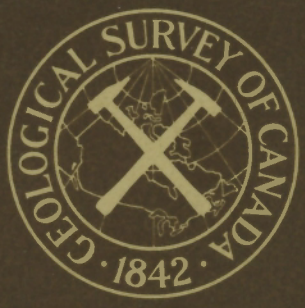

GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

PAPER 60-19

VIRGINIA FALLS AND SIBBESTON LAKE MAP-AREAS, NORTHWEST TERRITORIES

95F and 95G

Report, Map 22-1960 and Map 23-1960

R. J. W. Douglas and D. K. Norris

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CANADA

CONTENTS

Illustrations

VIRGINIA FALLS AND SIBBESTON LAKE MAP-AREAS, NORTHWEST TERRITORIES

INTRODUCTION

Virginia Falls and Sibbeston Lake map-areas are situated in southwestern District of Mackenzie, Northwest Territories. Sibbeston Lake map-area is bounded by latitudes 61 and 62°N, and longitudes 122 and 124°W. Virginia Falls map-area lies to the west between longitudes 124 and 126°. These map-areas form part of the region investigated geologically in 1957 on Operation Mackenzie, a general account of which has been published (Douglas, 1959a)[1].

Officers of the Geological Survey on Operation Mackenzie were W.B. Brady, B.G. Craig, R.J.W. Douglas, P. Harker, D.J. McLaren, A.W. Norris, D.K. Norris, B.R. Pelletier, and D.F. Stott. They were assisted in the field by D.A. Andrews, F.J.A. Arthur, R.K. Broeder, K.P.R. Cole, W.N. Hamilton, I.M. Harris, R.N. McCowan, D.B. McKennitt and J.B. Read. Crew of the helicopters, supplied by Associated Helicopters Ltd., were N.R. Staniland, R. Huff, J. Brochu, and R. Barnes, and crew of the Beaver aircraft, supplied by Pacific Western Airlines Ltd., were W. McKinney and J. Furber. A boat and barge were operated by G.P.J. Turner and D. Turner. Other members of the party included W.T. Spratt, radio operator; and E.A. Konisenta, H. Martell and M. McKay, canoemen. To all these men, the writers and other officers of the party extend their appreciation.

The geology of both map-areas was mapped and compiled jointly by the authors. Exposures of the Cretaceous rocks were examined by D.F. Stott, and the descriptions here are summarized from his report (Stott, in press). The Carboniferous and Permian strata were examined by P. Harker and W.B. Brady. Descriptions of these strata are taken mainly from a report by Harker (in preparation). Devonian and older rocks were examined within the map-areas by D.J. McLaren, A.W. Norris, B.R. Pelletier and P. Harker; their descriptions are summarized here.

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

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PHYSICAL FEATURES

Virginia Falls and Sibbeston Lake map-areas include part of the western Interior Plains, the southern elements of Franklin Mountains, Mackenzie Plain, and Mackenzie Mountains and, south of South Nahanni River, the northern elements of Liard Plateau (Bostock, 1948). The northern limit of Liard Plateau is placed by Bostock at South Nahanni River and Flat River. In this report, some ranges of Mackenzie Mountains are tentatively considered to extend south of South Nahanni River. A short distance west of Virginia Falls map-area are the Hyland Plateau and Selwyn Mountains of the Western Cordillera. The map-areas, accordingly, nearly span the Eastern Cordillera, which at this latitude is about 100 miles wide.

Eastern Sibbeston Lake map-area includes the western part of the Interior Plains which terminate abruptly against the eastern scarp of Nahanni Range. The Plains are crossed by Liard River which flows through a broad flood plain that narrows rapidly near the eastern border of the map-area as the low canyon of Liard Rapids is approached. Liard River is navigable by low draught boats between Fort Nelson, British Columbia, and Fort Simpson at the junction of the Liard and Mackenzie Rivers. The settlement of Nahanni Butte, which includes two trading posts, is at the junction with South Nahanni River.

On the Plains southeast of Liard River, a prominent scarp attains an elevation of 1,247 feet and is underlain by southeast-dipping upper Devonian strata. Three flat upland areas occur north of the river; the highest, known as Martin Hills, attains an elevation of 2,271 feet. It is underlain by Cretaceous strata with a resistant sandstone forming the crest, and is bounded on all sides by gentle slopes. The remaining part of the Plains, which is 500 to 1,000 feet in elevation, is mainly swampy ground studded with several shallow lakes. It is drained by a number of stream elements tributary to Liard River in the south and to Mackenzie and North Nahanni Rivers in the north. The Plains are heavily wooded. Exposures of bedrock are rare, being restricted to the larger rivers and the higher escarpments.

Nahanni Range, the southernmost range of the Franklin Mountains, is 80 miles long and lies mainly within Sibbeston Lake map-area. The range is narrow, attaining a maximum width of 4 miles and elevations of 4,000 to 4,500 feet. It is formed of hard, massive and resistant carbonates which support little vegetation.

Southern Mackenzie Plain is about 30 miles wide and is carved in soft shales and sandstones. This generally low land is interrupted by the Ram Plateau which reaches elevations of over 5,000 feet. Ram Plateau is deeply dissected, particularly where traversed by Ram River, with the drainage elements being deeply incised in steep-walled canyons carved in massive, grey and dark grey carbonates. The upper surface of the Plateau is a structural surface, stripped bare of the more readily eroded shales. Many abandoned river channels occur west of Ram Plateau. These probably represent channels of former north-flowing rivers that formed marginal to the ice-front of continental glaciers occupying the Interior Plains and the eastern part of Mackenzie Plain.

Mackenzie Mountains comprise several diverse physiographic elements that impart a pronounced north-south grain to the country. Prominent among these is the Nahanni Plateau, the easternmost division. Nearly flat lying rocks underlie the Plateau, and variations in the physical nature of these rocks contribute greatly to variations in the physiography of the region. In general, most of the Plateau is deeply dissected. The higher parts carry little vegetation. West of Nahanni Plateau are several north-trending ranges, which are named on the map. These ranges reach elevations of 5,000 to 6,000 feet. They are in part rugged and bare but mainly rather subdued and partly to completely vegetated. Within western Mackenzie Mountains some ranges trend east-west, divided by the valleys of South Nahanni and Flat Rivers or by Clearwater Basin, a tree-covered intermontane basin carved in soft rocks.

South Nahanni and Flat Rivers form the boundary between Mackenzie Mountains and Liard Plateau (Bostock, 1948). Their headwaters are in the Selwyn Mountains of Yukon. South Nahanni River flows southeasterly for 250 miles and joins Liard River at Nahanni Butte. For the lowest 25-mile stretch of its course the river flows in several channels through a wide gravel-covered valley, between grass- and tree-covered hills. Hot springs occur on the south bank near the entrance to First Canyon. This sombre canyon is 12 miles long and is cut to a depth of 3,500 feet in flat-lying, banded, dark strata forming the southern end of Nahanni Plateau. Beyond, through Deadman Valley, the river flows in several channels for about 8 miles before entering Second Canyon which is 4 miles long and is cut 4,000 feet deep through Headless Range. Third Canyon traverses Funeral Range for 12 miles; for most of its length it is cut to depths of 3,000 to 4,000 feet. At The Gate, South Nahanni River passes through a narrow, vertically walled gorge cut in varicoloured rocks. Beyond Third Canyon the South Nahanni is joined by Flat River, the largest tributary from the south. This is a region of open country with forested mountains south and north of the river. Above Virginia Falls—316 feet high and very spectacular—South Nahanni River flows slowly, following a serpentine course through a broad glaciated valley with trees extending to the water's edge.

Liard Plateau south of South Nahanni River is formed of several elements. In the east are the northern peaks of Liard Range which reaches prominence in Fort Liard map-area to the south. Farther west is Yohin Ridge, the approximate northern extension of Kotaneelee Range. These tree- and grass-covered peaks and ridges are composed of orange-weathering sandstone strata. The same strata are nearly flat-lying beneath Tlogotsho Plateau which lies south of Deadman Valley and west of Yohin Ridge. A prominent north- and west-facing scarp marks the edge of the plateau. The more western parts of Liard Plateau are subdued in nature, commonly vegetated, and the bedrock is poorly exposed. This country reflects to a large degree the nature of the underlying bedrock strata which are mainly dark shales or shaly carbonates, in contrast to the more resistant and cliff-forming rocks characteristic of Mackenzie Mountains to the north. Higher parts which trend northerly are nearly barren of trees. They are provisionally treated in this report as ranges, some of which are continuous with ranges in the Mackenzie Mountains to the north.

STRATIGRAPHY

PALAEOZOIC

Lower Palaeozoic (Map-units 1 - 15)

Sunblood Formation (Map-unit 1)

The term Sunblood formation was proposed by Kingston (1951) for the "entire section of Ordovician rocks" in the region of upper South Nahanni River traversed by him. The type section is on Sunblood Mountain, the lowermost beds occurring nearby at Virginia Falls.

The contact with older beds which Kingston referred to the Cambrian is not exposed, although some beds on Flood Creek, a tributary of South Nahanni River, could be older than those at the type section. The Sunblood formation is stated to be overlain by the Ronning, of Silurian age, and to be 2,800 feet thick between the base of Virginia Falls and the top of Sunblood Mountain.

Map-unit 1, as used here probably corresponds closely to the Sunblood formation, although the equivalence of the upper contacts may be in doubt. At Virginia Falls 350 feet of strata were measured comprising nodular- and massive-bedded limestone — dark grey, crypto- to fine-grained—in dark-grey-weathering beds 9 inches to 4 feet thick. Fossils collected are stated by G.W. Sinclair to be Middle Ordovician (Whiterock) in age. These beds are separated from the main section on Sunblood Mountain by a covered interval estimated to be 330 feet. On Sunblood Mountain 2,810 feet of strata were measured, bringing the total thickness of map-unit 1 to 3,490 feet. The succession on Sunblood Mountain consists of dark grey and dark-grey-weathering limestone, with coatings of pink, yellow and orange which give the rock a varicoloured appearance; this alternates with intraformational breccias, bioclastic fossiliferous beds and nodular and platy beds in 2- to 4-inch units or hard beds up to 8 inches thick. Towards the top the bedding becomes more massive. The top of the unit is drawn at a brilliant-orange-coloured limestone which forms the crest of Sunblood Mountain. Fossils are Middle Ordovician (Chazy and Wilderness) in age.

Map-unit 2

Map-unit 2 occurs on Nahanni Range. It is unfossiliferous but may be Ordovician or older as it is overlain by Map-unit 4 of Ordovician or Silurian age. About 500 feet of beds are exposed consisting of dolimite — mottled grey and pink, cryptocrystalline to fine-grained and partly silty — interbedded with grey to pink, fine grained, quartzose sandstone weathering brilliant orange and red. These beds are underlain by the Nahanni thrust.

Map-unit 3

Map-unit 3 overlies map-unit 1 and forms the dip-slope of Sunblood Mountain. It is composed of 2,530 feet of dark grey, rather massive to medium-bedded, fine- to cryptograined, grey-weathering limestone and minor interbedded dark grey shale, siltstone and sandstone. Several massive beds of light grey dolomite—weathering dark grey, and medium- to coarse-grained—occur about the middle of the formation. Fossils identified by G.W. Sinclair are Middle Ordovician (Wilderness and Trenton) in age.

Map-unit 4

Map-unit 4 overlies map-unit 2 on Nahanni Range. The lower part consists of massive, reefy, medium grey, fine-grained dolomites, in part porous and vuggy and containing an Ordovician or Silurian fauna as identified by G.W. Sinclair. The upper part comprises

TABLE OF FORMATIONS*

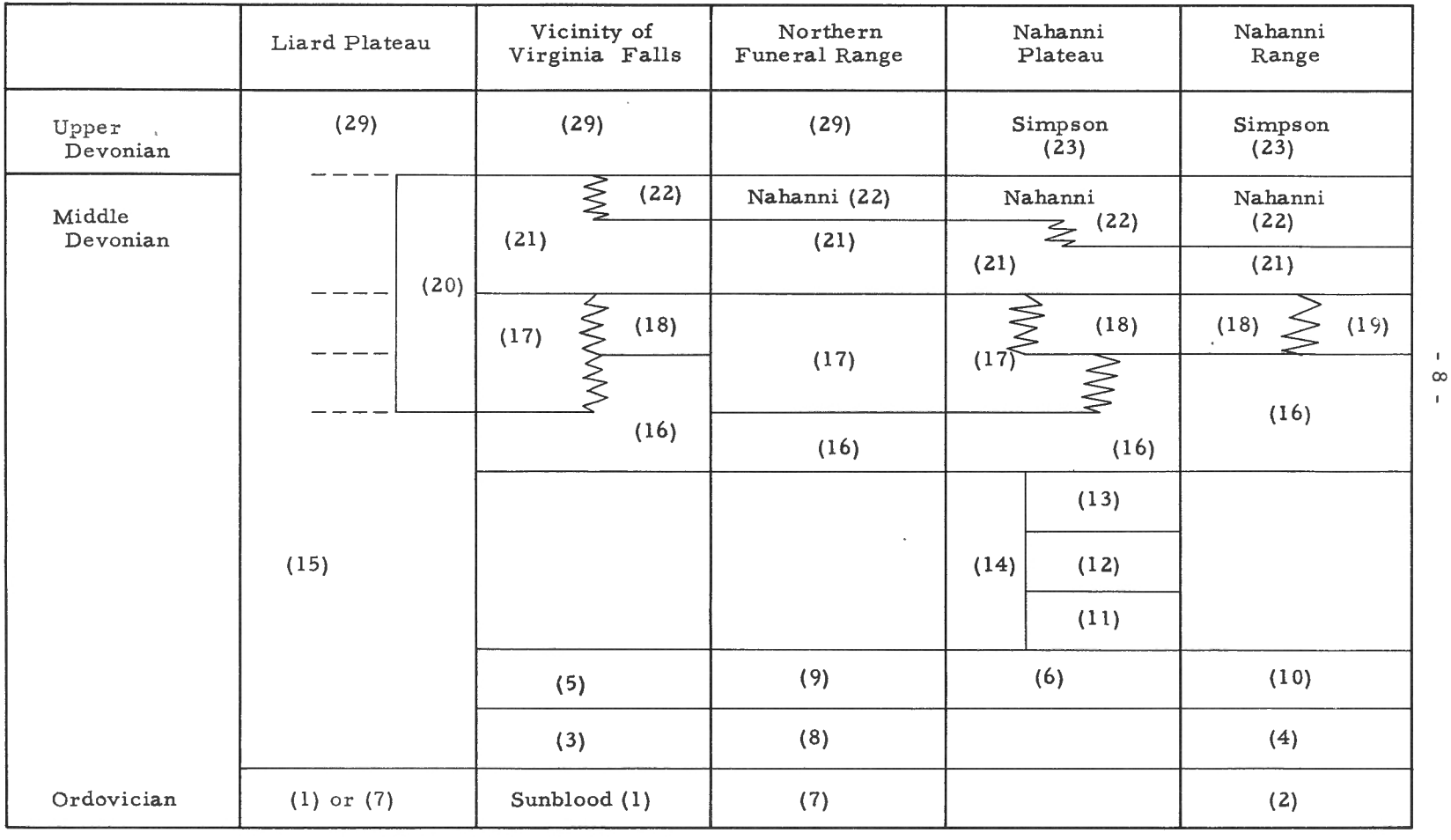
Era	Period or Epoch	Group or Formation (map-unit)	Lithology	Thickness (feet)
Cenozoic	Pleistocene and Recent	(36)	Alluvial sands and silts of Liard and South Nahanni Rivers	
Mesozoic	Upper Cretaceous	Fort Nelson (35)	Sandstone, fine-grained	180+
	Lower Cretaceous	Fort St. John (34)	Shale, grey; and siltstone	1,000±
Palaeozoic	Carboniferous	Mattson (33) Upper (33c)	Sandstone, calcareous limestone, shale	1,230 to 1,740
		Mattson (33) Middle (33b)	Sandstone, massive and thick-bedded	105 to 800
		Mattson (33) Lower (33a)	Sandstone, thinly bedded; shale	960 to 1,220
		(32)	Limestone, crinoidal and argillaceous; shales; sandstone	660 to 1,430
		(31)	Shale, fissile, black; thin limestone	510 to 615
		(30)	Sandstone, thinly bedded; limestone, silty	120 to 600
	Devonian and Carboniferous	(29)	Shale, dark grey (may include equivalents of map-units 23 to 32, and possibly some older beds)	3,000±
	Upper Devonian	(28)	Shale, black, fissile; mudstone; limestone	495+
		(27)	Siltstone, calcareous; mudstone, silty (may be equivalent to map-units 24 to 26)	
		(26)	Limestone, sandy	
		(25)	Limestone, bioclastic, argillaceous, massive, reefy	
		(24)	Shale, dark greenish grey; sandstone, calcareous	
		Simpson (23)	Shale, black, fissile; siltstone, thinly bedded	1,800±
	Middle Devonian	Nahanni (22)	Limestone, bioclastic, thick-bedded; shale; dolomite	310 to 830
		(21)	Shale, dark grey, calcareous; limestone, argillaceous	85 to 980
		(20)	Shale, dark grey, calcareous; limestone, argillaceous (undivided map-units 17 and 21)	
		(19)	Limestone, massive, cryptograined (equivalent to map-unit 18)	

Palaeozoic			(18)	Dolomite, coarsely recrystallized, massive bedded	310 to 540
			(17)	Limestone, argillaceous, thinly bedded; shale, dark grey (equivalent to map-units 16 and 18)	2,550
			(16)	Dolomite, fine-grained, black, banded dark and medium grey	495 to 2,630
	Devonian(?) and older		(15)	Limestone, shale, dolomite, sandstone (may include equivalents of map-units 3, 5, 8, 9, 14, 16, and possibly some younger beds)	
		(14) Undivided	(13)	Dolomite, fine-grained, black to brown, banded light and medium grey	2,370
			(12)	Dolomite, cryptograined, black, banded dark and medium grey	570
			(11)	Dolomite, fine-grained, grey, banded light and medium grey	1,160
			(10)	Dolomite, silty; sandstone	260
			(9)	Thinly bedded shaly beds	1,000±
			(8)	Includes sandstone, coarse-grained	1,000±
			(7)	Includes limestone, grey, orange- and pink-weathering (possibly equivalent to map-unit 1)	3,000±
			(6)	Dolomite, fine-grained, grey; limestone, grey, alternating grey and buff bands	5,020
			(5)	Shale, grey, graptolitic; limestone, thinly bedded, buff-weathering	3,800
			(4)	Dolomite, massive, porous and argillaceous, grey	1,200
			(3)	Limestone, dark grey; dolomite, massive; shale, grey-weathering	2,530
			(2)	Dolomite, cryptograined, pink; sandstone, orange- and red-weathering	500+
			Sunblood (1)	Limestone, cryptograined, thinly bedded, grey, orange, pink- to buff-weathering	3,490

*Relative position of map-units in this table does not necessarily imply relative stratigraphic position

Figure 1

Approximate Stratigraphic Relationships of Middle Devonian and Older Map-units



medium-bedded, fine-grained, medium to dark grey dolomite, variably argillaceous, thinly bedded and laminated. About 800 feet of beds are present at Little Doctor Lake where the base is not exposed. Where underlain by map-unit 3 the beds are about 1,200 feet thick.

Map-unit 5

In the region between Sunblood and Cathedral Mountains (in western Virginia Falls map-area) map-unit 5 consists of shale which is dark grey to black and partly calcareous, interbedded with thin, black cryptograined limestone beds up to 8 inches thick. Part of the shale is fissile and soft. Limestone increases in proportion upwards. The unit is light buff to tan weathering, generally recessive, and forms extensive talus slopes. According to A.W. Norris graptolites of Silurian age occur in the lower part and a shelly fauna of Silurian or possibly Devonian age occurs near the top. Total thickness is 3,800 feet.

Map-unit 6

On Tundra Ridge in western Nahanni Plateau are 5,020 feet of beds underlain by the Tundra Ridge thrust and succeeded by map-unit 11. They are divisible into several units that may be mapped along the ridge, but they were not recognized elsewhere and are accordingly not shown separately. Furthermore the relationship of these beds to map-units in the ranges to the west has not been established with certainty.

The basal 600 feet consists of massive to evenly thick-bedded, cliff-forming, grey-weathering limestone—cryptograined, and black to medium brownish grey. These beds are cut by thin irregular veinlets of white calcite. The succeeding 510 feet is thinly to irregularly bedded, black cryptograined limestone that is variably argillaceous and silty, commonly weathering dark, and is split by orange-red partings and thin argillaceous and silty bands. These beds are overlain by 2,270 feet of interbedded limestones and dolomites, weathering to form a banded, alternating buff and grey recessive unit. The limestone is black, cryptograined, thinly and evenly bedded, varying from argillaceous and silty to very silty and sandy, and weathering grey. The dolomite is commonly fine grained, cryptograined, brown and grey, thinly and evenly bedded, weathering in alternating pale orange-grey to light brown beds, and varies from argillaceous and silty to laminated and sandy. Some of the dolomite is finely porous. The uppermost 1,640 feet is similar to the preceding, but somewhat more resistant and massive. Limestone is absent, however, and the dolomite is medium to thick bedded, in part bioclastic, and generally more sandy.

Map-unit 7

In the vicinity of the Third Canyon of South Nahanni River and within the Funeral Range is a thick succession of beds which appear to be typically Sunblood formation. They weather characteristically reddish orange, brown and pink, and where examined consist of thinly bedded, irregularly and wavy laminated, fine-grained, dark grey

dolomitic limestone. No stratigraphic section was measured, and as the overlying succession differs from that of the type region, these beds are shown as map-unit 7. About 3,000 feet may be present.

Map-unit 8

Map-unit 8, on Funeral Range in the vicinity of South Nahanni River, was only partly examined. It includes massive-appearing beds which are dark-grey-weathering and more thinly bedded towards the top. Those near the base were found to be massive, coarse-grained, brown sandstone. The unit may be about 1,000 feet thick.

Map-unit 9

In northern Funeral Range and the valley of upper Prairie Creek, map-unit 8 is overlain by light buff and tan-weathering shaly beds that resemble those of map-unit 5. They are thinly bedded, slope and talus forming, and probably about 1,000 feet thick. Map-unit 9 was not examined on the ground, however it is readily recognized, and as its stratigraphic relationships to other established units are uncertain (as will be discussed under map-unit 16), it is designated separately.

Map-unit 10

On Nahanni Range map-unit 10 consists of 260 feet of silty, light brown, fine-grained dolomite—thin- to medium-bedded, interbedded with quartzose sandstone, and yellowish white to pink and grey. The unit is recessive and weathers a distinctive buff. Its thickness as mapped may exceed the above figure at some localities.

Map-units 11 to 14

On Nahanni Plateau and in northwestern Virginia Falls map-area is a thick sequence of grey-weathering banded dolomites referred to map-unit 14; where it is divided by a thin dark unit, as on Tundra Ridge, it is referred to map-units 11, 12 and 13.

On Tundra Ridge map-unit 11 consists of 1,160 feet of dolomite which weathers in alternating light and dark grey bands. The dolomite is partly cryptocrystalline to fine grained, dark grey to black, thick, evenly bedded, silty and granular. These beds are interbedded with fine- to medium-grained, light grey, massive to thick-bedded, coarsely vuggy dolomite weathering almost white, with suggestions of corals and other organic remains; or with very fine grained, granular to finely vuggy, medium-bedded, medium and light grey dolomite. Map-unit 12 is made up of 570 feet of dolomite—cryptograined to granular, medium brownish grey to black, thinly to evenly bedded, and weathering medium to dark grey. Map-unit 13 is 2,370 feet thick. It includes crypto- to fine-grained, very dark grey to black, medium- to thick-bedded dolomite, in part finely and coarsely vuggy and bioclastic. These beds are interbedded with fine-grained, light to medium brown, silty and sandy, thinly bedded dolomite.

Where examined, the undivided sequence of map-unit 14 was seen to consist of the above dolomites.

In the First Canyon of South Nahanni River, 650 feet of strata are assigned to map-unit 14. They consist of dolomite which is cryptograined, dark to medium grey and in part slightly greenish grey, and massive to evenly bedded—in beds 1 foot to 5 feet thick. The whole weathers banded dark and medium grey with local patches of orange-brown.

Map-unit 15

In southwestern Virginia Falls map-area, mainly south of South Nahanni River, the equivalents, if present, of most of the succession described in the foregoing are included in map-unit 15 (see Figure 1, column 1). Map-unit 15 is underlain by the red-weathering beds of map-units 1 or 7, and is overlain by the dark shales of map-units 20, 21 or 29 (described later). In general, the succession consists of interbedded dark carbonates, sandstones and shales, apparently differing little in topographic expression. They are poorly exposed and generally covered with vegetation.

The map-unit was examined at only scattered localities and at few stratigraphic levels. The basal beds include medium grey, fine-grained quartzose dolomite, brown-weathering fine-grained sandstone, and conglomeratic sandstone. Higher beds include limestone which is cryptograined, dark grey, thinly bedded, and weathering light grey mottled with pale yellowish orange. Other beds are limestone—fine-grained, black, thinly bedded—interbedded with dolomite which is fine-grained, medium grey and in part banded and weathering an alternating dark and medium grey.

Middle Devonian (Map-units 16-22)

Map-unit 16

In the First Canyon of South Nahanni River, map-unit 16 consists of 1,650 feet of dolomite—fine-grained, granular, massive to thick-bedded, and dark grey to black—interbedded with dolomite which is silty, very fine grained, black to brown, and massive-bedded, and with light brownish grey, thinly bedded dolomites, and with vuggy and porous dolomites. These rocks alternate in thick units that weather grey and dark grey, giving rise to a distinctive banded appearance.

On Cathedral Mountain 2,630 feet of beds are referred to map-unit 16. These consist of interbedded banded dolomites similar to those described above—fine- to medium-grained, granular, light grey and brown grading to dark brown and black, in part fetid, medium-bedded grading to massive- and thick-bedded, and weathering dark grey to black in alternating beds, giving the rock a banded appearance. Some beds are silty and sandy, others finely porous or vuggy. In the lower half these are interbedded with cryptograined dolomite which is massive to thick and evenly bedded, pale-grey or pale-brown, and weathering light grey. The contact with the underlying map-unit 5 is irregular and sharp, and suggests a disconformity.

On Nahanni Range the map-unit is lithologically similar. At Little Doctor Lake 2,430 feet is provisionally placed in map-unit 16. These beds consist of fine- to medium-grained dolomite which is medium to dark grey, thickly bedded, and weathering banded grey and dark grey. Some beds are finely porous or vuggy, variably fetid, and in some places laminated.

In central Nahanni Plateau the dolomites of map-unit 16 may be seen to grade northward into shales and shaly limestones of map-unit 17. The same facies change occurs on Ram Plateau, northern Headless, Manetoe and Arnica Ranges and southwestern Sombre Mountains. Through most of these ranges map-unit 16 is considered to extend as a thin unit below map-unit 17.

On Tundra Ridge the unit consists of 135 feet of black, cryptograined, massive dolomite with black chert nodules, overlain by 360 feet of grey, fine- to coarse-grained, bioclastic dolomite which is medium- to thick-bedded and in part laminated. In the valley of upper Prairie Creek, beds provisionally referred to this unit are possibly 200 feet thick. They include limestone—black, fine-grained with black chert bands, in beds 2 to 6 inches thick, and weathering medium grey—and dolomite which is finely crystalline and black. In southern Sombre Mountains the unit is also thin, and is composed of limestone—black, very fine grained, fetid, with prominent black chert stringers—in beds 1 to 4 feet thick.

The base of map-unit 16 appears to be unconformable. The underlying map-units vary in thickness and are not always present. On southern Tundra Ridge map-units 13 and 12 appear to have been bevelled, with map-unit 16 lying on map-unit 11. On upper Prairie Creek, Manetoe and Arnica Ranges, and in the northwestern corner of Virginia Falls map-area, map-unit 14 appears to have been truncated and, accordingly, is absent in the southwest. On Nahanni Range map-unit 14 does not appear to be represented. These interpretations were not fully corroborated and alternative interpretations, such as facies change, convergence or faulting, may be possible. Where map-unit 14 and its equivalents are absent, map-unit 16 lies on map-units 5, 9 or 10. The equivalence of map-unit 16 and other map-units on the Funeral Range to those of other parts of the area is not established.

Map-unit 17

On northern Nahanni Plateau map-unit 17 is 2,550 feet thick. The lower 1,655 feet comprises dark grey to black, platy, calcareous shale and calcareous mudstone, interbedded with black, silty to argillaceous, pale-buff-weathering, very recessive limestone. This is overlain by a locally resistant and cliff-forming unit, 225 feet thick, composed of black silty and argillaceous, thinly bedded to bioclastic limestone with black shale partings and weathering light buff. Succeeding beds, 670 feet thick, are black, platy to fissile, calcareous shale and blocky mudstone alternating with thin lenticular beds of black bioclastic limestone and thick- to massive-bedded, black, hard, argillaceous limestone. On a northern tributary to Ram River, in northern Nahanni Plateau, the upper part of map-unit 17 consists of 320 feet of mudstone—calcareous, variably silty and sandy, medium grey,

fine-grained, thinly bedded to fissile, and finely laminated—varying to limestone which is argillaceous, dark grey, fine-grained, and variably pyritic; the latter increases in proportion upwards, to nearly 50 per cent. Some beds of medium grey bioclastic limestone occur in the upper part. On Sundog Creek on the east flank of Nahanni Plateau the uppermost beds of the map-unit consist of argillaceous and silty, black to dark grey, fine-grained, thin- to thick-bedded, fossiliferous limestones. They may be partly dolomitized and grade southward into the coarse-grained dolomites of map-unit 18 farther up the creek. Map-unit 17 contains fossils, especially in the upper beds; they were identified by D. J. McLaren and A. W. Norris as Middle Devonian. Accordingly, its facies equivalent, the dolomites of map-unit 16, are also of Middle Devonian age.

Map-unit 18

Map-unit 18 is a thin unit of coarsely crystalline dolomite which commonly is underlain by the dolomites of map-unit 16, and grades laterally into the limestones of the upper part of map-unit 17. (See Figure 1.) On Nahanni Range the undolomitized limestones in equivalent stratigraphic position are shown as map-unit 19.

In the First Canyon of South Nahanni River map-unit 18 consists of 375 feet of coarsely recrystallized, very massive bedded, mottled white and black dolomite, weathering light grey, and interbedded medium-grained, black dolomite with large irregular masses of white calcite and dolomite. In the northwest corner of Virginia Falls map-area the map-unit includes rubbly weathering limestone—black, fine-grained, and in beds 6 inches to 10 feet thick—overlain by interbedded medium and light grey, medium-grained dolomite and coarse recrystallized dolomite in beds 10 to 25 feet thick. On top of Cathedral Mountain the map-unit consists of a minimum of 85 feet of dolomite which is mottled white, creamy brown and dark grey, coarsely recrystallized, slightly friable, generally massive, and light-grey-weathering. Thin brecciated layers show up on the weathered surface and form jagged erosional stacks and pillars. Downslope on Cathedral Creek the dolomite is seen to grade into massive-bedded limestones which are dark grey to black, fine- to crypto-grained, and in part granular.

Lateral gradation between the dolomites of map-unit 18 and the limestones of map-unit 17 may be observed at many localities in northern Virginia Falls map-area and on Ram Plateau in Sibbeston Lake map-area (see maps). It is very clearly displayed on Nahanni Plateau along Sundog Creek, a tributary to Ram River, and on the high scarp to the northwest where the contact is abrupt and nearly vertical.

On Nahanni Range at Nahanni Butte, map-unit 18 consists of 350 feet of very coarse grained dolomite—thick-bedded to massive, medium grey to black, and banded weathering. At Bluefish Lake, 540 feet of beds consist of similar dolomites with some interbedded argillaceous fetid dolomite. The beds are fractured with coarse calcite replacement closely resembling a breccia. At Little Doctor Lake the map-unit consists of 310 feet of limestone—medium to light

grey, crypto- or fine-grained, medium and thickly bedded, with argillaceous partings—partly altered to dolomite which is dark grey, fetid, medium to very coarse grained, and thickly bedded.

Map-unit 19

On Nahanni Range, massive-bedded limestone—grey to dark grey, medium to thickly bedded, and cryptocrystalline to fine-grained—occur as a facies equivalent of map-unit 18. They were not examined in detail and their thickness, although unknown, is probably the same or somewhat greater than that of map-unit 18 on the range.

Map-units 20, 21 and Nahanni Formation (22)

The term Nahanni formation was proposed by Hage (1945) for 450 feet of limestone beds of probable Middle Devonian age that form the upper part of the south-facing cliffs of Nahanni Butte. In Virginia Falls and Sibbeston Lake map-areas Nahanni formation includes rocks shown as map-unit 22, although beds of map-unit 21 were probably also included in the formation by Hage. Map-unit 21 and the Nahanni formation are facies equivalents (see Figure 1). The Nahanni limestones grade laterally into the shales and shaly limestones of map-unit 21 in a general southwesterly direction. In some regions map-unit 21 was not separated from the shales and limestones of map-unit 16; the combined rocks are shown as map-unit 20.

Where map-unit 21 is well developed, as on Headless Range, it consists of 560 feet of dark grey, calcareous shale, weathering pale yellowish grey; this is interbedded in the upper 150 feet with beds of limestone—dark grey to light brownish grey, cryptograined to bioclastic, and 10 to 50 feet thick. These beds are overlain by 295 feet of massive, cliff-forming limestones of the Nahanni formation. Towards the southern end of the range the limestones may be seen to grade laterally into interbedded black shale and black, argillaceous, dense, cryptograined limestone in beds 6 inches to 2 feet thick. On the second tributary to Meilleur Creek from the east, black, calcareous shale forms the lower part of the unit, 475 feet thick. Of this, the uppermost 50 feet is somewhat more resistant and may be considered a remnant of the Nahanni formation; the remainder is considered as map-unit 21.

This facies variation may be observed at several other localities, for example on the southwest flank of Nahanni Plateau, the east flank of Funeral Range, on Manetoe, Arnica and Dall Ranges, and on Sombre Mountains. On the creek near Cathedral Mountain map-unit 21 consists of 980 feet of interbedded shale—fissile and platy, weathering dark grey to black, and variably calcareous—and interbedded limestone which is black, cryptograined, hard and massive—in beds up to 4 feet thick. The Nahanni formation is absent.

On southern Nahanni Plateau and Nahanni Range, map-unit 21 is thin, and is essentially only a recessive unit at the base of the cliff-forming beds of the Nahanni formation. At Nahanni Butte the Nahanni formation is 350 feet thick, comprising dark grey limestone—fine-grained, vaguely medium- to thick-bedded—partly dolomitized

to dark and light grey, fine- to medium-grained, rarely coarsely crystalline dolomite. It is underlain by 130 feet of argillaceous limestone which is black, fine-grained and variably dolomitized, and is considered to represent map-unit 21. Similar beds are 85 feet thick at Bluefish Lake, 145 feet thick at Little Doctor Lake and 130 feet thick in the First Canyon of South Nahanni River. At these localities, the Nahanni formation is 310, 410, and 475 feet thick respectively.

The Nahanni formation thickens northwestward through Ram Plateau, where its thickness is 650 feet, and across northern Nahanni Plateau where it is 780 and 830 feet thick on the east and west flanks respectively. In this part of the map-area it consists of massive to thick-bedded, light to dark grey, fetid, fine-grained to bioclastic limestones weathering light grey. In places it is split into several small cliffs by interbedded, recessive, thinly bedded limestones, but generally it is a single massive cliff. The underlying shales and shaly limestones of map-unit 21 vary between 150 and 500 feet in thickness, depending on the stratigraphic level of the lowest massive cliff-forming limestone that is chosen as the basal unit of the Nahanni formation.

Upper Devonian (Map-units 23-29)

Virginia Falls and Sibbeston Lake map-areas embrace the Upper Devonian succession of the Interior Plains as described in adjacent Trout River map-area (Douglas, 1959b), and that of Mackenzie Plain west of Nahanni Range which is the southern continuation of the classical succession on North Nahanni River described by Hume (1922). Approximate stratigraphic relationships are shown in Figure 2.

Simpson Formation (Map-unit 23)

A nearly complete section of the Simpson formation (23) may be examined on several bends of the Ram River in eastern Virginia Falls map-area. Some 1,110 feet of beds of the lower part of the formation were measured. Higher beds and the contact with overlying map-unit 27 were not examined. The formation probably totals about 1,800 feet. The basal 220 feet is interbedded black, fissile to silty, non-calcareous shale and sandy mudstone—brown-weathering and partly stained with yellow sulphur. Succeeding beds are mainly shale—non-calcareous, dark grey, and fissile to silty—interbedded with sandstone which is argillaceous, thinly bedded, fine- to medium-grained, laminated and finely crossbedded. The basal beds are also discontinuously exposed in the saddle east of Nahanni Butte. On Liard River, below Blackstone River exposures described by Hage (1945) consist of hard shale, thinly bedded, and dark grey to black.

Map-units 24-26

Map-unit 24 as exposed on lower Birch River, is non-calcareous, dark greenish grey, fissile and laminated shale with a few thin beds of quartzose calcareous sandstone, greenish grey and medium-grained, in beds up to 2 inches thick. Map-unit 25 forms the northwest-facing escarpment between Blackstone and Liard Rivers. It was examined at localities along this ridge and on Birch River, and was seen to be

Figure 2

Approximate Stratigraphic Relationships of Upper Devonian and Carboniferous Map-units

	Tlogotsho Plateau	Mackenzie Plain and Liard Range	Interior Plains	Fort Liard and La Biche Map-areas (Douglas and Norris, 1959)	Great Slave and Trout River Map-areas (Douglas, 1959b)
Cretaceous			Fort Nelson (35)	Fort Nelson (18)	(24)
		Fort St. John (34)	Fort St. John (34)	Fort St. John (17)	(23)
Carboniferous	Mattson (33)	Mattson (33)		Mattson (8)	
	(32)	(32)		(7)	
	(31)	(31)		(6)	
	(30)	(30)		(5)	
?	(29)				
Upper Devonian		(28)			
		(29) (27)	(26)	(4)	(22)
			(25)		(21)
			(24)		(20)
?		Simpson (23)	Simpson (23)		Simpson (16)
Middle Devonian	Nahanni (22)	Nahanni (22)		(3)	

formed mainly of bioclastic limestone--slightly argillaceous, bituminous, light olive-grey to brownish grey, fine- to coarse-grained, and thin- to medium-bedded--and massive, coarse-grained, reefoid limestone which is light grey to yellowish grey, stromatoporoidal and coraliferous. The fauna indicates an Upper Devonian (Frasnian) age according to D. J. McLaren. Map-unit 26, exposed only on Blackstone River, is composed of sandy limestone. The fauna, identified by McLaren, is Upper Devonian (Famenian) in age and equivalent to that of the Trout River formation (included in map-unit 22 of Trout River map-area, Douglas, 1959b).

Map-units 27 and 28

Map-units 27 and 28 occur on the flanks of the broad syncline in Mackenzie Plain. It appears that the resistant unit, map-unit 27, loses its identity south of South Nahanni River and to the west. In eastern Virginia Falls map-area the entire Upper Devonian is represented by dark shales included in map-unit 29. A short distance north of Bluefish Mountain map-unit 27 consists of 330 feet of interbedded, thinly bedded to fissile, silty, black mudstone and dark grey, calcareous siltstones weathering light brown. A thin limestone bed at the top carries an upper Devonian (Famenian) fauna, according to McLaren. The overlying beds comprising map-unit 28 are well exposed on Bluefish Mountain. They consist of 200 feet of fissile, black, non-calcareous shale becoming slightly calcareous with thin sandstone in the upper 40 feet. These beds are underlain by 10 feet of thinly bedded, platy, argillaceous, fine-grained limestone and then by 285 feet of dark grey, non-calcareous shale with nodular mudstone bands.

Map-unit 29

In Deadmen Valley of Virginia Falls map-area, map-unit 29 spans the interval between the underlying limestones of map-unit 22 and the base of map-unit 30, and is approximately 3,000 feet thick. Where map-units 30, 31 and 32 are not recognized (as noted in subsequent paragraphs), map-unit 29 includes their equivalents as well, and is overlain by the Mattson formation, map-unit 33. In southwestern Virginia Falls map-area, the base of map-unit 29 may be somewhat lower and rest on map-units 19 or 20 (see Figure 1). The rocks included in map-unit 29 were examined at only a few scattered localities, but appear in general to comprise a succession of dark grey shales with rare, interbedded, thin hard beds of sandstone and limestone.

Carboniferous (Map-units 30-33)

Map-unit 30

On Yohin Ridge in southwestern Sibbeston Lake map-area, map-unit 30 consists of about 600 feet of brown-weathering, thinly bedded sandstone, fine to medium-grained, with minor interbedded siltstone and black shale. There it corresponds to "unit 1" of Patton (1958) and to "map-unit 5" of Douglas and Norris (1959). On Bluefish Mountain it is represented by 120 feet of grey, medium-grained, dense limestone with minor silty, dark grey, calcareous shale. On

the north side of Tlogotsho Plateau, beds referred to map-unit 30 are limestone--finely crystalline to cryptocrystalline, slightly argillaceous and silty, laminated and dense--with 2- to 6-inch black chert bands. On the west side of the plateau this unit does not appear to be present, having graded into the shales of map-unit 29.

Map-unit 31

Map-unit 31 on Yohin Ridge consists of 530 feet of shale--non-calcareous to calcareous, black, and fissile to paper thin--with occasional nodules and nodular layers of dark brownish grey mudstone. It corresponds to "unit 2" of Patton (1958) and to "map-unit 6" of Douglas and Norris (1959). It is 615 feet thick on Clausen Creek. On Bluefish Mountain the map-unit is represented by 510 feet of similar shale, with rare thin beds of siltstone and sandstone.

Map-unit 32

At Jackfish Gap map-unit 32 comprises 1,430 feet of interbedded, medium- to thickly bedded, medium- to coarse-grained, grey, crinoidal and fossiliferous limestone with thin- to medium-bedded, fine-grained, dark grey, argillaceous and bioclastic limestone; and dark grey calcareous shale; and thin beds of fine-grained, grey, calcareous sandstone, and fine-grained dolomite. Several faunal zones are recognized by Harker (Bull. in preparation) ranging in age from Upper Kinderhook to Lower Chester. Map-unit 32 corresponds to "unit 3" of Patton (1958) and to "map-unit 7" of Douglas and Norris (1959). On Twisted Mountain the formation consists of 1,380 feet of similar limestones and shale with the basal 130 feet of grey to greenish grey, medium-grained sandstone; the base is not exposed. Some 760 feet of beds are present on Bluefish Mountain but the top is not exposed.

In Virginia Falls map-area, on the north face of Tlogotsho Plateau, map-unit 32 is represented by 660 feet of interbedded limestone—grey, fine- to medium-grained, partly crinoidal and coarse-grained, varying to argillaceous, dark grey, fine-grained and thinly-bedded—and shale which is dark grey calcareous, and fissile to thinly bedded. The amount of shale is proportionately greater in about the middle and the top parts of the unit. The other parts, mainly limestone, are cliff-forming and persist along the face of the plateau. These units may be traced westward to where they lose their identity and appear to grade laterally into dark grey shales of map-unit 29. Near the south border of the map-area immediately below the sandstones of the Mattson formation, shales in the stratigraphic position of map-unit 32 are fissile to thinly bedded, hard, dark grey to black and non-calcareous.

Mattson Formation (Map-unit 33)

The type locality of the Mattson formation is at Jackfish Gap in Yohin Ridge, in southwestern Sibbeston Lake map-area. The name was proposed by Patton (1958) to include 3,734 feet of strata overlying his "unit 3", which is map-unit 32 of this report. Some 3,160 feet of

strata were measured at this locality. At Mattson Gap on Liard Range just south of the map-area a section measured 3,700 feet thick. A partial section on Twisted Mountain, 1,060 feet thick, probably represents the greater part of the formation present; higher beds are removed by the pre-Cretaceous unconformity.

The divisions of the Mattson formation noted in Fort Liard and La Biche map-areas (Douglas and Norris, 1959) are also represented in Sibbeston Lake and Virginia Falls map-areas. Although not well controlled by ground observations the distribution of these divisions gives an indication of the rapidity and direction in which the Mattson formation is bevelled by the pre-Cretaceous unconformity.

The lower part (33a) consists of sandstones—fine-grained, light grey, thinly bedded and partly carbonaceous and finely crossbedded—interbedded with minor black, silty, carbonaceous shale. Coal seams occur near the top of the unit at Jackfish Gap. It weathers light yellowish brown, is generally recessive where overlain by higher strata of the Mattson formation, and is cliff-forming where these are absent. Thicknesses at Tlogotsho Plateau, Jackfish Gap, Mattson Gap and Twisted Mountain, are 1,220, 1,175, 1,165 and 960 feet respectively. The middle part (31b) is mainly fine- to medium-grained in part coarse-grained, light grey to light brown sandstones which are medium- to massive-bedded and generally thickly crossbedded. They weather orange-brown, and being in part friable, form alternating resistant and recessive zones. The unit as a whole is generally resistant and cliff-forming. It is 750 feet thick at Jackfish Gap and 800 feet at Mattson Gap. The upper sandstone on Twisted Mountain, a massive unit 105 feet thick, is thought to represent the remaining middle part of the Mattson formation. Thicknesses of the upper part (31c) are 1,230 and 1,730 feet at Jackfish and Mattson Gaps respectively. This part consists of fine- to coarse-grained fossiliferous limestones interbedded with fine-grained, light grey, medium-bedded, calcareous sandstones and minor black, fissile, concretionary shale and sandy dolomites.

MESOZOIC

Cretaceous (Map-units 34 and 35)

Fort St. John Group (Map-unit 34)

The Fort St. John Group was found exposed only near Nahanni Range, north of Grainger River. There, beds high in the group, consist of 150 feet of fissile grey shale overlain by similar shale with interbedded thinly bedded, rusty-brown-weathering siltstone, about 150 feet thick.

Formations comprising the Fort St. John group in the Liard River region are described by Stott (in press). Preliminary account of the group in Fort Liard and La Biche map-areas to the south is given by Douglas and Norris (1959).

Fort Nelson Formation (Map-unit 35)

The Fort Nelson formation is exposed on Martin Hills in northeastern Sibbeston Lake map-area. The exposures on the southeast side consist of sandstone—thinly bedded, fine-grained, light olive-grey, and finely laminated and crossbedded--interbedded with silty, dark grey and fissile shale, in places rubbly and concretionary. Beds which measured 180 feet thick probably constitute the lower part of the formation.

Igneous Rocks, La Biche Map-area

Samples of igneous rocks were collected in 1959 by W.B. Brady of the Union Oil Company of California from the adjacent La Biche map-area. Through the courtesy of that company they were made available to the Geological Survey of Canada and have been examined and described by G.C. Taylor, as follows:

Specimens from the southern areas of map-unit 21 of La Biche map-area are trachyte consisting of phenocrysts of orthoclase (15%), hornblende partly altered to chlorite and magnetite (10%), and biotite (5%) in a groundmass of felted feldspar and hornblende. Accessory minerals are apatite, sphene, magnetite and muscovite. In some specimens the microlites show a pronounced flow orientation.

Specimens from the northern part of the area shown as map-unit 1 of La Biche map-area consist of very coarse grained syenite. The constituent minerals are: orthoclase (80%), anhedral and partly sericitized; hornblende (10%), fine-grained and partly altered to chlorite; biotite (5%), partly altered to chlorite and magnetite; and accessory minerals apatite, magnetite and sericite.

STRUCTURAL GEOLOGY

Virginia Falls and Sibbeston Lake map-areas embrace the northern part of Liard Plateau, the southern termination of Mackenzie Mountains, Mackenzie Plain and Franklin Mountains, and the western part of the Interior Plains. In the following discussion, the structural elements within these areas are dealt with mainly from east to west. Where certain elements are more naturally related along strike than across strike, they are treated to reveal these relations to best advantage.

Within the Interior Plains the structure of the Upper Devonian rocks south of Liard River is a gentle southeast-dipping homocline overlain unconformably by Cretaceous rocks. This part of the area forms the northwest flank of a broad basin that underlies part of the Trout River and Fort Liard map-areas. Small reversals to northwest dips occur on lower Birch River and along Liard River. From assumed contacts, the base of the Cretaceous lies at 800 to 900 feet elevation along Blackstone River, and at 700 feet beneath Martin Hills. The intervening ridge of Upper Devonian strata, however, reaches an

elevation of between 1,100 and 1,200 feet along most of its length. Accordingly, the structure along Liard River may be simply a broad fold paralleling the trend of the Upper Devonian ridge. However, it may be much more complex.

The principal structural feature within Sibbeston Lake map-area is the north-trending Nahanni Range of Franklin Mountains. It lies right-hand en echelon from Liard Range in Fort Liard map-area and left-hand en echelon from Camsell Range in Camsell Bend map-area to the north. In contrast to Liard Range with fold and fault structures in Mississippian and younger rocks, Nahanni Range is a west-dipping, essentially homoclinal thrust sheet of Middle Devonian and older rocks. It is underlain by Nahanni thrust, which at the surface appears to dip gently west and in places to be nearly flat.

Although generally north-trending, Nahanni Range is sinuous in detail, the different parts being aligned north, northwest and northeast. Minor re-entrants alternate with salients along the range. The structure of the range, particularly the northern part, is generally homoclinal with strata on the west flank dipping consistently from 20 to 35° W.

Culminations and depressions divide the range into several segments. The more southerly depressions occur where minor folds and faults interrupt the generally uniform westerly dip. They appear to be related to rapid changes in the stratigraphic position of Nahanni thrust with respect to hanging-wall strata. Approximate closure with respect to the top of the Nahanni formation (map-unit 22) is of the order of 1,000 to 3,000 feet. The structural simplicity of the north half of the range is apparently related to the low stratigraphic position of Nahanni thrust and the constancy of position at this structural level. Exposures of bedrock in the foot-wall of Nahanni thrust are exceedingly rare and only one was observed immediately north of Grainger River gap. There, interbedded sandstones and siltstones of high Fort St. John group dip 80° W, overturned.

Most of Yohin syncline in Mackenzie Plain is a simple fold trending north from about South Nahanni River to beyond the north boundary of the map-area. It is a broad structure with flanks dipping 20 degrees, and it plunges very gently southward so that at the north boundary of the area Upper Devonian sandstones form the core. To the south, progressively younger strata are present; in the vicinity of South Nahanni River, Mattson formation and possibly Cretaceous rocks form the core of the structure. There, the simple structure develops into a number of folds, of which the westernmost is considered the southern continuation of Yohin syncline. Thus at South Nahanni River the structure consists, from east to west, of Bluefish syncline, Twisted Mountain anticline and Yohin syncline.

Bluefish syncline is shallow, with flanks dipping about 10 degrees. Strata of the east flank are assumed to be repeated by a steeply-west-dipping thrust because of their anomalous thickness. The syncline is interpreted to continue south beneath Liard flood plain into adjacent Fort Liard map-area.

Twisted Mountain anticline is slightly asymmetric westward with its east flank dipping 15 degrees and its west flank dipping 35 degrees. A minor west-dipping thrust breaks the west flank and drag-folds contort the east flank. The mountain from which the fold is named consists almost entirely of strata of map-unit 32 with a thin capping of sandstones of the lower Mattson formation. Liard fault is considered to end in the axial region of Twisted Mountain anticline. Liard syncline plunges gently northward and terminates on the west flank of Twisted Mountain anticline. To the west lies Mattson anticline. It is apparently compound, comprising several fold elements, all plunging northward. The more easterly component is broken by a small west-dipping fault and it appears to end on the west flank of Twisted Mountain anticline. The central element plunges abruptly into the core of Yohin syncline. The western element is broken by contraposed cross-faults. These faults separate Yohin syncline from Kotaneelee syncline, its apparent structural continuation to the south.

Ram Plateau is a broad dome-shaped structural high, ovate in plan, with its long axis trending north. Its topographic expression is a stripped surface on the Nahanni formation that dips very gently away from the culmination about 4 miles south of the intersection of Ram Creek with the west boundary of Sibbeston Lake map-area. The oldest beds exposed in the core of the structure are those of map-unit 17. Minor structural complications are gently plunging folds at the north end, and northeast-trending normal faults with either east or west sides relatively down. At the south end is a small uplifted block with what appear to be compressional features within it. It is surrounded by small linear faults apparently downthrown towards the block.

Nahanni Plateau, a structural high involving Middle Devonian and older rocks, forms the eastern flank of Mackenzie Mountains. It is strongly elongate and consists of two principal structural elements. The northern two thirds is essentially a structural terrace flanked on the west by the east-dipping homocline of Tundra Ridge. The terrace is modified into a gentle syncline and anticline in the north and into a gentle northeast-facing homocline in the south. It is bounded on the south by Tundra thrust and by a zone of contraposed east- and west-dipping thrust faults and associated folds. The southern third of the Plateau is open against this zone, and strata on its flanks dip gently away from the culmination.

The northeast-trending fault and fold zone dividing Nahanni Plateau into two structural elements consists principally of en echelon, contraposed, east- and west-dipping thrust faults which converge downwards. Of these the more westerly dips eastward and apparently ends where Tundra thrust changes to a southwest strike and assumes a steep dip. The more easterly thrust faults dip west and flank a series of small, right-hand en echelon folds.

Tundra thrust is a major east-dipping fault underlying Tundra Ridge and extends from about Deadmen Valley in the south to within a few miles of North Nahanni River beyond the map-area in the north. It has a sinuous trace throughout most of its length, and it dips at low to moderate angles, becoming steeper in the north. Towards its southern termination Tundra thrust changes direction abruptly, steepens,

and ends in the axial region of a small anticline. Except for its extremities, Tundra thrust maintains essentially the same stratigraphic position with respect to its hanging-wall strata. In the foot-wall on the other hand, its stratigraphic position is extremely variable. These variations may be due to irregularities in the line of cutt-off on the formations as the thrust was initiated, or to truncation of structures existing prior to thrust-faulting.

Tlogotsho Plateau is a broad, very gentle saucer-shaped homocline dipping gently southward. It forms part of northern Liard Plateau.

Southern Headless Range is an east-dipping plate underlain by a steep east-dipping thrust fault. Northern Headless Range, on the other hand, is a west-dipping plate underlain by a steep west-dipping thrust. These bounding faults appear to end where South Nahanni River cuts through the range and foot-wall strata of both faults are exposed. The structure is essentially an anticline that during its formation developed westward asymmetry in the south, eastward asymmetry in the north, and was eventually faulted.

Funeral Range is bounded on the west by Funeral thrust, a major east-dipping fault, and along part of its east flank, by west-dipping faults. Accordingly, these faults converge downwards. Towards the north end of the range, however, they give way to the Tundra and Manetoe thrusts, major east- and west-dipping faults which diverge downwards, and which approach one another in the north.

The southern part of Funeral Range is essentially a broad anticline complicated by several small discontinuous folds and west-dipping thrust faults, of which Gate fault is the largest. Gate fault cuts diagonally across the range, reaches maximum stratigraphic throw along its central part and rapidly decreases in throw northwards to probably zero displacement beneath Tundra thrust. In northern Funeral Range between Tundra and Manetoe thrusts, the structure is essentially a north-plunging syncline bounded by faulted anticlines. Displacement on these latter faults is in the same sense as on the associated overlying Manetoe and Tundra thrusts.

Manetoe Range is a steeply west-dipping thrust sheet underlain by Manetoe thrust. Throughout its length, Manetoe thrust appears to maintain a constant stratigraphic position with respect to hanging-wall strata, but like Tundra thrust, it is extremely variable with respect to foot-wall strata.

Vera syncline lies immediately west of Manetoe Range. It occupies the valley of Vera Creek throughout most of its length and then follows a tributary of Wrigley Creek toward the north boundary of the area. At South Nahanni River the east flank of the syncline is faulted and folded. It is assumed to end a short distance south.

Arnica Range consists of a west-dipping succession of strata underlain by Arnica thrust. Along the crest of the range the beds are essentially flat and on the west flank they dip 30 to 40 degrees, with steeper dips where the range is cut by a contraposed, east-dipping

thrust fault. Arnica thrust is flat or very gently west-dipping and is apparently folded over an anticline which lies west of Vera syncline. At its northern extremity it swings abruptly westward, loses stratigraphic throw rapidly, and dies out within strata of map-unit 17.

South of South Nahanni River the structural continuation of Manetoe and Arnica Ranges is a moderately-west-dipping homocline underlain by Mary thrust, a major west-dipping fault which may be the southern continuation of Manetoe thrust. Major salients and re-entrants in west-dipping Mary thrust and overlying plate, oppose salients and re-entrants in the contraposed east-dipping Funeral thrust and Funeral Range. Specifically, at the divide between Meilleur River and Mary Creek, where Funeral thrust swings westward, Mary thrust swings eastward. To the north where Funeral thrust swings eastward, Mary thrust swings westward. The region between these thrusts is a broad, south-plunging syncline—the Mary syncline.

In northwest Virginia Falls map-area is a prominent structural and topographic low, named Clearwater depression. It is flanked on the east by Arnica Range, on the north by Sombre Mountains, and on the southwest by Sunblood Range. Strata of these ranges rim the depression and dip toward it at remarkably steep angles. Minor folds, particularly in the northeast part, plunge equally steeply and appear to end abruptly down the plunge. However, two prominent arcuate folds, Dall and Wrigley anticlines, persist and lie right-hand en echelon to divide the depression into two parts.

In Sombre Mountains north of the area are several east-dipping thrust faults that have considerable displacement. Within the area these thrusts terminate abruptly in association with steeply plunging folds marginal to Clearwater depression.

Sunblood Range is a prominent northwest-trending homocline flanked on the southwest by South Nahanni River. Strata within it dip about 20° NE and include the oldest known beds within the map-area. Sunblood Range is limited on the east by Dall anticline and a northeast-trending fault whose west side has been apparently uplifted. To the northwest however, the homoclinal succession swings in arcuate fashion around the west flank of Clearwater depression.

South of South Nahanni River and west of the southern continuation of Arnica and Manetoe Ranges is a broad area underlain by strata of map-unit 29. These rocks are flat or only very gently warped but appear contorted adjacent to the west-dipping fault bounding Caribou Range on the east. Caribou Range is a north-trending, steeply-east-dipping homocline bounded on the west by Caribou thrust. To the west are north-trending folds that give way northwards to more gentle structures in the mountains between Flat and South Nahanni Rivers. Near the junction of Flat and Caribou Rivers, strata are steeply dipping and acutely folded in association with the northern continuation of Caribou thrust.

Summary

The principal structural elements in Virginia Falls and Sibbeston Lake map-areas are dominantly north trending, and consist of homoclinal thrust sheets, faulted folds, and broad, elongate uplifts and depressions. The area as a whole exhibits a remarkable structural symmetry; major thrust faults dip either east or west, and large folds have axial planes dipping in either direction. Some axial planes undergo reversals in dip along strike.

The linear ranges commonly exhibit a sinuous course with northeastward-trending segments alternating with those trending north and northwestward. Some such ranges are underlain by major thrust faults which also exhibit similar variations in surface trace. These sinuosities are apparently not related to significant changes in dip of the thrust planes and their associated plates. Some suggest the perpetuation of variations in trend of the line of cut-off of the formations from the initial stages of faulting. Other sinuosities suggest flexuring during late stages of the deformation. The irregular distribution of hanging- and foot-wall strata along the strike of some of these thrusts may substantiate the former conclusion, although the possibility of truncation of pre-existing folds must not be overlooked.

Adjacent ranges which appear to have arisen from faulted folds commonly change trend in harmony, from northwest to northeast. Adjacent ranges which appear to have arisen as thrust sheets without appreciable initial folding commonly change trend so that salients and re-entrants face one another. These northeast and northwest trends are also apparent in some large thrust faults and folds within the broad uplifts and suggest an influence of pre-existing faults on the Laramide(?) structures.

The broad uplifts and depressions commonly have gently dipping flanks. Minor folds around the upturned edges of some depressions however, plunge steeply, but must end abruptly down the plunge because of the shallow depths of the depressions.

ECONOMIC GEOLOGY

It is not practicable to mention in this report all observed horizons which have features favourable for the storage of oil and gas, nor to discuss their probable extent beneath specific structures.

In general, the successions described from the Nahanni Range and Nahanni Plateau may be expected beneath parts of the adjoining Mackenzie Plain, western Interior Plain and the Tlogotsho Plateau. Several facies changes and unconformable relationships were observed. Of these, the most significant are: the change from the massive, organic limestones of the Nahanni formation to shales and shaly limestones of map-unit 21; the changes from the coarsely recrystallized dolomites of map-unit 18 and the granular and vuggy dolomites of map-unit 16 to the shales and limestones of map-units 17 and 19; and

the absence through unconformable relationships and convergence of much of the lower part of the Nahanni Plateau succession on Nahanni Range and also the succession of the range beneath the Plains to the east. These stratigraphic relationships may occur in structural situations so that they serve as stratigraphic traps for the accumulation of oil and gas.

Major closed structures are present beneath Ram Plateau and parts of Nahanni Plateau but most of the potential reservoir rocks are exposed at the surface. The Mattson anticline of Liard Range and the fold and fault structures en echelon to the northeast probably involve, at depth, the Nahanni and older formations in closed structures beneath thick upper Devonian shales. (See cross-section E-F, Sibbeston Lake map-area.) These structures are probably of comparable geometry to those exposed in southern Nahanni Range. The structural features of the western part of the Interior Plains are unknown, except for the possible structure along Liard River, which has been briefly described. This structure may not be simple and is probably complicated by an abrupt introduction of late Palaeozoic strata beneath the lower Cretaceous beds and older Palaeozoic strata at depth, as suggested by their presence in the mountains to the west.

Two wells have been drilled within the Sibbeston Lake map-area. Shell Liard Rapids No. 1 was drilled to a depth of 401 feet. A later well, Shell Liard No. 2, reached a total depth of 2,237 feet. Geological data pertaining to it is confidential as of the date of publication of this report.

Lead, zinc and copper minerals are known to occur within the areas. The copper occurs on the south end of Nahanni Range in a vertical zone of fracturing about 70 feet wide, within coarse recrystallized dolomite and calcite. Minerals observed were azurite and malachite in a gangue of fine-grained quartz and dolomite.

The lead and zinc occurrence on Prairie Creek was not examined by officers of the Geological Survey. It is reported (A.D. Wilmot, Fort Reliance Minerals Limited) to be associated with a north-trending fault and to consist of argentiferous galena and sphalerite in a gangue of quartz and calcite. There is minor azurite and malachite staining.