrix of limestone, light grey, micro-crystalline, locally with pin-point vugs; outcrop is honeycombed by differential weathering; thickness variable	6	41

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
4	Dolomite, grey, microcrystalline, very argillaceous, massive and conchoidal-fracturing at base, becoming irregularly platy upwards; weathers buff; questionable mud-cracks	5 1/2	35
3	Dolomite (dolsiltite?), brick-red, pinkish buff, and mottled, micro-crystalline, very argillaceous; mainly shaly, minor massive, partly colour-laminated; colour is very impersistent laterally; at top and 1 1/2 feet below top, 2-inch and 1-inch beds of shale, green, yellow, spattered with purple-red, very dolomitic	7 1/2	29 1/2
2	60% dolomite as below; 40% dolomite, purple-red mottled with white, buff, or pink, microcrystalline and very fine crystalline, partly dolarenite and dolsiltite, partly silty, very argillaceous, grading to mudstone and shale, very dolomitic; rare calcite-filled vugs; near top, 6-inch bed of dolomite, white to yellow, fine inequicrystalline with abundant inter-crystalline clay, vuggy	12	10
1	Dolomite, light greenish grey, partly spattered with red, very fine crystalline (dolarenite ?), silty, very argillaceous, grading to shale, very dolomitic; alternately massive and platy to shaly; weathers yellowish buff	10	10
	Contact planar, fairly sharp, slightly sheared.		
	Total thickness of Yahatinda Formation	41	

Unit	Thickness in Feet: Unit	Thickness in Feet: Total from Base
Eldon Formation		
Dolomite, grey, massive, resistant	not measured	

(Note: this section contains no equivalents of the 58 feet of Pika beds present in Section 37 A, nearby).

9. "END MOUNTAIN", NORTHEAST SPUR (SECTION 38)
(Lat. 51°12'N, Long. 115°07'W)

The section described below (see No. 38, Fig. 7), was measured at timber-line on the northeast spur of "End Mountain",[1] overlooking the "Dry Fork" of Ghost River. The rocks are well exposed.

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
	Fairholme Group—Cairn Formation		
2	Dolomite, brown, very fine crystalline, fetid, partly medium bedded, massive, partly laminated, platy	not measured	
1	Covered	17	131 1/2
	Yahatinda Formation		
10	Dolomite, light grey with minor purple laminae, microcrystalline and very fine inequicrystalline (partly dolsiltite and dolarenite?), argillaceous, very silty; flaggy, weathers buff	5 1/2	114 1/2
9	Dolarenite and dolsiltite, mainly grey to buff, minor red to purple, partly very silty and sandy; rubbly, very poorly exposed	29	109
8	Dolsiltite and dolarenite, brick-orange and purple-red, minor buff to white and greenish white, commonly mottled; silty to very silty, argillaceous; minor siltstone, dolomitic; mainly thin bedded, chippy, rubbly	30 1/2	80

[1] This is the "End Mountain" of Clark (1954), Patterson and Storey (1962), and others, not the mountain 1 1/2 miles to the west, so identified on 1:50,000 map-sheet 82 O/3 East.

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
7	Pebble-conglomerate, purple-red, pebbles of dolomite and dolarenite in a matrix of dolarenite; fragments of (fish) bone	1	49 1/2
6	Dolarenite and dolsiltite, purple-red, brownish red, very argillaceous; partly massive, partly shaly	7 1/2	48 1/2
5	Dolarenite, purple-red, some beds, laminae, and mottles bleached to buff; generally argillaceous, very silty, partly sandy, partly pebbly, rare grains of glauconite; alternately massive and crudely platy; at top, prominent maroon Liesegang rings due to weathering	14 1/2	41
4	Conglomerate-breccia, as unit 7, but coarser	1 1/2	26 1/2
3	Dolarenite, purple-red, very fine to very coarse grained, argillaceous, very silty, partly sandy, very rare glauconite pellets; thin- and medium-bedded	8 1/2	25
2	Dolarenite as unit 3 with a 6-inch and a 12-inch bed of breccia-conglomerate; angular to subrounded cobbles of Cambrian dolomite reach a maximum diameter of 6 inches	6	16 1/2
1	Covered	10(?)	10
	Total thickness of Yahatinda Formation	114 1/2	
	Underlying beds—Pika Formation	(not measured)	

10. WINDY POINT (SECTION 40)
(Lat. 52°16'N, Long. 116°24'W)

The following section (No. 40, Figs. 3 and 4) was measured at exposures directly uphill from the site of the McDermott-Triad Cline River No. 9-17 well, on the north bank of the North Saskatchewan River in lsd. 9, sec. 17, tp. 38, rge. 17, W. 4th mer., just east of Windy Point. Exposures are good.

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
	Fairholme Group—Cairn Formation		
2	Dolomite, brown, crystalline, containing abundant large tabular 1-inch-thick bodies of black chert and abundant silicified stromatoporoids; very massive, cliff-forming	20+	333
1	Covered	35	313
	Lynx Formation (upper division)		
	The units described below form bold, persistent cliffs.		
11	Dolomite, grey, light brown, fine- and very fine crystalline, scattered vugs; non-bedded, grey-weathering, massive	23	278
10	Dolomite, light grey, light yellowish and pinkish grey, fine- and very fine crystalline, minor microcrystalline, mostly silty, with laminae and rare thin beds of siltstone; laminated, massive; 23 feet and 37 feet above base, 10-inch beds of sandstone, grey to yellowish white, very fine grained, very dolomitic	84	255

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
9	Dolomite, light brown and brownish grey, fine-crystalline to microcrystalline, partly sandy; laminated and cross-laminated, massive; lenticles and very thin beds of dark grey chert occur at intervals	25	171
8	Sandstone, as unit 6	1	146
7	Dolomite, light brown, mottled, very finely crystalline, relict pelletoid fabric; also dolomite, yellowish grey, microcrystalline, silty, grading to dolomitic siltstone; blebs of grey chert at base	12	145
6	Sandstone, very light yellowish grey, fine-grained, poorly sorted, low roundness and sphericity, very dolomitic	1	133
5	Dolomite, brownish grey, very fine and microcrystalline, mostly silty to very silty; laminated, massive, dark-grey weathering, monotonous	32	132
4	Dolomite, very silty, and siltstone, dolomitic, brownish grey to purplish brown, microcrystalline; laminated and cross-laminated, some ripple-marks, weathers grey and buff	40	100
3	Dolomite, grey, greyish brown, fine- and very fine crystalline, silty, interbedded, inter-laminated and inter-lensed with siltstone, brown, greyish brown, dolomitic; laminations disturbed, wavy; unit is massive, weathers mottled brown; 17 feet above base, a horizon of hemispherical stromatolites with 6 inches relief	50 1/2	60
2	Shale, grey, red, green, mottled, very dolomitic, very compact, conchoidal fracture	1	9 1/2

Unit		Thickness in Feet Unit	Total from Base
1	Dolomite, yellowish and brownish grey, fine- and very fine crystalline, also inter-laminated and inter-lensed dolomite and siltstone as unit 3; unit is capped by a layer of egg-shaped stromatolites one foot high; oolitic dolomite locally present at base to a maximum thickness of 8 inches	8 1/2	8 1/2
	Sharp contact with underlying recessive shales		
	Total thickness of upper Lynx	278	

Lynx Formation (lower division)

The section was continued downward to the top of the Pika Formation. Trilobites were collected from the lower Lynx, 133, 205, and 230 feet below the base of the upper Lynx (G. S. C. Localities Nos. 52578 to 52580, inclusive).

11. WHITERABBIT CREEK (SECTION 46)
(Lat. 52°03'N, Long. 116°21 1/2'W)

The following section (see No. 46, Fig. 3) was measured on the northwestern termination of the ridge separating Whiterabbit Creek and Siffleur River, near the junctions of these streams with North Saskatchewan River. The actual line of measurement is in the bottom of a gully which drains westward into a strike-gully eroded in the Flume Formation. The strata dip southwesterly at 55 to 60 degrees. Exposures are fair to good. Lithologic descriptions are based on field examination supplemented by laboratory examination of representative specimens.

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
	Fairholme Group (Flume Formation)		
	The uppermost of the units described below is moderately resistant, the remainder moderately to very recessive.		
5	Limestone, brownish grey, dense, dolomitic, massive, with abundant silicified stromatoporoids	7	237
4	Dolomite, alternately grey and brown, very fine crystalline, mainly thick-bedded, massive, with minor flaggy intervals	35	230
3	Breccia; angular fragments of brown dolomite in a matrix of grey dense limestone	2	195
2	Limestone, grey, dense, in thin- to thick-lenticular beds	14	193
1	Covered	3	179
	Total thickness of Flume Formation described .	61	

Unit		Thickness in Feet Unit	Total from Base
	Mons and Sarbach Formations (?), undifferentiated		
	The units described below are resistant, and form a narrow ridge.		
9	Dolomite, grey, pink, mottled, fine-crystalline, microcrystalline at top, slightly to very silty, partly argillaceous, partly stromatolitic; mainly very thick bedded, massive, with a few flaggy beds at top	46 1/2	176
8	Dolomite, grey, buff, commonly red-mottled, fine- and very fine crystalline, partly slightly argillaceous, with earthy appearance; massive, mainly stromatolitic; uppermost bed, and a bed 7 feet above the base, consist of pancake-shaped stromatolites of buff dolomite, whose surface relief is infilled with coarse flat-pebble conglomerate and red, or red- and buff-mottled mudstone-dolomite	13 1/2	129 1/2
7	Dolomite as above, interbedded with patchily grey and maroon shaly mudstone-dolomite	6	116
	Mons and Sarbach Formations, undifferentiated		
	The units described below are unequally resistant, forming a series of narrow strike ridges of the massive units, separated by poorly exposed or non-exposed intervals occupied by the thin-bedded and argillaceous units.		
6	Dolomite, as unit 4; prominent stromatolites	6	110

Unit		Thickness in Feet Unit	Total from Base
5	Dolomite; fine pink rhombs with abundant intercrystalline green clay, partly silty; platy to flaggy, tan-weathering; poorly exposed near base	18	104
4	Dolomite, grey, very fine crystalline, thin-bedded, laminated; weathers buff-grey; obviously derived from thin-bedded limestone as in the underlying unit; interrupted by thick massive beds of fine crystalline dolomite, partly flat-pebble conglomerate, capped by hemispherical stromatolites	32	86
3	Poorly exposed; limestone as unit 1	13	54
2	Covered	9	41
1	Limestone, grey, very fine grained, thin-bedded, with tan-weathering argillaceous partings; several horizons of cabbage-like stromatolites composed of dense grey limestone; a few beds of flat-pebble conglomerate; some ripple-marked beds; poorly exposed in uppermost 10 feet	32	32
	Total thickness of Mons-Sarbach described (including units 7 to 9)	176	

Measurement was continued downward through the typical "Mons" putty-coloured, fossiliferous shales into the top of the upper division of the Lynx Formation. The total thickness of the Mons-Sarbach, undifferentiated, including units 7 to 9, is 647 1/2 feet.

12. CHANNEL-FILLING BEDS, TYPE LOCALITY OF "GHOST RIVER FORMATION" (SECTION 61) (Lat. 51°18 1/2'N, Long. 115°12'W)

Reference Section of the Yahatinda Formation

The section described below (see No. 61, Fig. 6) was measured and sampled in detail in a shallow gully about 300 yards south of the line of the type section of the Ghost River Formation (No. 62, Fig. 6, and Fitzgerald, 1962b). In contrast to Fitzgerald's section, which contains 137 feet of Lynx beds, this section contains only 43 feet of Lynx. On the other hand, basal Devonian red beds (Yahatinda Formation) are 73 feet or more thick in this section, and only 5 feet thick in the former. These relationships are explained as follows: the missing Lynx beds were cut out at a channel at the base of the Devonian, and the extra-thick Yahatinda section accumulated in this channel.

The section is described in two parts, A and B. In section A, which reveals the greater thickness of Yahatinda beds, the Cambrian-Devonian contact is covered. In section B, about 100 feet north of A, the Cambrian-Devonian contact is well exposed, along with 43 feet of Lynx beds which underlie it, but 13 feet or more of basal Yahatinda beds are missing by non-deposition (see Fig. 6). Exposures along the line of section are good, but elsewhere in the vicinity are generally very poor.

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
	Section A		
	Fairholme Group (Cairn Formation)		
4	Dolomite, brown, very fine crystalline, fetid, very thick bedded, massive; abundant silicified stromatoporoids; cliff-former, weathers brown	not measured	
3	Dolomite, brown, very fine crystalline, fetid, partly with various intraclast fabrics; small blebs of chert common; rare silicified small stromatoporoids; medium- and thin-bedded, massive, flaggy, platy	18	145

Unit		Thickness in Feet Unit	Total from Base
2	Dolomite, brownish grey, yellowish grey, microcrystalline, partly calcareous, partly very argillaceous; laminated, partly with apparent organic burrows, thick-bedded, massive, weathers yellow and light grey	7	127
1	Covered. Interval apparently includes some Yahatinda beds	47	120
	Total thickness of Cairn Formation measured less than	72	

Yahatinda Formation

The units described below are moderately recessive and generally covered by talus from the Cairn Formation.

6	Covered. See unit 1 above.		
5	50% dolarenite, maroon, pinkish grey, greenish grey, poorly sorted, very silty, argillaceous, partly laminated; thick-bedded, crumbly; 50% siltstone, light grey, pink, purple-red, argillaceous, very dolomitic, commonly with chips of green shale and maroon mudstone, very thin bedded, platy, weathers red and yellow; 4 feet below top, an 8-inch bed of dolomite micro-breccia	23 1/2	73
4	Siltstone yellow-grey, argillaceous, dolomitic, largely laminated and cross-laminated, medium-bedded, flaggy, yellow-weathering, and dolarenite, light yellow-grey, very fine grained, silty and sandy; minor beds of shale, grey, soft, silty, platy, with abundant reed-like plant impressions	16 1/2	49 1/2

Unit		Thickness in Feet Unit	Total from Base
3	Dolarenite, pinkish grey mottled with maroon, partly deep purple-red, very argillaceous; scattering of grains of quartz sand and silt, very rare glauconite grains; rare beds of fine dolomite breccia; scour-and-fill structure common; mostly thin bedded, laminated, massive; maroon Liesegang rings developed by weathering; one boulder of Cambrian dolomite, 2 1/2 feet in diameter	21	31
2	Dolarenite as below, with several thin beds of breccia; unsorted, angular blocks up to 6 inches x 1 inch of Cambrian dolomite and siltstone, in a matrix of finer breccia and dolarenite	3	10
1	Dolarenite, purple-red, argillaceous, sandy, and siltstone, purple-red, dolomitic; thin- and medium-bedded, commonly laminated; cross-bedding and cut-and-fill common; rare "floating" cobbles of Cambrian rocks; very rare hematite-replaced plant fragments	7	7
	Base of Yahatinda not exposed.		
	Total thickness of Yahatinda Formation more than	73	

Section B

Yahatinda Formation

4	Same as unit 4 of Section A	not measured	
3	Same as unit 3 of Section A	18 1/2	61 1/2

Units 1 and 2 of Section A are missing.

Unit		Thickness in Feet Unit	Total from Base
	Erosional contact; enlargement of fractures by solution; brecciation; collapse; introduction of green shale and maroon mudstone along fissures and into solution-openings; underlying rocks locally stained red; 3 feet of erosional relief visible in outcrop.		
	Lynx Formation		
	(For detailed description of numbered members, see Appendix, p. 80).		
3	Dolomite, largely silty, and minor siltstone, dolomitic; here modified by weathering (see above)	30 1/2	43
2	Silty shale, here maroon in colour with green alteration along cracks; this colour-modification is attributed to pre-Yahatinda weathering	1 1/2	12 1/2
1	Dolomite, silty, and siltstone; thin inter-beds and partings of shale; here both shale and siltstone are red in colour; the anomalous colour is attributed to Devonian weathering	11	11
	Total thickness of Lynx Formation present	43	
	(Compare with 137 feet of Lynx present 300 yards to the north at Fitzgerald's section).		
	Arctomys Formation (Covered)		

13. HUMMINGBIRD CREEK (SECTION 70)
(Lat. 52°04'N, Long 116°13'W)

The following section (see No. 70, Fig. 4), was measured in the Second Range, immediately southeast of the north fork of the main branch of Hummingbird Creek. Sections in the immediate vicinity have been briefly described by Harker, et al. (1954, p. 55). The field description was supplemented by laboratory examination of representative specimens.

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
	Fairholme Group—Cairn Formation		
	The units described below grade from moderately cliff-forming above to recessive below.		
3	Limestone, brown, pelletoid, dolomitic, with sparse silicified small stromatoporoids	4	414 1/2
2	Dolomite, brown, fine and very fine crystalline, fetid, partly calcareous, laminated, medium-bedded	8 1/2	410 1/2
1	Conglomerate. Matrix is limestone, grey, microcrystalline; clasts, angular and subangular, rarely subrounded, are mainly of limestone, grey and pink, microcrystalline, dolomitic, and of dolomite very similar to unit (1) (below), but calcareous and porous; clasts present in minor quantity are dolomite, brown, very fine crystalline, euhedral, and shale, light green, weathered. The clasts are unsorted; largest seen were 2 1/2 inches in diameter, equant, and a 5-inch by 1-inch slab	12	402
	Total thickness of Cairn Formation measured ..	24 1/2	

Unit		Thickness in Feet Unit	Total from Base
	Yahatinda Formation		
	The units described below are very recessive.		
2	Covered	4	390
1	Dolomite, grey, argillaceous, with unsorted clastic fabric, partly pebbly; thin- and medium-bedded, with several very thin shaly beds; one small fish-bone fragment	6	386
	Abrupt lithologic change.		
	Lynx Formation (upper division)		
	The units described below are mainly strongly cliff-forming, becoming less so towards the top of the formation.		
13	Dolomite, as unit 11	20 1/2	380
12	Dolomite, maroon to grey, microcrystalline, slightly argillaceous, laminated; colour laterally impersistent	10	359 1/2
11	Dolomite, grey to near-white, fine- and very fine crystalline, slightly silty, monotonous, non-bedded, massive; locally stained pink, especially at top; top 2 feet locally flat-pebble conglomerate	39 1/2	349 1/2
10	Dolomite, purple-red grading to grey, very fine crystalline, slightly argillaceous, thin-bedded, flaggy, pink-weathering; 4 inches of relief on scoured base of unit.	5	310
9	Dolomite as below, but medium-bedded; locally stained pink in patches	13	305

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
8	Dolomite, light grey, mottled in greys, very fine crystalline, non-bedded, massive, grey-weathering, very monotonous	41	292
7	Dolomite, grey and pinkish grey, mottled (spattered) with purple, very fine crystalline, very argillaceous; weathers purplish buff; a single massive bed	3	251
6	Dolomite, mottled in greys, fine crystalline, massive, grey-weathering, uniform	9	248
5	Dolomite, grey, subordinate pink, very fine and microcrystalline, laminated, slightly flaggy; at base only, very rare lenticles of white chert; grey-weathering, very monotonous	99	239
4	Dolomite, grey, minor pinkish grey, mainly microcrystalline and aphanitic, very silty, grading to siltstone; laminated, massive, weathers light grey; several thin beds dark grey chert; 8 to 12 feet above the base, much sandy dolomite and chertified sandy dolomite	35	140
3	Dolomite, grey and light grey, very fine and fine-crystalline, very slightly silty, laminated, massive, weathers pitted cream-grey	30	105
2	Dolomite, grey and grey-brown, partly pink-spotted, very fine to fine-crystalline, mostly silty to very silty; mainly thin-bedded, very massive, grey-weathering;		

Unit		Thickness in Feet Unit	Total from Base
	chert, largely pink, in blebs and stringers, common in uppermost 50 feet, especially abundant in uppermost 10 feet; the very silty beds are thin, laminated, partly ripple-marked	62	75
1	Dolomite, pinkish grey and grey with pink spots, fine crystalline, relict calcarenitic fabric, oolitic at base; massive, locally crossbedded	13	13
	Unit 1 overlies structurally disturbed beds above a major thrust fault.		
	Total thickness of upper Lynx beds described ..	380	

14. CLEARWATER RIVER (SECTION 72)
(Lat. 51°52'N, Long. 115°54 1/2'W)

The following section (see No. 72, Fig. 4), was measured on cliffs overlooking Harrison Flats, on the north side of Clearwater River, two miles downstream from the mouth of Peters Creek.

Exposures are excellent. Lithologic descriptions are based on examination in the field.

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
	Fairholme Group—Cairn Formation		
	The uppermost of the units described below is moderately cliff-forming, the remainder moderately recessive.		
3	Limestone, brown, pelletoid, massive; abundant partly silicified stromatoporoids	not measured	
2	Limestone, brown, dense, platy; first appearance of *Amphipora* 4 feet above base	10	574
1	Limestone breccia, poorly exposed at top	25	564
	Total thickness of Cairn Formation measured	35	

Basal contact of Cairn Formation appears planar in poor, intermittent exposures. Beds above and below the contact are parallel. No red coloration is present in the underlying beds. Rare pipes of dolomite-block breccia, cemented with muddy dolomite, extend to a maximum of 29 feet below the base of unit 1, above. These pipes are interpreted as effects of pre-Cairn solution-weathering.

Unit		Thickness in Feet Unit	Total from Base
	Lynx Formation (upper division)		
	The units described below form persistent cliffs broken by ledges.		
12	Dolomite, grey, microcrystalline, very thick bedded, laminated, massive, grey-weathering, very monotonous	38	539
11	Dolomite, light grey, largely aphanitic, with several zones of sandy dolomite, and laminae and discontinuous thin beds of medium-grained sandstone; prominently laminated, massive, weathers cream-coloured	24	501
10	Dolomite, grey, microcrystalline, thick bedded, massive, becoming prominently laminated at the top; a zone 10 to 15 feet above the base contains numerous large flattened spheroids of white chert	31	477
9	Dolomite, grey, microcrystalline, thick-bedded, commonly laminated, massive, grey-weathering; abundant blebs and rare lenses of chert, light grey to white; zones 4 to 5 and 16 to 20 feet above the base contain much sandy dolomite and thin beds of sandstone, medium-grained, dolomitic	20	446
8	Dolomite, grey, very fine and microcrystalline, thick-bedded, partly laminated, massive; weathers grey, pitted	57	426
7	Dolomite, grey, microcrystalline, largely silty, and siltstone, dolomitic; laminated, massive, stringers of silicified siltstone weather in relief	6	369

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
6	Dolomite as below, but lacking chert	37 1/2	363
5	Dolomite, grey, microcrystalline and very fine crystalline, very thick bedded, massive, interrupted by numerous intervals of dolomite, grey, microcrystalline, cream-weathering, displaying strong lamination and contorted lamination. Sparse blebs and nodules, and very rare thin beds of light-coloured chert, occur in the non-laminated dolomite	61 1/2	325 1/2
4	Dolomite, grey faintly mottled with purple, microcrystalline; non-bedded, massive, buff-weathering; "stacked" wavy laminae suggest stromatolites; grades upward to dolomite, grey speckled with rusty-red, very fine crystalline, with scattered blebs of quartz	44 1/2	264
3	Dolomite, grey, partly mottled in greys, mainly fine crystalline, massive	64 1/2	169 1/2
2	Dolomite, light grey, fine crystalline as below, alternating with intervals of dolomite, pink to lavender below, very light grey above, microcrystalline, argillaceous, laminated, recessive	17	155
1	Dolomite, grey, microcrystalline, mainly with relict calcarenitic fabric; very thick bedded, massive, grey-weathering; locally crossbedded and cross-laminated; about 75 feet above the base, a zone with quartz-filled vugs; towards the top, the dolomite becomes partly light grey, fine equicrystalline	138	138

Unit	Thickness in Feet Unit	Total from Base
Total thickness of upper Lynx measured	539	

Underlying beds—Lynx Formation (lower division)

Measurement of the section was continued downward to, and including, an incomplete section of the Pika Formation.

15. DESCRIPTION OF THIN, PERSISTENT LITHOLOGIC UNITS COMPRISING THE LYNX FORMATION, GHOST RIVER AREA

(Based on measured sections 57 and 64, see Fig. 6)

Unit		Thickness in Feet: Unit	Thickness in Feet: Total from Base
	Lynx Formation (upper division)		
9	Dolomite, light grey and pinkish grey, very fine and microcrystalline, relict oolitic fabric; thick-bedded, massive, weathers cream-grey; resistant cliff-former	10+	
8	Dolomite, grey yellowish grey, pinkish grey, mainly very fine crystalline, silty, grading to dolomitic siltstone; relict calcarenitic fabric near top, locally pebbly, commonly sandy in middle part; partly laminated, convoluted laminations common; thick-bedded, massive, weathers yellow-orange, with small irregular siltstone bodies in relief; resistant cliff-former	68 (max.)	
7	Dolomite, light grey and yellow-grey, locally tinged or speckled with pink, very fine and microcrystalline, very slightly argillaceous; rare thin beds of siltstone; thick-bedded, massive, weathers cream-coloured, smooth; resistant cliff-former	12	25
6	Mainly siltstone, grey, grey-brown, locally pink-tinged, dolomitic; ripple-marked, very lenticularly thin-bedded, cross-laminated; minor silty dolomite; basal 5 feet contains very thin beds of shale, black and green-grey, silty; resistant cliff-former	13	31

Unit		Thickness in Feet Unit	Total from Base
Note:	Because the (6) - (7) and (7) - (8) contacts are based on proportion of siltstone, rather than on absolute characters, they are less definite than other contacts; this is reflected in the variable thicknesses of units 6, 7, and 8.		
	Lynx Formation (lower division)		
5	Shale, light brownish grey, very dolomitic, silty, grading to very argillaceous dolomite; chippy above, platy below; minor thin beds of dolomite, grey to brown, silty, cross-laminated, grading to siltstone; recessive	19	22
4	Dolomite, mainly pink, minor pinkish grey and grey, micro-crystalline, partly argillaceous, partly with laminae of siltstone; several very thin beds of platy dolomitic shale; several beds in the interval contain nodules of chert, white, light grey, pink, normally with well-preserved calcarenitic and/or oolitic fabric; topmost cherty horizon locally contains silicified stromatolites; interval is thin- to medium-bedded, flaggy to massive, weathers yellow, locally pink; moderately resistant	10	19
3	Dolomite, grey, pinkish grey in upper half, very fine and micro-crystalline, slightly silty and argillaceous; rare thin (1/4-inch) lenticular laminae and lenses of grey chert; minor beds of siltstone; mainly thick-bedded, massive, with very minor flaggy and shaly interbeds; weathers cream-coloured, smooth; resistant cliff-former	27	29

Unit		Thickness in Feet: Unit	Total from Base
2	Shale, brown, fissile, with abundant laminae of grey siltstone; recessive	1	2
1	Dolomite, light grey, brown, microcrystalline, very silty; abundant laminae, small lenses, and burrow-fillings of siltstone, dolomitic; thin interbeds of black shale; resistant cliff-former	11	13

Underlying beds: Arctomys Formation (recessive)

The above units correspond to the units described by Fitzgerald (1962b) as follows:

Units (this Paper)	Units (Fitzgerald)
9	not present
6, 7, 8	14, 15, 16
5	12, 13
4	11
1, 2, 3	8 (part), 9, 10
Arctomys	4 (part), 5, 6, 7, 8 (part).