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R. B. CAMPBELL

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GEOLOGY OF GLENLYON MAP-AREA,
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MEMOIR 352

GEOLOGY OF GLENLYON MAP-AREA, YUKON TERRITORY (105 L)

By
R. B. Campbell

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PREFACE

Work on Glenlyon map-area was commenced as part of a systematic program of exploratory geological mapping in central Yukon Territory.

Unfortunately the work failed to disclose much promising prospecting ground, but the detailed stratigraphic and structural information obtained by the writer will be useful in interpreting the geology of other more likely areas.

Y. O. FORTIER,
Director, Geological Survey of Canada

OTTAWA, December 9, 1964

MEMOIR 352 — Geologie des Glenlyon-Kartenblattgebiets (Yukonterritorium).
Von R. B. Campbell

Beschreibung einer Reihe von Falten und Verwerfungen in sedimentären und vulkanischen Gesteinen im südlichen Zentralgebiet des Yukonterritoriums, aus der Zeit des späten Präkambriums bis zum Tertiär.

ТРУД 352 — Геология Гленлаинского листа геологической карты, Юконская Территория.
Р. Б. Кампбелл

Отчет описывает серию осадочных и эффузивных пород смятых в складки и разбитых сбросами. Возраст этих пород обнажающихся в южно-центральном Юконе простирается от поздне-докембрийского до третичного.

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GEOLOGY OF GLENLYON MAP-AREA, YUKON TERRITORY

Abstract

Glenlyon map-area covers about 4,900 square miles in south-central Yukon Territory. Though mountainous the area is within the Yukon Plateau.

Tintina Trench, the locus of a major fault, trends northwesterly across the map-area. Northeast of the Trench, Proterozoic sedimentary rocks apparently are unconformably overlain by a sedimentary Carboniferous sequence, which in turn is succeeded by a volcanic and sedimentary unit of probable Permo–Triassic age.

The section southwest of the Trench is different from that to the northeast though some of the strata are of the same age. Ages are tentative because of lack of fossils, but by correlation with the rocks of nearby areas ages may be assigned with some certainty. Strata representing all periods from Cambrian to Mississippian and a Permo–Triassic sequence are thought to be present. The Devono–Mississippian and Permo–Triassic sections contain volcanic rocks. Older units are sedimentary. In the extreme southwest corner of the map-area are mainly sedimentary Upper Triassic and Jurassic rocks. Cretaceous and/or Tertiary terrestrial deposits and Tertiary volcanic rocks underlie small areas.

Extensive granitic batholiths are probably late Mesozoic in age. Ultramafic rocks, believed to be Palaeozoic, are restricted to the area near Little Salmon Lake.

Folds vary in trend from east to northwesterly. Several inferred northwesterly trending faults bound blocks geologically distinct from adjoining blocks.

A lead–zinc–silver deposit east of Little Salmon Lake is the only mineral deposit of importance within the map-area.

Résumé

La région de Glenlyon occupe une superficie d'environ 4,900 milles carrés dans le centre sud du Yukon. Même si la région est montagneuse, elle est comprise dans le plateau du Yukon.

La tranchée Tintina, emplacement d'une faille principale, s'oriente vers le nord-ouest de la région. Au nord-est de la tranchée, une succession sédimentaire carbonifère repose apparemment en discordance sur des roches sédimentaires du Protérozoïque et elle est recouverte, à son tour, par une unité sédimentaire et volcanique datant probablement du Permien–Trias.

La section au sud-ouest de la tranchée est différente de celle qui est au nord-est, bien que certaines des couches soient du même âge. On détermine l'âge

à peu près, à cause de l'absence de fossiles mais, par corrélation avec les roches des régions avoisinantes, on peut déterminer l'âge avec un peu de certitude. On s'attend de trouver des couches représentant toutes les périodes, du Cambrien au Mississippien, et une succession du Permien–Trias. Les sections dévoniennes–mississippiennes et permiennes–triasiques contiennent des roches volcaniques. Les unités plus anciennes sont sédimentaires. Dans l'angle sud-ouest de la région, il y a surtout des roches sédimentaires du Trias supérieur et du Jurassique. De petites aires reposent sur des gisements du Crétacé ou du Tertiaire.

Des batholithes granitiques étendus datent probablement du Mésozoïque supérieur. On trouve dans la région avoisinante du lac Little Salmon exclusivement, des roches ultramafiques qui datent, croit-on, du Paléozoïque.

Les plis s'orientent de l'est au nord-ouest. Plusieurs failles présumables orientées vers le nord-ouest séparent des blocs géologiquement distincts des blocs avoisinants.

Un gisement de plomb, zinc et argent, à l'est du lac Little Salmon, est le seul gisement minéral d'importance dans la région.

Chapter I

INTRODUCTION

Location and Access

Glenlyon map-area covers about 4,900 square miles situated between latitudes 62 and 63°N and longitudes 134 and 136°W in central Yukon Territory. There are no settlements or residents in the area.

No roads enter the map-area, though preliminary surveys have been made for a road through the valley of Little Salmon River and along Magundy River into Pelly River valley. It is proposed that this road extend from Carmacks on Yukon River to the settlement of Ross River on Pelly River. The main road from Whitehorse to Dawson and Mayo lies west of the map-area. It crosses Yukon River at Carmacks and Pelly River at Pelly Crossing, 10 and 18 miles, respectively, from the west boundary of the area.

Before the road was built, Yukon River provided the main access into central Yukon Territory and, in summer, large stern-wheel steamboats travelled upon it. Pelly and Macmillan Rivers are navigable for river launches of moderate size. Little Salmon River is passable for small boats only and is best negotiated at high water stages. Pack horses may be used throughout the area. Float-equipped aircraft are available at Whitehorse and Dawson, and many lakes within the map-area are suitable for landings.

Climate

No weather stations are situated within Glenlyon map-area but climatalogical data for Mayo Landing (Table I), 40 miles to the north, give an indication of the climate for a large region of central Yukon Territory. Winters are very cold but summers are mild and pleasant, and in June and July daylight is almost continuous. The extremes of temperature recorded from winter to summer are 73°F below zero to 96°F above. The mean annual precipitation at Mayo is 11.2 inches, about half of which falls in the four months from June to September (Kendrew and Kerr, 1955, p. 216). Although data are lacking, precipitation is probably greater in the high mountains of Glenlyon Range than in the surrounding lower country.

Ms received 15 October, 1964.

Ice breaks up in the rivers in early May but the lakes generally remain frozen until late May. Freeze-up begins in October.

Table I

Climatological Table for Mayo Landing, Yukon (Altitude above m.s.l. 1,625 feet)

Month	Air Temperature (°F)			Precipitation (in.)		Number of days		
	Daily Mean	Mean of Max.	Daily Min.	Mean (total) of all forms	Mean Snowfall	Rain	Snow	Frost in screen
Jan.	−11	−1	−20	0.8	7	0	8	31
Feb.	− 5	6	−16	0.4	4	0	5	28
March	13	26	− 1	0.4	4	0	4	31
April	30	42	18	0.3	2	2	3	27
May	46	58	34	0.8	0	7	1	13
June	56	69	42	1.4	0	9	0	2
July	58	72	45	1.6	0	12	0	0
Aug.	53	66	40	1.8	0	13	0	6
Sept.	43	54	32	1.2	1	10	0	14
Oct.	29	37	22	0.9	6	3	5	26
Nov.	4	12	− 4	0.8	8	1	7	30
Dec.	−10	0	−19	0.8	8	0	8	31
Mean	26	37	14					
Total				11.2	41	57	41	239
No. of years observation	26	26	26	26	26	17	17	11

From Kendrew and Kerr, 1955, p. 216.

Flora

Despite the small total precipitation, ample moisture is available for vegetative growth during the short summer season. Forest growth is light but widespread and extends up the valley sides to elevations between 4,000 and 4,500 feet above sea-level. The largest trees grow in the main river valleys. White spruce about 100 feet tall were observed along the banks of Macmillan River.

The vegetation on slopes facing north and east is very different from that on slopes facing south and west. The former are heavily moss-covered and support associations of rather stunted white and black spruce, willow, and labrador tea, whereas the latter sustain white spruce, aspen poplar, lodgepole pine, and various grasses and shrubs including sage. Cottonwood is restricted to the river and stream valleys and large stands of small lodgepole pine grow on some dry, flat areas. Alpine balsam is commonly found near timber-line, and arctic black birch, willow, heather, grasses, and other alpine plants at higher elevations.

Large areas of Tummel Basin (*see* Map 1221A, *in pocket*) and of Earn, Little Salmon, and Drury Lake valleys were burned within the last 45 years. These areas are now covered by stands of small spruce, poplar, and pine along with extensive growths of willow and arctic black birch with local patches of alder. Here and there windfall is a serious hindrance to travel.

Fauna

Large game animals were not plentiful in the map-area during the period from 1949 to 1954 when field work was in progress but there seemed to be an increase of moose, particularly, over that period. Woodland caribou were observed in small groups on most of the alpine areas but the largest herds seemed to be confined to the northern part of Glenlyon Range. Sheep, which are intergrades between the white Dall sheep and the dark Stone sheep, were seen only in Glenlyon Range and on Tay Mountain. Grizzly, black, and brown bears, though not plentiful, occur in all parts of the area. A few wolves were seen and smaller fur-bearing animals are common.

Game birds include grouse, ptarmigan, ducks and geese. Grayling can be found in many streams, and lake trout, whitefish, and pike are common in the rivers and lakes.

Previous Work

In 1843 Robert Campbell, an official of the Hudson's Bay Company, crossed the divide from the headwaters of Liard River to Pelly River which he followed down to its junction with Yukon River. Some time later Campbell established Fort Selkirk at the confluence of the two rivers. In the course of his travels, Campbell named Pelly River and many of its tributaries including Glenlyon River.

The next reported exploration of Pelly River was in 1887 by G. M. Dawson (1888) who made a rapid examination of the bedrock and unconsolidated deposits along the banks. In 1902 R. G. McConnell (1903) explored Macmillan River, and in 1908 Joseph Keele (1909) studied the geology along the headwaters of Pelly and Ross Rivers.

W. E. Cockfield (1929) in 1928 made a geological reconnaissance of Little Salmon and Magundy valleys. A reconnaissance study of the geology along Pelly River valley between Macmillan River and Hoole Canyon was made by J. R. Johnston (1936) in 1935.

From 1932 to 1949 H. S. Bostock was engaged nearly continuously in mapping areas near Glenlyon map-area. These areas include Laberge to the south (Bostock and Lees, 1938), Carmacks to the west (Bostock, 1936), McQuesten to the northwest (Bostock, 1948b), and Mayo to the north (Bostock, 1947).

Present Work

The present work was begun by the writer in 1949 and continued through the field seasons of 1950 to 1954 inclusive. In 1956 J. O. Wheeler spent about 4 weeks mapping along Yukon and Little Salmon valleys.

Acknowledgments

The writer wishes to acknowledge the friendly assistance and ready source of information always available from Mr. J. C. Wilkinson and family, former owners of Pelly Farm near Fort Selkirk.

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Chapter II

PHYSIOGRAPHY AND GLACIATION

Physiography

Glenlyon map-area lies within the Interior System of the Canadian Cordillera (Bostock, 1948a). More specifically it is part of Yukon Plateau which has been divided by Bostock into many smaller units. Included within the broad definition of the plateau are the prominent Pelly Mountains of which Glenlyon and Big Salmon Ranges in Glenlyon map-area are part. The map-area includes part of Tintina Trench, a feature similar to the Rocky Mountain Trench. The Trench was called Tintina valley by Bostock (1948a) and earlier workers.

The outstanding topographic feature is Glenlyon Range in the east-central part of the map-area. Summit elevations over much of the range exceed 6,500 feet and broad areas rise above 5,000 feet. Many cirques are developed in the mountains and deep, trough-like valleys extend down from them. The cirques and trough valleys are cut into what was once a smoothly rolling, hilly surface upon which streams flowed in broad, open valleys. Remnants of this surface are widespread throughout the range and are particularly evident on the ridges around Pass, Jar, and Felix Creeks, and also around Harvey Creek. The flat tops of Mount Harvey and the next mountain to the southeast are about 4,000 feet above nearby Pelly River and are separated from it by steep, rugged slopes (Pl. I). This abrupt transition from the smooth upland surface to the rugged walls of the valleys and cirques is characteristic of the mountains of Glenlyon Range. Such deep dissection of the old surface suggests that the master streams have cut down rapidly, perhaps due to regional uplift, but local differential uplift may also have played a part.

Many other mountainous and hilly parts of the map-area contain less obvious remnants of an old, subdued topography above which a few peaks are prominent. The abrupt discontinuity from the upland surface to the younger valleys is rarely so obvious as in Glenlyon Range.

In a general way the old upland surface slopes gently westward from more than 5,000 feet in and around Glenlyon Range to 4,000 feet or less near Frenchman Lake. The surface lies from 2,000 to more than 3,000 feet above the floors of the major valleys.

In the northwestern part of the map-area, a large, heavily drift-covered lowland lies distinctly below the level of the old plateau surface. The limits of this lowland, here called Tummel Basin (*see* Map 1221A) are roughly Macmillan River on the north, Ess Lake on the south, Tummel River on the east, and Tatlmain Lake on the west. The surface of the basin is mostly between 2,000 and 2,500 feet above sea-level.The main stream valleys are cut to a depth of 100 to 400 feet into the surface, above which project a few scattered rocky knobs up to 500 feet high. The maximum relief in the basin is less than 1,000 feet.

An important topographic feature of Glenlyon map-area is Tintina Trench which extends on a bearing of N50°W from the southern part of Pelly Mountains for more than 400 miles into Alaska. In Glenlyon map-area, the Trench is marked by Pelly River, Detour Lakes, and Little Kalzas River and Lake. Northwesterly from the deep trough between Glenlyon Range and Tay Mountain, the northeast side of the trench is low but the great face of Glenlyon Range makes a prominent scarp on the southwest and rises to a maximum of more than 5,000 feet above the valley floor. Northwest from Glenlyon Range, the Trench loses its identity by merging with Tummel Basin but reappears again as Little Kalzas valley.

The time of uplift and dissection of the upland surface of Yukon Plateau is a matter that has been discussed by many writers. Early opinions were summarized by Cockfield (1921, pp. 6–7). The problem is mentioned in several later reports (e.g. Bostock, 1936, 1948a, and 1948b; and Wheeler, 1961). In Carmacks map-area (Bostock, 1936) and in the area of Sixty Mile and Ladue Rivers (Cockfield, 1921), sedimentary and volcanic rocks believed to be Eocene, but possibly late Cretaceous, are truncated by the erosion surface.

Flat-lying basaltic lavas in several parts of Yukon Territory flowed out on a topographic surface much like the present (Bostock, 1936), that is, after dissection of the old plateau surface. These flows are, in part, Pleistocene or older. Thus the evidence indicates that the plateau surface was uplifted sometime in the Tertiary.

Drainage

All streams in Glenlyon map-area are part of the great Yukon River system; the main river itself crosses the southwest corner of the area. Most of the map-area is drained by Pelly River and its tributaries, but the southern one-third is drained mainly by Little Salmon River.

The valley floors of the main streams, that is, of Yukon, Pelly, Little Salmon, and Macmillan Rivers, are all below 2,000 feet elevation, and those of the main tributaries, such as Kalzas, Earn, Tay, and Magundy Rivers and Needlerock Creek, are below 2,500 feet. These master drainage routes were probably excavated by rejuvenated streams following uplift of the Yukon Plateau. Some of these valleys became main channels of glacial flow during the Pleistocene and were thereby modified and deepened.

As many of the smaller tributaries failed to deepen their valleys at the pace of the major streams, they continued to flow on the elevated plateau surface much as before, and plunged down steep-walled gorges to the main valleys below. Tributaries of this nature are common in Glenlyon Range where remnants of the old

PLATE I. View looking south across Glenlyon Range showing relatively rugged topography in contrast with the view from the opposite direction (see Pl. II). Pelly River and the mouth of Harvey Creek are in the foreground. (R.C.A.F. Photo T9-37R) plateau surface cover wide areas. Deepening of these valleys by local valley glaciation did not suffice to bring them into accord with the large streams which bound the range, and many of them still debouch from the mountains through rugged canyons.

Remnants of the plateau surface are small in most parts of the map-area where dissection is further advanced than in Glenlyon Range. In such places tributary streams fall on steep gradients from near the ridge tops to the main valleys.

The drainage shows no clearly defined pattern. Perhaps the nearest approach to a preferred direction is that marked by Tintina Trench in which Pelly River flows for some distance. To the southwest, a few valleys, most notably those of Drury Lake and part of Tummel River, parallel the Trench. The main drainage route in the southern part of the area, Little Salmon valley, lies about east-west which is not parallel with any obvious bedrock structure.

Northeast of Tintina Trench the main valleys trend about N70°E as shown by parts of the valleys of Tay, Earn, Macmillan, and Kalzas Rivers. The pattern is not strong and has no apparent explanation.

In general, streams of the map-area form a dendritic pattern, altered here and there by glacial activity. Some of these changes are discussed in the following section dealing with glaciation.

Glaciation

The glaciation of Glenlyon map-area was studied mainly by detailed examination of aerial photographs in which many topographic features resulting from glaciation are clearly discernible though they may not be obvious on the ground. Data from this study are plotted on a map showing glacial features only (*see* Map 1222A).

Clear evidence of a single major ice advance has been found in the map-area. Topographic features of this glaciation are little modified by subsequent erosion and the deposits are fresh and unweathered. Apparently beyond the limits of the last glaciation, in Carmacks map-area to the west, Bostock (1936, pp. 9, 10, and 48) found evidence of older glaciations as he did in Dublin Gulch to the north (Bostock, 1948a, p. 64). Aitken (1959, p. 6) observed deposits of at least two glaciations near Atlin, and Péwé, *et al.* (1953) described multiple glaciation from many parts of Alaska.

Bostock kindly made the aerial photographs of Carmacks map-area available in order that the writer might undertake a study to show the relationship of the well-marked glacial features in Glenlyon map-area to the limit of glaciation farther to the west. The photographs were not available when Bostock (1936) made his original study. The writer's work showed good evidence of three glacial advances. The glacial features in Glenlyon map-area result from the most recent of these.

During its last recognized advance, the Cordilleran ice-sheet entered Glenlyon map-area from the east and south; and the ice surface in a general way sloped down to the west (*see* Map 1222A). The advance of the last mountain ice-sheet was preceded, perhaps very appreciably, by local valley glaciation in Glenlyon Range and by a few small valley glaciers in some of the other high mountains. The valley glaciers receded and apparently disappeared prior to the maximum advance of the last ice-sheet, even though the cirques and peaks were not overridden. Furthermore, the valley glaciers did not revive following retreat of the ice-sheet.

Valley Glaciation

In Glenlyon map-area, most local valley glaciers developed in the mountains of Glenlyon Range, but small ones extended down from cirques on Tay, Kalzas, and Earn Mountains, and in the mountains on the south boundary of the area about 15 miles from the southeast corner.

In general, cirques developed on the north or northeast sides of the highest summits of the rather subdued pre-glacial topography of Glenlyon Range. From the cirques glaciers extended down the valleys as far as 10 miles or more. The ice eroded typical U-shaped troughs and near the cirques greatly oversteepened the valley walls. The steep-sided trough valleys and cirque headwalls contrast conspicuously with the older more rounded topography. If viewed from the northeast (Pl. I), thus looking into the cirques and glaciated valleys, the topography of Glenlyon Range appears more rough and rugged than when viewed from the southwest (Pl. II).

The floors of all cirques in the map-area are above 5,000 feet elevation, but some, notably those that face northwest or west as on Drury Spire and Tay Mountain, are above 5,500 feet. Active ice apparently occupied all the cirques in the map-area during the last stage of valley glaciation with but one probable exception. The exception is a southerly facing basin near the head of Jar Creek. This cirque is smoothed and rounded in contrast with the others and its floor lies above 5,500 feet. It may be a relic from a previous period of valley glaciation.

At the height of the last period of valley glaciation, ice flowed from the cirques and down the valleys of Glenlyon Range locally reaching the edges of the range and possibly extending into the surrounding main valleys. This is true of the glacier that reached more than 10 miles down Felix Creek from Truitt Peak, and also for the ice in Jar, Fan, and other creeks. Valley glaciers not in Glenlyon Range were very small and scarcely reached beyond their cirques.

In deepening and widening their valleys, the main glaciers in Glenlyon Range truncated spurs leaving triangular facets and hanging tributary valleys (Pl. III).

Many cirques in the range lie above the limit of the last advance of the Cordilleran ice-sheet. Above this limit large talus slopes have developed from the headwalls of the cirques and the adjacent slopes of the valleys. The streams seem to have well-developed, regular, long profiles, and the mountain slopes, downstream from the talus slides, merge smoothly with the valley bottoms. The forms of the cirques and U-shaped valleys, with their triangular facets and hanging tributaries, are the only features, either erosional or depositional, that can be attributed to local valley glaciation with the probable exception of one series of end moraines at about 5,000 feet elevation on Lyon Creek. No other moraines resulting from

PLATE II. View looking north across Glenlyon Range showing the more rounded character of the topography when viewed from this direction. The foot of Drury Lake is in the left foreground. (R.C.A.F. Photo T7-134L) valley glaciation have been recognized. This is in marked contrast with the situation related to glaciation by the ice-sheet.

No evidence that an appreciable quantity of ice formed in the cirques of Glenlyon map-area after withdrawal of the continental ice-sheet was found. In Quiet Lake map-area to the southeast, Wheeler (personal communication) observed several small glaciers around Fox Mountain in the floors of large cirques at elevations between 6,000 and 6,500 feet. He believes that this ice formed subsequent to the retreat of the ice-sheet. If the two areas are assumed to have similar precipitation, no ice, apparently, could form or persist in the lower cirques of Glenlyon Range from a time prior to the last advance of the ice-sheet.

One may suppose that valley glaciers existed in Glenlyon map-area several times during the Pleistocene Epoch. No evidence has been recognized, however, to suggest that valley glaciers developed in response to conditions that led to the development of the mountain ice-sheets; rather the development of the latter seems to have come with conditions that eliminated the former.

Cordilleran Ice-sheet

Ice from two sources moved into Glenlyon map-area during the last advance of the Cordilleran ice-sheet. (*See* Map 1222A.) From a centre apparently in northern Cassiar Mountains, ice flowed northwesterly down Yukon River valley and entered the map-area along the southern boundary west of longitude 134°30′W; this ice has been termed the Cassiar lobe by Wheeler (1961, p. 10). Westerly and northwesterly flowing ice entered the map-area along the eastern boundary from a source in the southern Selwyn Mountains, and is here termed the Selwyn lobe.

The directions of flow and the topography of the surface of the ice-sheets have been inferred from an exhaustive photo-study of topographic forms produced by the ice.

Topographic Features Resulting from Ice-sheet Glaciation

Features of Ice Erosion

All valleys in Glenlyon map-area have been modified by ice-sheet glaciation to some extent. Some are troughed with U-shaped transverse profiles; this is particularly true of those valleys that contained a tongue of ice that behaved essentially as a valley glacier. A good example is the valley of the most westerly headwater branch of Tummel River in Tummel Hills. Scouring and oversteepening of valley walls is a feature common to most of the major valleys.

In glacially modified valleys truncated spurs and triangular facets are common. These features are well developed on the northeastern and southwestern faces of Glenlyon Range. The facets have been little modified by post-glacial erosion and only the large tributaries were able to cut appreciable canyons in an effort to re-establish accordant junctions with the main streams.

Giant grooves and rock benches have been carved on the walls of many valleys by moving ice. Where well developed these features give valley walls a

PLATE III. View looking south across the southern part of Glenlyon Range: Jar Creek in foreground, Felix Creek on left, and Little Salmon Lake in distance. It illustrates the cirques and trough-shaped valleys produced by local valley glaciation, and also shows truncated spurs and hanging valleys. (R.C.A.F. Photo T10-128R) conspicuous, horizontally lined effect (Pl. II). Glacial deposits as well as bedrock are grooved. Such linear features are common low on valley walls and may be associated with drumlins in such places as Tummel Basin.

In Tummel Basin and other flat areas, bedrock hillocks or rock drumlins are scoured and streamlined by glacial erosion. The hillocks may have a tail of drift extending from the lee side in typical crag-and-tail topography. Drumlins are also common in these areas and all gradations can be found from rock drumlins through crag-and-tail features to drumlins with no evidence of associated bedrock.

Tarns and mamillated outcrops mark the tops of ridges composed of coarsely jointed granitic rocks in parts of Glenlyon Range, particularly at the southeast end.

Small scale scratches or striations on bedrock surfaces are not common, and of the few observed, most appear to have been but recently exhumed from beneath a drift covering. In general, the directions of flow indicated by striae agree closely with those determined from larger features plotted from the aerial photographs.

Features of Deposition

Drumlins, lateral moraines, kame terraces, and pitted terrain are described here, but deposits lacking distinctive topographic form are not discussed.

Drumlins. Tummel Basin contains hundreds, perhaps thousands, of drumlins, far more than are indicated by symbols on the map. Indeed the symbols on the glacial map accurately represent the direction of movement indicated by the drumlins but not necessarily the location of an individual drumlin. These fields of drumlins have been termed 'drumlinized till plains' by Armstrong and Tipper (1948, p. 288) and are well described and illustrated by them. Some drumlins show a streamlined form clearly indicative of a definite direction of ice movement but many are roughly symmetrical in long profile and show only the line of ice movement, not its direction. Material in the drumlins is unweathered and seems to have been deposited during the last glaciation but examinations of it are few and scattered.

The most extensive development of drumlins is in Tummel Basin but they are also numerous in the valley of Earn Lake. In other parts of the map-area drumlins, confined mainly to the valleys and low-lying areas, occur singly and in small groups.

Lateral moraines and kame terraces. The tops of many mountains and hills projected above the ice at the maximum stage of the last advance. The ice at the maximum stage apparently maintained a constant level for an appreciable period of time. Under these conditions well-marked drift deposits formed at the ice margins around nunatak areas. These deposits formed long, narrow, discontinuous embankments of which many have been preserved.

Wheeler (1961, p. 15) classified similar deposits in Whitehorse map-area as elongate drift ridges. In Glenlyon map-area, most of these features are ice marginal deposits and no doubt include lateral moraines and kame terraces. Some, which go uphill and downdale as around Afe Peak, are probably mainly morainal; others have uniform gradients and could be all or partly kame terraces. A comprehensive study

PLATE IV. Vertical aerial photograph of Moraine Mountain, which clearly shows the moraine ringing the top of the mountain at an elevation of just below 5,000 feet. (R.C.A.F. Photo T10-117C) of the material in these deposits would be necessary to solve the problem of their origin, but the configuration of many of the ridges suggests that they are, primarily, moraines rather than kame terraces. The term lateral moraine in this report will henceforth be used for kame terraces and other elongate ice-contact deposits.

The lateral moraines are small embankments rarely rising more than 20 feet above the general slope of the hillside; most are probably less than 10 feet high. The moraines commonly enclose depressions on the uphill side in which, here and there, small ponds have formed. Because of their small size the moraines are difficult to see in the field but are prominent in aerial photographs. The upper limit of glaciation is not everywhere marked by lateral moraines owing either to lack of deposition or to removal by subsequent erosion.

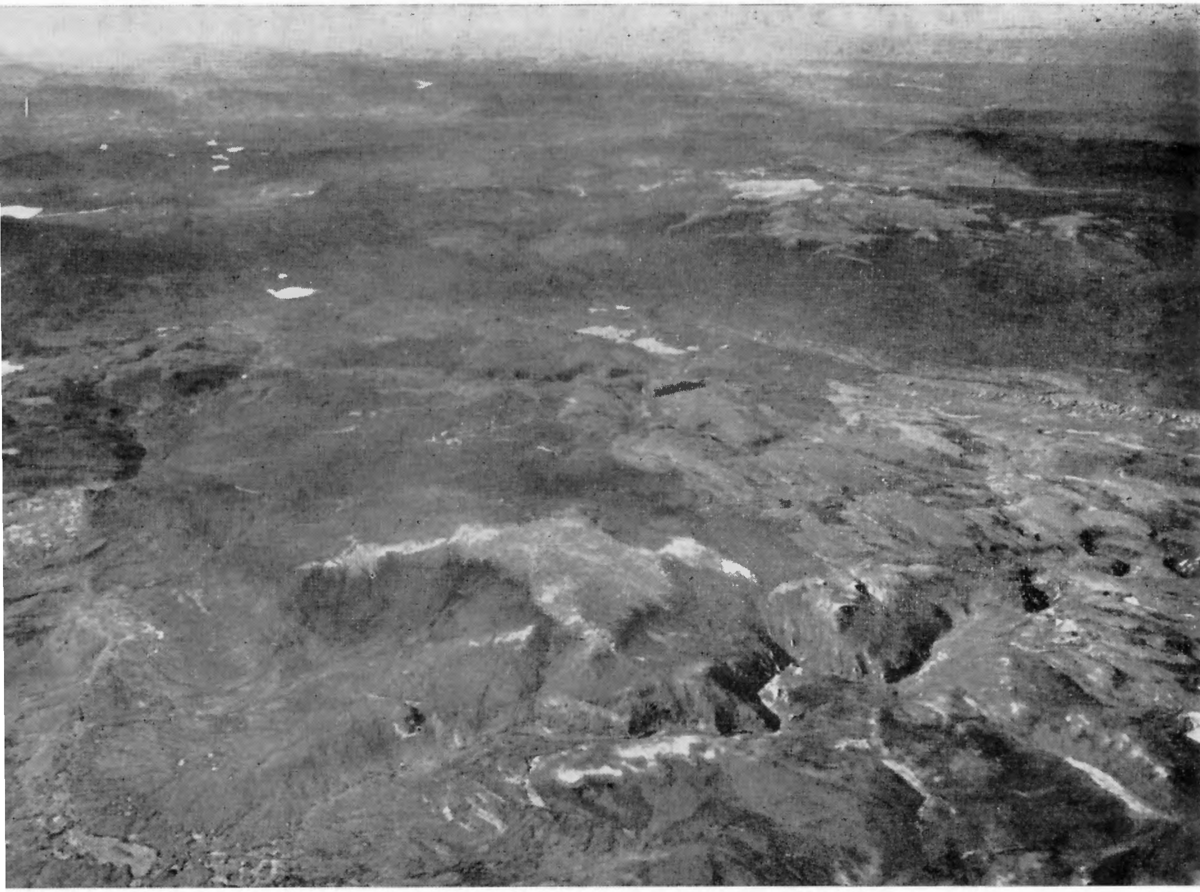

PLATE V. Direct overflow channel. View looking south over the western part of Tummel Hills. The valley of Needlerock Creek on right and the divide between the drainage of Bearfeed Creek and the west branch of Tummel River in left foreground. The channel begins in the saddle in the ridge east of Needlerock Creek and extends down to the west in a prominent canyon. (R.C.A.F. Photo T10-111R)

PLATE VI. Lateral overflow channel. View looking south to Little Salmon Range across the northern part of Drury Lake. In the right foreground, the headless channel slopes down to the right and is cut into bedrock on the slopes of Moraine Mountain. In the left foreground are other smaller channels. (R.C.A.F. Photo T10-118R)

The configuration of the lateral moraines is controlled by topography. On the sides of valleys with many tributaries, the moraines wind in and out and up and down as they pass from the spurs to intervening valleys. Such moraines are well displayed on the southwest side of Glenlyon Range and around Afe Peak; in the latter locality, an almost continuous moraine winds around the peak for a distance of more than 25 miles. Some lateral moraines are nearly straight for more than 3 miles; one, on the hill east of Frenchman Lake, is about 6 miles long.

Perhaps the most spectacular lateral moraine in the map-area completely encircles the top of Moraine Mountain and tails off to the north in the direction of glacial flow (Pl. IV). Below the moraine the slopes are mantled with drift whereas above it the mountain top is a mass of tumbled granitic blocks.

Pitted terrain. There are few, well-defined, mappable eskers in Glenlyon map-area. Most are short and sinuous and occur in complex topography pitted with numerous kettles. Many of these ridges may actually be crevasse fillings rather than eskers. The pitted terrain seems to have formed mainly by the partial burial and wasting of large masses of stagnant ice. Excellent examples of this type of terrain were observed near Frenchman Lake, along the upper reaches of Needlerock Creek, and near The Detour on Pelly River. Material in the pitted terrain is mostly fine gravel and sand.

Abandoned Stream Channels

Abandoned glacial stream channels of several sorts are prominent in the area. Various types have been described and illustrated by Wheeler in Whitehorse map-area (1961, pp. 11–13), and all the types described by him and at least one additional type are common in Glenlyon map-area. Abandoned glacial stream channels are "... the most obvious of all indicators of the pattern of deglaciation" (Wheeler, 1961, p. 11).

Wheeler (p. 11), following other workers, has divided the channels in Whitehorse map-area into two main categories: direct overflow channels and lateral overflow channels. In Glenlyon map-area another category, direct outwash channels, must be added; this third category, although somewhat similar to the first, is much less restricted in its relation to topography.

Direct overflow channels. When the ice-sheets thinned and retreated some valleys became ice-free or nearly so, while other adjoining valleys were still choked with ice. Under these conditions meltwater could run from an ice-filled valley over divides into an open valley beyond. Such streams were able to cut steep-walled canyons locally as they rushed down the valley sides (Pl. V). All the direct overflow channels observed indicate that ice retreated to the east and southeast thus vacating valleys successively from west or northwest to east or southeast.

Lateral overflow channels. As the name indicates, lateral overflow channels were formed by streams flowing between the ice margin and the valley walls. These channels may be long, shallow depressions on valley sides or small notches in spurs cut into bedrock or drift, or they may be channels cut several hundred feet into bedrock and several miles long (Pl. VI). In most instances, the gradients of the channels are clearly evident and indicate the approximate slope of the ice surface at the time the channels were formed. In many places, a series of parallel channels at successively lower levels show the positions of the ice surface as wasting proceeded. The lateral overflow channels generally indicate that the ice surface sloped to the west or northwest and that the ice retreated to the east and southeast.

Direct outwash channels. During the period of wasting and retreat, large debris-laden streams emerged from the margins of the ice-sheets and, in some places, flowed in channels other than present major drainage routes for long periods of time. These streams formed wide, braided channels and locally cut great canyons, in places miles long, through bedrock (Pl. VII). At present many of these channels are dry or contain only small streams and lakes.

Another type of direct outwash "channel" can be seen along Needlerock Creek and lower Tummel River. These "channels" are marked by floods of debris which seem to drown the topography along the stream courses. The flat surface of these

PLATE VII. Direct outwash channel. View looking south roughly along the western boundary of the map-area. Frenchman Lake is in the left distance and Tatchun Lake, in Carmacks map-area, in the centre distance. Yukon River is on the extreme right. An abandoned braided channel forms a light-coloured strip in the left middle distance. It leads to the right into a deep canyon which connects to McGregor Creek in Carmacks map-area and extends to Yukon River. (R.C.A.F. Photo T10-94R) deposits is much like the surface of a lake; the margins wind in and around drumlins and hillocks which do not seem to be eroded; rather they are inundated. Present streams have cut into the deposits and carved flood plains of their own. These "channels" are puzzling; they resemble long, narrow lake basins but the deposits in them seem to be too coarse for deposition along the length of lakes and the surfaces have very low, but nevertheless distinct gradients. They appear to have formed by rapid deposition of a flood of debris from a large volume of water along a very low gradient, probably for a rather short period.

Lake Basins

All the existing lakes in Glenlyon map-area seem to owe their origin, in one way or another, to glacial activity. Little Salmon and Drury Lakes apparently lie in bedrock basins formed by scouring and deepening by ice. No obvious bedrock closure forms the basins of Frenchman, Tadru, Ess, and Earn Lakes which seem to be entirely in glacial drift. The many small lakes in Tummel Basin lie in shallow depressions in the drift.

Several shallow glacial lakes are believed to have formed behind ice dams. Some of these were enlargements of existing lakes. These old lake basins are marked by flat silt and sand deposits but no shorelines have been noted. The valley of Magundy River was apparently once flooded by an enlarged Little Salmon Lake. Presumably downcutting at the outlet caused the level of the lake to drop.

Stagnant ice in and around The Detour, and possibly masses of outwash as well, apparently dammed Pelly and Earn Rivers so that a lake extended from the present site of Earn Lake down Earn River valley and into Pelly River valley to near Detour Lakes and the mouth of Harvey Creek.

Several shallow and probably short-lived lakes formed in Tummel Basin either behind ice dams or behind barriers of drift. Ragged Lake appears to be a remnant of a much larger body of water that was denied access to Pelly River by an ice dam and forced to overflow through a well-marked channel into Needlerock Creek.

Terraced deposits of silt with some sand and gravel are found along the valleys of Menzie Creek and Tay River. These seem to be beds that were deposited in lakes which formed against ice in Pelly River valley. Similar lakes, dammed by active ice, must have formed in some of the high valleys of Glenlyon Range.

In Macmillan River valley and along the first 15 miles of Pelly River above the mouth of Macmillan River, thick clays and silty clays are believed to be lake deposits though conclusive proof is lacking. The clay, when saturated with water, slides on very low gradients and several slide scars have been observed. Some of these slides must have dammed Macmillan River for brief periods.

Drainage Changes Caused by Glaciation

In pre-glacial time, the ancestral Pelly River may have flowed along Tintina Trench to the northwest through the valley presently occupied by Little Kalzas Lake. At present the Pelly leaves the Trench at the mouth of Tummel River and flows westward through a narrow, rocky valley into Carmacks map-area where it cuts through Granite Canyon. The present valley of the river was glaciated by at least the last advance of the Cordilleran ice-sheet and possibly by the last two advances. If Pelly River were deflected from an ancestral course along Tintina Trench by glacial activity, then this must have happened early in the Pleistocene.

Minor diversions of streams are exhibited by Pelly River at The Detour and by the lower few miles of Little Salmon River. The Detour was first described by Dawson (1888, p. 126). The diversion begins at the mouth of Harvey Creek where the river swings abruptly to the northeast then curves back to the north and finally to the west to rejoin its original course which was through the site of the present Detour Lakes. This diversion was apparently caused by a dam of drift and stagnant ice at the present site of Detour Lakes. The ponded water evidently escaped through a low saddle into Earn River valley which probably was flooded at the same time. The large lake thus formed included parts of both Pelly and Earn River valleys. This lake drained, apparently, somewhere near or west of the mouth of Earn River and, as the outlet rapidly cut down, the lake emptied, and the resulting stream became incised through the saddle from Pelly River valley into Earn River valley. When the ice dam around Detour Lakes melted the Pelly was too deeply entrenched to resume its original course.

The diversion of the lower reaches of Little Salmon River was clearly caused by an ice mass in the old channel. The new channel extends from the start of the northern deflection of the present river for about 4 miles southwesterly to Yukon River, which it joins about 6 miles above the present river junction. The river became notched into its diversion channel and was unable to return to its original course when the ice obstruction had melted.

An outstanding example of stream capture resulting from glacial activity is shown by Harvey Creek. The elbow of capture is marked by the point where the creek makes an abrupt bend from a southerly to an easterly course about 11 miles from its mouth. From this bend a steep-walled canyon, cut into bedrock, extends southwesterly to join East Tummel River with perfect accordance. The floor of the canyon not far west of the bend is lower than the stream bed of Harvey Creek and contains a string of ponds through which a slow current flows. The headwaters of Harvey Creek once clearly flowed through the canyon to East Tummel River and apparently meltwater from a tongue of ice extending up lower Harvey Creek must also have poured through the canyon during the period of deglaciation. Harvey Creek valley was greatly deepened by ice flowing through it and the divide between the creek and East Tummel River was lowered. When the ice vacated the valley and normal stream flow began, the present headwaters for some reason, flowed into Harvey Creek. A recapture of the headwaters by East Tummel River could take place.

Movement of the Last Ice-sheet

The last recognized major advance of the Cordilleran ice-sheet was into Glenlyon map-area from two sources. From an ice-divide in the western side of Selwyn Mountains (Roddick and Wheeler, paper in preparation), ice forming the Selwyn lobe flowed generally westerly into and across part of Glenlyon map-area. The

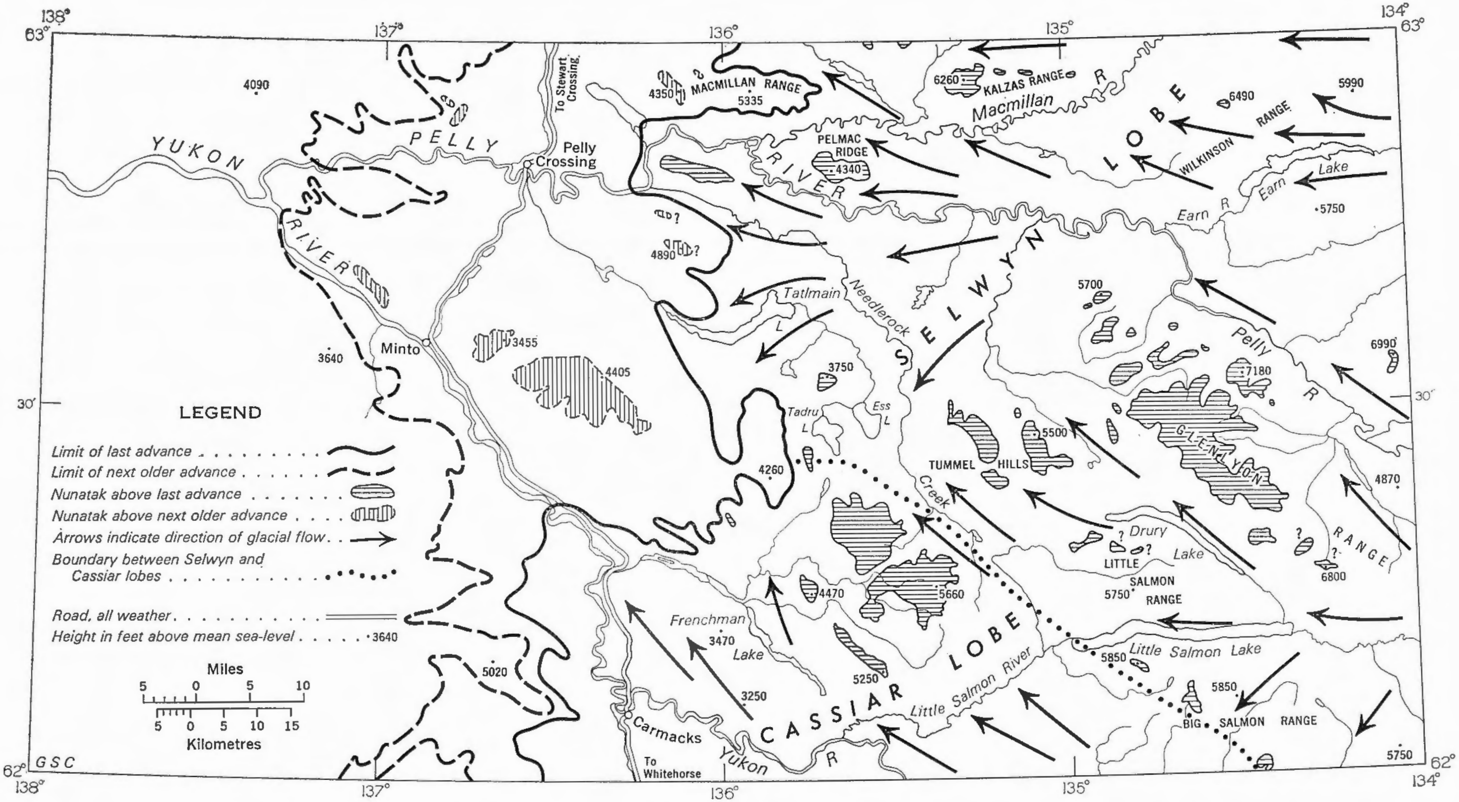

FIGURE 1. Extent of the two most recent ice-sheets recognized in central Yukon Territory. Glenlyon and Carmacks map-areas on right and left respectively. Evidence of a third, still older glaciation is visible west of the oldest limit shown.

southwestern corner of the area was invaded by ice of the Cassiar lobe which flowed northwesterly from a divide in northern Cassiar Mountains.

These two great Cordilleran glacier lobes extended only a few miles beyond the western boundary of the map-area (Fig. 1). Over some of the area ice was too thin to cover the hilltops and many nunataks projected above it. Under these conditions topography had a profound effect on the direction of glacial flow.

Selwyn Lobe

Ice of the Selwyn lobe flowed nearly straight west wherever topography permitted. The great barrier of Pelly Mountains rising along the southwest side of Pelly River could not be surmounted, and although ice of the Selwyn lobe penetrated up the mountain valleys, it was diverted mainly to the northwest along Tintina Trench (Roddick and Wheeler, in preparation). The deep valley of Magundy River provided an escape route to the west and a tongue of ice flowed through it. The area south of Magundy River and Little Salmon Lake lay in the "shadow" of the high Pelly Mountains and so could be invaded by Selwyn ice by southwest flow over the valley rim. Similar conditions prevailed north of Little Salmon Lake where ice flowed northwesterly behind the protective shield of Glenlyon Range. The flow of the Selwyn lobe down Little Salmon valley apparently ceased where ice of the Cassiar lobe was encountered.

Ice in Pelly River valley flowed along, into, and locally through Glenlyon Range. At the northwest end of the range it was able to turn westerly and, augmented by a large flow from Earn River valley, it expanded in a huge fan-shaped bulb across Tummel Basin.

Cassiar Lobe

The northwesterly direction of flow of ice of the Cassiar lobe down Yukon River valley coincided with the general trend of the main valleys with no major deflections, in contrast with the Selwyn lobe.

Upper Limit of Glaciation

Clearly discernible "lateral moraines" along valley walls and around many hilltops fall into a consistent pattern and are believed to mark the upper limit reached by ice of the two glacial lobes. In places with no moraines, an upper limit of glaciation may be marked by the change from obviously glaciated to apparently unglaciated terrain. In other places no apparent features mark the upper limit, but in most such places the limit may be extrapolated from nearby data.

Over a large part of Glenlyon map-area sufficient information is available on the upper limit of the last ice-sheet to permit approximate contouring of the ice surface at its maximum (Map 1222A). The contours for 4,500 feet and below seem to pass smoothly from those indicating the surface of the Selwyn lobe to those for the Cassiar lobe. This, together with evidence to be mentioned later, suggests that the two lobes stood at their maxima at the same time. The contours marking the surface above 4,500 feet at the junction of the two lobes (south of Little Salmon

Lake) indicate that ice from each source sloped down as it extended into Big Salmon Range and that a depression in the surface lay between the two ice masses. Control of these contours is weak, but Roddick and Wheeler (in preparation) have shown that such a depression probably existed in Pelly Mountains farther to the southeast.

A study of aerial photographs of Carmacks map-area showed that ice of the last advance did not extend far beyond the border of Glenlyon map-area (Fig. 1). Advance ceased when the ice thickness became less than 1,000 feet.

The contours indicate that the surface of the Selwyn lobe declined at the rate of roughly 50 feet per mile from the east boundary of the map-area near Earn Lake to the western boundary near Pelly River. It is obvious that topography must have a profound effect on the gradient of the surface of the flowing ice. The surface of ice confined to a valley and flowing upstream will tend to decline relatively steeply. Thus, one might expect steep gradients on the ice surface under conditions that existed around Glenlyon, Little Salmon and Big Salmon Ranges.

In Carmacks map-area west of the terminus of the last ice advance, many features of glaciation indicate the direction of flow and both the lateral and vertical limits reached by an earlier advance of Selwyn and Cassiar lobes, which expanded out from Pelly and Yukon River valleys (Fig. 1). Topographic features of this glaciation are not as sharply preserved as those of the last advance but generally are clearly discernible.

A still older and more extensive ice-sheet extended westward beyond the limit of glaciation shown by Bostock (1936, Map 922A). Though no definite limits could be determined for this old glaciation it seems to indicate the existence of ancient Selwyn and Cassiar lobes.

On the hilltops and ridges between Macmillan Range and Afe Peak in Glenlyon map-area, the writer had been puzzled by many indistinct and some rather clear-cut glacial features that lie well above the limit of the last glaciation. It was not then known that discernible topographic features of older glaciations were to be found elsewhere. It is now apparent that these observations are consistent with the concept of older and more extensive glaciations.

Deglaciation

Much information derived from aerial photographs depicts forms produced during thinning and retreat of the ice sheets. Much of the history of deglaciation can be deduced from a study of the data shown on the map.

As previously mentioned, a smooth transition from the surface of one lobe to the other apparently existed at the maximum stage, implying that the ice lobes stood at their maximum stages at the same time. Features indicating direction of movement are consistent with this and show that one lobe at its maximum did not flow over the area occupied by the other lobe at its maximum, except as noted below.

Many of the lateral moraines are at or close to the upper limits of the last ice-sheets. This is particularly true of those that are long, continuous, and well marked. In general, lateral moraines that lie well below the limit of glaciation are discontinuous and do not show a well-defined pattern although an exception to this will be noted. Lateral moraines are rare in the northeastern part of the map-area which was almost completely inundated by ice. The ice-sheets seemed to remain at their maximum stages for an appreciable time during which moraines were built, and when wasting and retreat began it continued without noticeable break until the ice disappeared from the area. No evidence was observed of minor readvances.

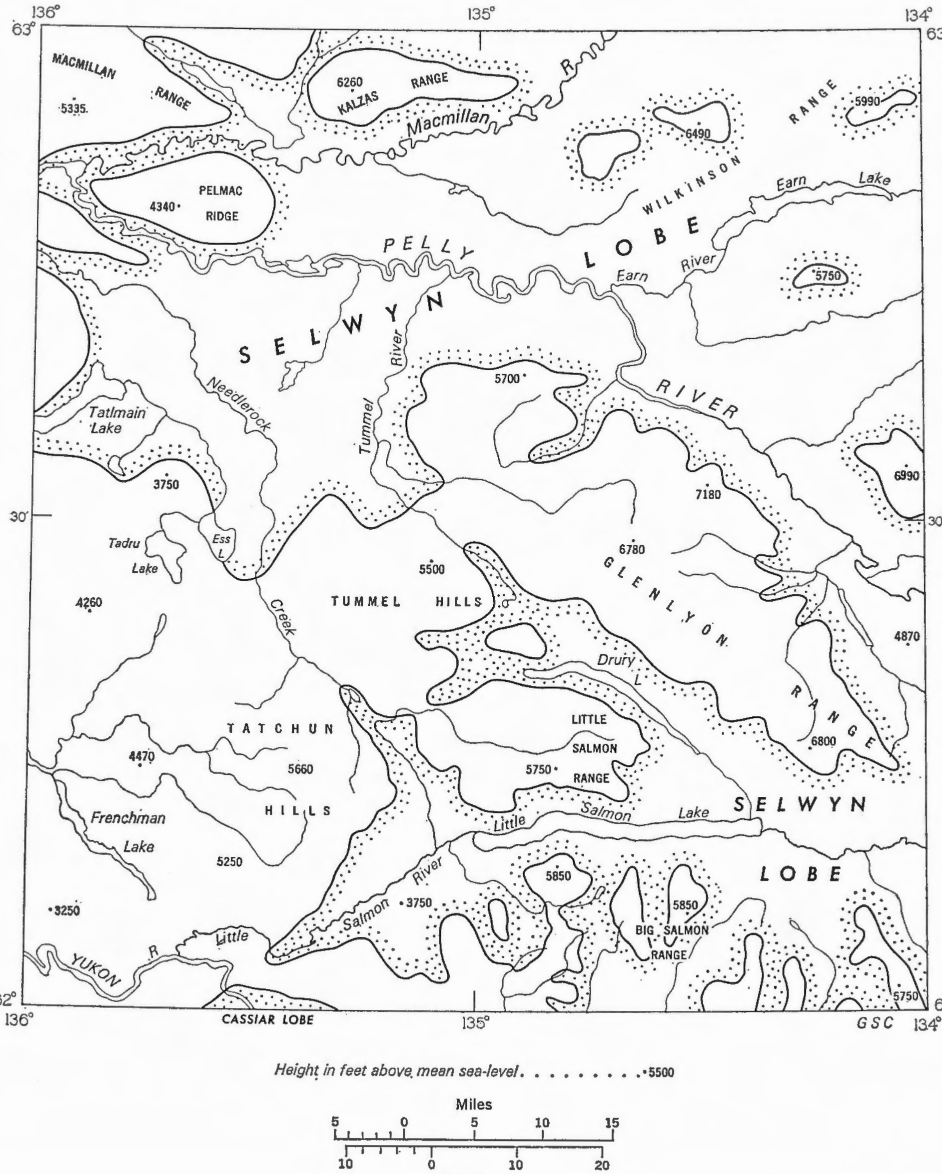

FIGURE 2. Extent of the last Cordilleran ice-sheet in Glenlyon map-area at a time when deglaciation was well advanced. The limits of the ice-sheet shown based on little or no control; suggestive only.

Initially, the effects of wasting and retreat were more pronounced in the Cassiar lobe, and as this ice retreated to the south up Needlerock and down Kelly Creek valleys it was replaced by that of the Selwyn lobe extending from the north out of Tummel Basin. At a later stage the margin of the Cassiar lobe retreated far to the south and Selwyn ice, though wasting and thinning, flowed out of Little Salmon Lake valley and covered the lower parts of the country as it became exposed (Fig. 2). This reinvasion of ice from another source produced a distinct series of lateral moraines along the hillsides south of Little Salmon River and in parts of the country south of Little Salmon Lake and River. A particularly obvious moraine surrounds the top of the hill five miles south of the west end of the lake. The slope of this moraine shows that it was made by ice flowing to the south.

A similar situation developed between the two segments of the Selwyn lobe that flowed around Glenlyon Range and coalesced at the north end of Tummel Hills. As wasting began, the ice margin retreated more rapidly southeasterly into Tummel Hills toward Drury Lake than it did to the north and northeast. This permitted the margin of the ice in Tummel Basin and northern Glenlyon Range to flow to the south. One result of this was the building of a huge ice-contact deposit in the northern Tummel Hills across the valley of the westerly headwater branch of Tummel River. The south slope of this deposit gently declines in the upstream direction into the valley and the north slope is very steep. Both the south slope and the flat at the bottom of the north slope are marked by kettles.

Great blocks of ice were isolated and stagnated as thinning and retreat proceeded. A particularly interesting example occurred in Yukon and Nordenskiold River valleys in Carmacks map-area close to the extreme limit of the last advance of the Cassiar lobe. An immense block of ice more than 25 miles long became isolated along the west side of the valley and the river was forced against the east side. Bedrock spurs were notched and the river became entrenched into some of these cuts (Bostock, 1936). Five Fingers Rapid apparently formed at this time.

At the maximum and during the early stages of retreat of the ice lobes, large, debris-laden, meltwater streams formed braided direct outwash channels in the southern part of Tummel Basin and in the drainage of Tatchun River. As the ice withdrew, major valleys of the present day became ice-free and were able to carry most of the meltwater; many of the early channels were abandoned.

An interesting relic of the deglaciation period is the field of parabolic dunes, now timbered and inactive, on the south boundary of the map-area 3.5 miles west of the 135th meridian. These were formed apparently by winds crossing the Yukon River outwash flats when the Cassiar lobe had retreated to the south.

In the final episode of glaciation, tongues of ice probably lay in Earn, Pelly, and Magundy River valleys close to the east boundary of the map-area long after the Cassiar lobe had disappeared to the south. Here and there masses of stagnant ice, buried in outwash, slowly melted and produced the present pitted terrain. Locally the melting of such masses released water ponded in peri-glacial lakes. Long after all ice left the map-area Macmillan, Pelly, and Yukon Rivers must have carried large but gradually diminishing volumes of meltwater.

Chapter III

General Geology

Glenlyon map-area is underlain by sedimentary, volcanic, and plutonic rocks which range from Early Palaeozoic and possibly Precambrian to Tertiary. Owing to the scarcity of determinable fossils the designated ages for the various map-units are based largely on inference and correlation with the rocks of nearby areas. Only the Lower Mississippian Kalzas Formation in the northern part of the map-area yielded fossils from which a precise age could be determined.

A profound geological discontinuity is marked by Tintina Trench. The stratigraphic succession on one side is, in general, not reflected on the other even though some rocks on one side may be time-equivalents of those on the other.

The rocks of Glenlyon map-area are divisible into northwesterly trending blocks each characterized by distinctive geology. At least some of these blocks are bounded by major faults. One such block extends diagonally across the area from the southeast to near the northwest corner, and includes the topographically prominent Glenlyon Range. In these mountains, large masses of granitic rock intrude metasedimentary strata of the Harvey Group which are thought to be lower Palaeozoic. In the northern part of the range and northwestward into Tummel Basin, Harvey Group rocks are succeeded by strata of the Askin Group(?) which is correlated with Silurian and Devonian rocks to the southeast in Quiet Lake map-area. This roughly diagonal block is, apparently, bounded by faults. On the northeast side is Tintina Trench which is believed to mark the locus of a major transcurrent fault and on the southwest side is a fault inferred to extend southeast and northwest from the lower part of Drury Lake valley.

Immediately northeast of Tintina Trench are volcanic and sedimentary rocks of the Anvil Range Group which is thought to be younger than the Late Palaeozoic sedimentary succession of the Earn Group and the strata of map-unit 1 which lie still farther to the northeast. The Earn Group contains much bedded chert, thick sections of chert conglomerate, and limestone known to be Lower Mississippian. Map-unit 1, confined to the extreme northeast corner of the map-area is characterized by red and green slate believed to be Late Precambrian.

Southwest of the fault that is inferred to pass through the lower part of Drury Lake valley is a group of rocks (map-units 6 and 7) of diverse lithology and metamorphism. Volcanic rocks and their metamorphic derivatives are prominent and, together with metasedimentary rocks, comprise a eugeosynclinal suite that may be correlated with Mississippian strata in northern Cassiar Mountains. Serpentinite is associated with the volcanic rocks of this group. These rocks have an irregular southwest margin beyond which is a group of dominantly volcanic rocks (map-unit 16) thought to be Permian and/or Triassic. In the southwestern corner of the map-area are volcanic and carbonate rocks of the Upper Triassic Lewes River Group and clastic sedimentary rocks of the Jurassic Laberge Group.

Near the 135th meridian and the south boundary of the map-area are two small outcrops of conglomerate and sandstone which may be part of the Upper Jurassic and/or Lower Cretaceous Tantalus Group. Similar rocks in Tintina Trench, in The Detour, may be of the same age.

All the rocks mentioned above, with the exception of the Tantalus Group and the conglomerate in The Detour, are intruded by bodies of granitic rocks in Glenlyon map-area, and it is known from other areas that some granitic intrusive masses are younger than the Tantalus Group and hence are Lower Cretaceous or later. In Glenlyon map-area, field evidence does not permit close dating of the period of intrusion of the granitic rocks.

Several scattered small intrusions of silicic porphyritic rocks are correlated with similar intrusions regarded as Tertiary in other parts of the Yukon.

The youngest bedrock deposits in the map-area are Tertiary basic volcanic rocks.

Unconsolidated Pleistocene and Recent deposits cover a high percentage of the surface of Glenlyon map-area, particularly in the western part.

Stratified Rocks

Proterozoic(?) Rocks (Map-unit 1)

The rocks of map-unit 1, thought to be the oldest in the map-area, are exposed in a few small scattered outcrops in the extreme northeast corner. Slate is the dominant rock type. Much of it is brick red, some is bright green, and some is dark grey and black. In the more southerly exposures the rocks are brown and grey sandy quartzite. No significant data on the thickness, succession, or structure of these rocks was obtained. They are believed to lie unconformably beneath or to be in fault contact with strata of the Earn Group.

Rocks characterized by the presence of red and green slate are widely distributed in Mayo map-area to the north (Bostock, 1947) and in Tay River and Sheldon Lake map-areas to the east (Roddick and Green, 1961a and 1961b). Roddick (personal communication) believed that these rocks in the nearby areas are part of a widespread Late Precambrian unit. The characteristic lithology plus the fact that they are roughly on trend with those to the north and east leads to the conclusion that these rocks in Glenlyon map-area are probably Late Precambrian.

Harvey Group

The Harvey Group consists of three rock units named from Harvey Creek in the northern part of Glenlyon Range. In an earlier publication (Campbell, 1954),

Table of Formations

Era	Period or Epoch	Southwest of Tintina Trench: Formation or Map-unit	Southwest of Tintina Trench: Lithology	Northeast of Tintina Trench: Formation or Map-unit	Northeast of Tintina Trench: Lithology
Cenozoic	Pleistocene and Recent	23	Recent stream deposits; gravel, sand and silt: glacial deposits; till, gravel, sand, silt, clay: bog deposits and volcanic ash	23	Recent stream deposits; gravel, sand and silt: glacial deposits; till, gravel, sand, silt, clay: bog deposits and volcanic ash
			Unconformity		Unconformity
	Tertiary	22	Basaltic and trachytic flows and breccia; conglomerate and shale		
			Relation of unit 22 to 21 unknown; unconformable on other units		
		21	Quartz-feldspar porphyry	21	Rhyolite (quartz) porphyry
			Intrusive contact; relation of unit 21 to unit 20 unknown		Intrusive contact; relation of unit 21 to unit 20 unknown
Mesozoic	Jurassic and/or Cretaceous and (?) earlier	20	Granodiorite, quartz monzonite, quartz diorite, syenite, diorite, basic rocks, and gneissic granodiorite	20	Granodiorite, quartz monzonite, and quartz diorite
			Intrusive contact; relations to unit 19 unknown		Intrusive contact; relations to unit 19 unknown
	Upper Jurassic and Lower Cretaceous (?)	Tantalus Group(?) 19a	Chert-pebble and chert-cobble conglomerate and sandstone	Tantalus Group(?) 19b	Conglomerate, shale, and sandstone
			Base not exposed		Base not exposed; possible fault contacts
	Lower Jurassic and (?) later	Laberge Group 18	Arkose, conglomerate, sandstone, siltstone, and argillite		
			Relations uncertain; possibly unconformable on Lewes River group		
	Upper Triassic	Lewes River Group 17	Andesite, basalt, limestone, conglomerate, and greywacke		
			Base not exposed		
	Upper Triassic or (?) earlier	16	Andesitic and basaltic volcanic rocks; minor rhyolite, argillite, and limestone		
			Relations unknown		
Palaeozoic	Mississippian or later			Anvil Range Group 15	Andesitic and basaltic flows, breccia, and tuff, diorite, slate, phyllite, slaty limestone, chert, and carbonaceous shale
		14	Serpentinite		Possible unconformable contact
			Intrusive and/or fault contacts with rocks of unit 7		
	Lower Mississippian or later			Earn Group (10-13) 13	Thin-bedded chert, argillite, quartzite, and minor limestone

Palaeozoic					Conformable contact
	Lower Mississippian			Kalzas Formation 12	Limestone; minor argillite and chert
					Conformable contact
	Lower Mississippian and/or earlier			Crystal Peak Formation 11	Chert-pebble and chert-cobble conglomerate and breccia; minor quartzite
					Possible unconformable or disconformable contact
				10	Chert, argillite, quartzite, limestone, and chert conglomerate
					Possible unconformable contact
	Mississippian(?) or earlier	9	Chert-pebble and chert-cobble conglomerate, slate, sandstone, greenstone, tuff, limestone, and hornfels		
			Unconformable contact with units 2 to 5; relation to units 6 and 7 unknown		
		8	Slate, argillite, chert, quartzite, lime-silicate rocks, limestone, greenstone		
			Relations unknown; fault contacts in part		
		6 and 7	Greenstone, greenschist, quartz-sericite and quartz-chlorite schist, quartzite, limestone, amphibolite, quartz-mica schist, argillite, and phyllite		
			Contacts not exposed; fault contacts in part		
	Silurian(?) and Devonian(?)	Askin Group(?) 5	Quartzite, dolomitic quartzite, dolomite, siliceous dolomite, limestone, slate, and argillite		
			Base not exposed; may have conformable contact with unit 4		
	Middle Cambrian(?) and later	Harvey Group (2-4) 4	Slate, phyllite, spotted slate, hornfels, argillite, and limestone		
			Conformable contact		
	Lower Cambrian(?)	3	Limestone, phyllitic limestone, lime-silicate gneiss, phyllite, slate, and skarn		
			Conformable contact		
	Lower Cambrian(?) or earlier(?)	2	Quartzite, quartz-mica schist, marble, amphibolite, lime-silicate gneiss, and skarn		
			Base not exposed		
Pre-cambrian (?)	Proterozoic(?)			1	Red, green, and grey slate; quartzite
					Base not exposed

the lower unit (map-unit 2) was placed in the Yukon Group, a catch-all for metamorphic rocks in central Yukon Territory, and the upper units (map-units 3 and 4), which are well exposed along the valley of lower Harvey Creek, formed the Harvey Group. It is now proposed that the three units, which form a conformable succession, be included together as the Harvey Group. No obvious correlation exists between the rocks of map-unit 2 and rocks that have been placed in the Yukon Group in other areas; thus the use of the name Yukon Group tends to confuse rather than clarify the stratigraphic relationships.

In no single locality is a type section of the Harvey Group exposed; indeed, structural complications and lack of critical exposures make it difficult to select type sections even for the individual units. Faults, intrusive rocks, areas of no exposure, and local intense minor folding prevent accurate measurement of thicknesses in almost all sections.

Distribution and Thickness

Strata of the Harvey Group are confined to Glenlyon Range, its extension to the mouth of Tummel River, and the extreme eastern part of Big Salmon Range. All three units of the group are found in the northern part of Glenlyon Range where they extend northwestward from near the junction of Glenlyon River and Jar Creek to beyond Front Mountain, and into the lower reaches of East Tummel River. The lower unit occurs alone in the southern end of Glenlyon Range and in Big Salmon Range.

Neither top nor bottom of the section can be observed, as the succession is cut off downwards by large masses of intrusive granitic rocks, and the upper contact with the overlying Askin Group(?) is not exposed.

Not even a good approximation of the thickness of map-unit 2 can be given as the section is interrupted by many granitic bodies, both large and small, and intersected by numerous faults. No marker beds were located, hence correlation between fault blocks is difficult. From the large thickness of beds of map-unit 2 exposed in the ridges separating Pass Creek from Jar Creek and Jar Creek from Felix Creek, the unit seems to be considerably in excess of 10,000 feet thick but no estimate of the amount of duplication caused by intense folding and faulting can be made.

Both top and bottom of map-unit 3 are exposed in many localities, but no one section from which a reliable measurement of the thickness could be made was found. Available information from many different localities indicates a thickness ranging from 1,200 to over 2,000 feet; about 1,400 feet is probably the best estimate.

The upper unit of the Harvey Group (map-unit 4) on the hillside north of Pass Creek appears to be at least 4,500 feet thick, but the top of the section is not known and many minor folds contort the beds.

Lithology

Map-unit 2

The most abundant rocks of the lower unit of the Harvey Group are micaceous quartzite and quartz-mica schist. As the resistant quartzose rocks outcrop prominently, their abundance, relative to more schistose micaceous types, may be overestimated. These rocks are shades of grey and brown on both weathered and fresh surfaces, and large exposures present a rather drab appearance. Bedding is usually discernible and schistosity is generally parallel with it. Calcareous rocks are interbedded with the quartzite and schist and, though relatively of small quantity, are widely distributed. Calcareous rocks are particularly abundant on Skarn Ridge and on the mountain 2 miles north-northeast of it. Fine- to medium-grained, cream-coloured, buff and grey weathering marble forms prominent beds ranging from a few feet to several tens of feet thick. Lime-silicate rocks, associated with the marble, include fine-grained, green, layered gneiss, coarse garnet-diopside skarn, and amphibolite. On Skarn Ridge a bed consists entirely of rosettes of fibrous anthophyllite. The lime-silicate rocks are developed in specific beds or groups of beds and evidence of bedding may be retained in completely transformed rocks such as amphibolite.

The quartzose rocks are feldspathic and typically are quartz-plagioclase-biotite schist. Plagioclase, mainly calcic oligoclase, is the dominant feldspar but potash feldspar is common. Although these rocks are fine grained they contain some porphyroblasts, particularly of plagioclase, exceeding 4 mm in length. Apatite is a common accessory mineral and garnet, andalusite, and rarely staurolite are less common. Seventeen modal analyses were made on samples of quartzose schist selected at random (Appendix, Table VI). In these analyses quartz varies from 3 to 73 per cent, and biotite from 5 to 62 per cent. The average composition of all analyses is 46 per cent quartz, 22 per cent plagioclase, 22 per cent biotite, 6 per cent potash feldspar, 4 per cent muscovite, and less than 1 per cent of other minerals.

In a common lime-silicate rock, layers of diopside and calcic plagioclase, with or without hornblende, biotite, and quartz, alternate with layers of quartz, more sodic plagioclase, and biotite. The layers are 1 mm or less and the rocks generally are fine grained. Amphibolite consists mainly of pale green hornblende and some plagioclase (about medium labradorite). In a few localities, diopside is an important constituent and where it is, hornblende is less abundant than elsewhere. In four modal analyses of amphibolite, plagioclase varies from 25 to 49 per cent and hornblende plus diopside from 46 to 71 per cent (Appendix, Table V).

Original composition. The rocks of the lower unit of the Harvey Group were, prior to their metamorphism, impure quartz sandstone and siltstone in thick, well-bedded sequences with scattered interbeds of shale and limestone. The limestone evidently accumulated as discontinuous pods rather than as continuous sheets. All the amphibolite is associated with calcareous rocks and presumably formed by the metamorphism of impure limestone. Although theoretically possible, there is no evidence that it resulted from the transformation of volcanic rocks.

Map-unit 3

The middle unit of the Harvey Group (map-unit 3) is composed mainly of thin-bedded, platy, grey and brown, finely crystalline limestone. Locally structures resembling ripple-marks were observed. Interbedded with the limestone are thin layers of argillaceous material. At the bottom of the section the limestone has been partly converted to thinly layered (1 mm to 1 cm) lime-silicate gneiss. Layers rich in one or all three of diopside, pale green amphibole, and biotite alternate with layers comparatively rich in quartz. Plagioclase (about An_{30}) occurs in both femic- and quartz-rich layers and, rarely, tiny grains and veinlets of potash feldspar are present in these rocks. The layering seems to represent original beds that were alternately calcareous and argillaceous or quartzose. Argillaceous beds associated with the lime-silicate rocks have been converted to fine-grained quartz-biotite schist, but higher in the section similar material forms phyllite and slate.

Limestone well above the base of the section is recrystallized, but otherwise is not affected by metamorphism except in one locality. Garnet and calcic plagioclase are developed in the limestone along the contacts of the large granitic dyke about 5 miles southwest of Mount Harvey. Associated argillaceous rocks are converted to andalusite-cordierite-biotite hornfels. Perthite is abundant in this zone of contact metamorphism.

Map-unit 4

In Glenlyon Range, phyllite and slate of the upper unit of the Harvey Group (map-unit 4a) commonly are dull dark grey, but some are brown. Here and there the phyllite is more schistose and shiny silvery black. The rocks weather to nondescript shades of brown and grey. These rocks display thin (1 mm to 5 mm), light-coloured layers, relatively richer in quartz, spaced from a few millimetres to several centimetres apart. All of these rocks consist mainly of very fine quartz, chlorite, and sericite.

In Glenlyon Range, argillaceous rocks near the contacts of granitic rocks are converted to blue-black biotite-andalusite-cordierite hornfels, which retains the compositional layering of the phyllite and slate but otherwise is harder and less fissile. Quartz, biotite, and plagioclase (about An_{30}) in the hornfels are very fine grained; andalusite and cordierite grains range up to 5 mm. The mica may or may not be well oriented. Rarely, tiny veinlets of potash feldspar cut the other minerals. Weathered exposures of the hornfels zone are deep brownish red; the colour is derived from the oxidation of finely disseminated pyrrhotite. In some places the hornfels zone is absent and in others it is as much as 2,000 feet wide. Between the hornfels and the unaffected slate and phyllite is a zone of spotted slate locally reaching several thousand feet in width. The spots are dark brown or black and represent the actual or incipient crystallization of andalusite or cordierite. In some places very fine biotite has developed and the rock is less fissile than elsewhere.

Light grey weathering, dark grey, siliceous and limy argillite, and minor, slaty, black limestone form the section of the upper Harvey Group (map-unit 4b) in the most easterly outcrop area near the junction of Pelly and Tummel Rivers. Similar rocks outcrop around the granodiorite intrusion on the north and west sides of the hill immediately south of the mouth of Tummel River. Close to the contact of the granodiorite, the argillaceous rocks are more blocky, less fissile, and some are fine-grained quartz-biotite hornfels. The outcrops in the banks of Tummel and Pelly Rivers are highly fissile, dark, limy, slaty argillite.

Structural Relations

Internal Structural Relations

The Harvey Group is a conformable succession and the contacts between the three units are not sharply defined. The top of the lower unit is marked by an abrupt decrease in quartzose rocks and increase in calcareous rocks, and similarly, the top of the middle unit is marked by more abundant argillaceous beds, which finally dominate the section and have been mapped as the upper unit of the group.

In the northern part of Glenlyon Range, beds of the Harvey Group dip mainly to the north and strike generally within 10 or 15 degrees of west. This is shown most clearly by the attitude of the top and bottom contacts of the middle unit (map-unit 3) of the group. These contacts dip 15 to 45 degrees to the north wherever observed, except on the mountain 3 miles north of Moraine Mountain where the lower contact dips southwesterly. In the lower unit of the group, the general dip of the strata is northerly though small folds cause reversals. These small folds trend west or a little north of west and plunge about 20 degrees. Their axial planes seem to be nearly vertical. In the upper unit of the group the attitude of the strata is erratic near the intrusive contact of the granodiorite mass that forms the northeastern front of the range.

Far to the south, in Big Salmon Range, strata of the lower unit seem to dip mainly to the south, but there the data are inconclusive. There, also, west-trending folds plunge to the west.

The Harvey Group in the northern part of Glenlyon Range appears to lie on the northern limb of a large west-trending, westerly plunging anticlinorium. The core of this postulated structure is occupied by continuous masses of granodiorite in the southern part of Glenlyon Range. Owing to the faults within and bounding Glenlyon Range, no single horizon can be traced around the nose of the plunging structure.

Bedding and cleavage or schistosity in the Harvey Group are parallel except in the crests of small isoclinal folds which are most common in the upper unit. These folds measure just a few inches from limb to limb, their axial planes are parallel with the bedding, and the axes are parallel with the strike or they may plunge a few degrees to the west. The cleavage intersects the bedding in the crests of the folds but is parallel with it in the limbs. These observations suggest an alternative to the interpretation that the Harvey Group in Glenlyon Range lies on the northern limb of a large anticlinorium. These rocks, perhaps, have been highly compressed into a series of isoclinal folds, the axes of which are horizontal or plunge gently westward, and the axial planes of which dip gently or moderately to the north. A later and perhaps unrelated episode of folding may have produced the present reversals in dip, involving both bedding and schistosity. Present data permit either interpretation.

The many faults that cut the Harvey Group in northern Glenlyon Range can be readily and accurately mapped where they intersect the contacts between the three units of the group. The strike of northwesterly trending faults changes from south to north. Near Pass, Jar, and Lyon Creeks the strike is about N10°W, whereas near East Tummel River and Harvey Creek it is close to N50°W. Near the divide between Pass and Little Sheep Creeks these faults are offset by west-trending faults.

Most of the northwesterly trending faults have caused a right hand displacement of north-dipping contacts. The westerly trending faults show left hand displacement.

The horizontal offset of the contact of the lower and middle units of the Harvey Group on the northwesterly trending faults between Jar Creek and East Tummel River is about 12 miles. The minimum possible movement necessary to explain the offset of the contact is about 3 miles of strike-slip (northeast side southeast) and 5 miles of dip-slip (northeast side down), an oblique movement of close to 6 miles. The uniformity of the attitude of the contact in the various fault blocks might readily result from the offset of a series of uniformly dipping beds by a number of strike-slip faults. A similar situation resulting mainly from dip-slip movement would require a uniformity of attitude for many miles down dip, which is much less likely to occur.

External Structural Relations

The major faults that are thought to lie along the northeast and southwest sides of Glenlyon Range isolate the Harvey Group from most other rocks of the map-area; intrusive granitic bodies, strata of the Askin Group(?), and of map-unit 9a are exceptions. The contacts with the last two map-units are not known to be exposed. The Askin Group(?) apparently overlies the Harvey Group without angular discordance, but the clastic sedimentary rocks of map-unit 9a are presumed to lie unconformably on beds of both groups.

The top of the lower unit of the Harvey Group in Glenlyon Range is nearly granite-free, but the stratigraphically lower parts (southward) contain more and more granitic rocks, commonly as sills too small to show on the map. The proportion of granitic rocks is greater nearer the continuous mass of grandiorite that underlies the southern part of the range. In the southern end of Glenlyon Range and in Big Salmon Range, small bodies of granitic rocks are common in the lower unit of the Harvey Group.

The long, narrow, granodiorite mass on the northeast margin of Glenlyon Range cuts off the top of the section along a sharp contact with the upper unit of the Harvey Group. West of Front Mountain a fault separates the upper unit from rocks of the Askin Group.

Metamorphism

The metamorphic character of rocks of the Harvey Group is described in the section dealing with the lithologies of the three units of the group. A few points of interest are noted here.

The change in metamorphism within the Harvey Group is directly related to the stratigraphy. The rocks of the lower unit fall within the amphibolite facies (Fyfe, Turner, and Verhoogen, 1958), whereas those of the upper unit, excluding hornfels, are within the greenschist facies. The change between the two takes place rather abruptly at the bottom of the middle unit.

The only clue to the age of metamorphism is to be found in its relation to the associated granitic rocks. The hornfels of parts of the upper unit is superimposed on the slate and phyllite; hence these rocks had become fissile prior to the intrusion of the granitic bodies. Locally, cross-cutting granitic rocks include disoriented fragments of schist of identical character to the intruded rocks. Thus the rocks of the lower unit apparently were in their present metamorphic condition prior to the intrusion of the granitic rocks, even though many small sills have a weak foliation parallel with the contacts and with the schistosity and bedding of the enclosing rocks. Such sills evidently were intruded parallel with the pre-existing foliation.

Age and Correlation

No fossils were found in the Harvey Group and the group cannot be directly related to rocks that have been dated palaeontologically. As these strata are intruded by Mesozoic granitic rocks, they can be regarded at least as Cretaceous or older, but only by correlation with rocks of known age in other areas can the age of the Harvey Group be more closely estimated.

The succession of the Harvey Group, in which quartzose rocks are overlain by a carbonate unit that in turn is succeeded by a thick sequence of argillaceous rocks, resembles that of Cambrian and Ordovician rocks in Pelly and Cassiar Mountains to the southeast. Rocks of this age have been mapped in Tay River (Roddick and Green, 1961a), Quiet Lake (Wheeler, Green, and Roddick, 1960a), Finlayson Lake (Wheeler, Green, and Roddick, 1960b), Wolf Lake (Poole, Roddick, and Green, 1960), McDame (Gabrielse, 1963), Rabbit River (Gabrielse, 1961), Kechika (Gabrielse, 1962b), and Cry Lake (Gabrielse, 1962a) map-areas.

These rocks extend more than 350 miles southeastward from Glenlyon Range, and in the various map-areas have been divided into two or more mappable units. In every case, the lowest beds in the Cambrian section are mainly quartzite with lesser amounts of siltstone, shale, slate, phyllite, and pebble-conglomerate. In Quiet Lake and adjoining map-areas, a phyllite unit overlies the quartzite and underlies a prominent Lower Cambrian *Archaeocyathid*-bearing limestone; the three units together have been named the Armchair Group by Roddick and Wheeler (report in preparation). Above the limestone is a distinctive, thick, phyllite unit termed the Lapie Group by Roddick and Wheeler, and equivalent rocks are called the Kechika Group by Gabrielse (1963).

Although the correlation of the Harvey Group with the Cambrian and Ordovician rocks to the southeast is not certain, similarities in the succession, coupled with the location of the Harvey Group just beyond the northeastern end of more than 350 miles of essentially continuous exposures of the lower Palaeozoic rocks, make the correlation probable. The lower unit of the Harvey Group is similar, and probably equivalent to the metamorphic rocks found in the central and western parts of Quiet Lake map-area (Wheeler, Green, and Roddick, 1960a, map-unit A). The latter rocks consist mainly of quartz-mica schist but include some carbonates, locally in very large masses (mapped separately as map-unit B). Whether or not these rocks are also equivalent to the Lower Cambrian quartzite of the Armchair Group is not known. The lower unit of the Harvey Group is, thus, lithologically similar to one group of rocks and has a stratigraphic position similar to another, but the relationship of these two groups is not known.

The Harvey Group is tentatively correlated with the Cambrian and Ordovician rocks of the Armchair and Lapie Groups.

Askin Group (?) (Map-unit 5)

The name Askin Group has been applied by Roddick and Wheeler (report in preparation) to a succession of Silurian and Devonian dolomites and quartzites (map-unit 4 on the preliminary map of Quiet Lake map-area [Wheeler, Green and Roddick, 1960]), which has been traced for many miles southeastward through Pelly Mountains. Similar rocks have been mapped by Gabrielse (1963) in the northern Cassiar Mountains in British Columbia.

The name Askin Group(?) is used here with a query because no determinable fossils were found in these rocks in Glenlyon map-area, and the correlation is based on lithological similarities only.

Rocks of the Askin Group(?) underlie the extreme northwestern end of Glenlyon Range west of Front Mountain and extend westward and northwestward into Tummel Basin. In Tummel Basin outcrops are small and widely scattered, and in the northwestern part of Glenlyon Range the exposure is poor.

Lithology

The rocks of the Askin Group(?) are almost entirely quartzite and carbonate. Most of the carbonate is dolomite though limestone is not uncommon.

Quartzite and dolomite with limestone, in part argillaceous and slaty, underlie the ridge west of Front Mountain, extend westward across Tummel River into Tummel Basin, and form scattered outcrops north of Pelly River. Quartzite is found in a small group of exposures on the southwestern flank of the hill (elevation 3,642 feet) immediately south of the mouth of Tummel River and also on the banks of Tummel River 3 miles above its mouth.

The quartzite of the Askin Group(?) is a fine-grained, locally cherty-looking, dark to light grey or buff, grey or brownish weathering, bedded or massive rock. Crossbedding was observed in a single exposure. The dolomite is fine grained, buff or mottled grey, grey weathering, and may be bedded or massive. The quartzite and dolomite are closely associated and seem to grade from one to the other through siliceous dolomite and dolomitic quartzite. A fine breccia of siliceous dolomite was observed.

Dark to medium grey, grey weathering, fine-grained limestone is locally associated with the dolomite and is prominent in the most westerly exposures along the north bank of Pelly River. The limestone is well bedded and locally is silty or argillaceous. On the south side of the hill three miles west of Front Mountain limestone is interbedded with dark grey argillite. There, and in the Pelly River exposures, the carbonate rocks become more dolomitic upward in the stratigraphic section. The dolomite is overlain in turn by quartzite. On the north bank of Pelly River the carbonate section is at least 1,700 feet thick, but no estimate of the thickness of quartzite can be made.

Most of the constituent grains of the rocks of the Askin Group(?) are less than 0.5 mm in diameter. Much of the quartzite consists of more than 95 per cent quartz. Some of the rocks seem to be cemented entirely by overgrowths on the original well-rounded, sedimentary grains, but others have no obvious cementing material, and rounded grains lie in a matrix of finer grained, more angular quartz. Some of the quartzite from the hill west of Front Mountain contains recrystallized quartz grains that have developed intricately sutured mutual contacts.

The dolomite of the Askin Group(?) is finer grained than the quartzite. The carbonate grains are irregular and angular in shape, and commonly mixed with tiny angular grains of quartz, which in places equal the dolomite grains in abundance.

Structural Relations

Internal Structural Relations

Because of the limited exposures of the Askin Group(?), little is known of its structure. On the hill west of Front Mountain the beds strike a few degrees north of west, and appear to be folded in a broad syncline about an axis that lies near the northern base of the hill. The structure, however, may not be as simple as it appears. The carbonate unit, which extends roughly along the crest of the ridge, is, toward its western end, not as clear cut as shown on the map because the carbonate outcrops are interspersed with quartzite. There, also, both dolomite and quartzite outcrop in the few exposures south of the main carbonate unit. Thus structural complications and/or facies changes in the western end of the ridge are probable.

Beds in the Askin Group(?) north of Pelly River strike from a few degrees south of west to northwest, but the carbonate unit as a whole trends nearly west. Dips are northerly but become vertical near the fault along Tintina Trench. Superficially, at least, the beds appear to be on the northern limb of a west-trending anticline just as they do, for the most part, south of Pelly River.

External Structural Relations

Beds of the Harvey Group appear to lie on the northern limb of a large west-trending anticlinorium though the outcrop pattern is complicated by many faults. So too, the Askin Group(?) appears to lie on the same limb of the same fold as the next younger unit above the Harvey Group. No major angular discordance appears to exist between the two groups though the exact nature of the contact is not known. In Pelly Mountains (Roddick and Wheeler, in preparation), no angular unconformity was found between the units to which the Harvey Group and Askin Group(?) are correlated.

Lack of exposure in critical localities renders it difficult or impossible to determine the precise contact between the Harvey Group and Askin Group(?). Perhaps the dark argillaceous limestone below the dolomite marks a gradational change downward into the argillaceous rocks of the upper unit of the Harvey Group (map-unit 4).

An inferred fault of large displacement is believed to separate the Harvey Group on Front Mountain and near the mouth of Tummel River from the Askin Group(?) to the southwest. This fault seems to be responsible for the offset of the carbonate unit and overlying quartzites from west of Front Mountain to north of Pelly River. It probably is also responsible for carrying the upper strata of the Harvey Group far to the northwest near Tummel River. If this apparent repetition is caused by faulting, then a large component of left-lateral movement is implied.

West of Tummel River, chert conglomerate and other clastic sedimentary rocks overlie, apparently unconformably, the strata of the Askin Group(?), though here again the contact is not exposed.

As the Askin Group(?) lies in the northwestward extension of the fault-isolated Glenlyon Range block, the group cannot be directly related to any rocks outside this block. Other than the relationships already mentioned it is known that small intrusions, probably of Mesozoic age, cut the group.

Age and Correlation

In Pelly Mountains, Wheeler, Green, and Roddick (1960a) have mapped rocks of Silurian and Devonian age which consist almost entirely of dolomite and quartzite. Roddick and Wheeler (report in preparation) have named these rocks the Askin Group. In northern Rocky and Cassiar Mountains in British Columbia, Gabrielse (1961, 1962a, 1962b, and 1963) found rocks of the same age and generally similar lithology. An examination of the stratigraphic sections in the mountains for several hundred miles southeast of Glenlyon map-area shows that only Silurian and Devonian rocks combine dolomite and quartzite in such an association as that of the Askin Group(?). Therefore, there can be little doubt that the Askin Group(?) is of Silurian and Devonian age.

None of the fossils collected from rocks of the Askin Group(?) proved to be helpful in determining the age of the rocks. Most were found in the carbonate unit on the hill west of Front Mountain. Crinoid stems are common and other fossils consist of indeterminable fragments of brachiopods and corals, according to P. Harker of the Geological Survey of Canada.

Mississippian(?) or Earlier Rocks (Map-units 6 and 7)

No name is proposed for the rocks of map-units 6 and 7, as individually they do not fulfil the requirements of formations nor together the requirements of a group (American Commission on Stratigraphic Nomenclature, 1961).

The age of these rocks is unknown, except by a speculative correlation with rocks many miles away. Possibly they include rocks of widely different ages, perhaps equivalent to rocks mapped as other units elsewhere in Glenlyon map-area.

It is apparent from Laberge map-area to the south (Bostock and Lees, 1938) and Carmacks map-area to the west (Bostock, 1936) that the rocks of map-units 6 and 7 are continuous with strata included in the Yukon Group. In the adjoining areas, the Yukon Group is said to be Precambrian or later which does nothing to disqualify the use of the term for the rocks under consideration. The Yukon Group, however, was originally believed to be Precambrian by Cairnes (1912 and 1914) and the term connotes Precambrian age to many people. Limestone included in map-unit 6 in the northern part of the map-area contains distinct fossils, mainly crinoid stems, from which no definite age could be determined, but it is certainly not Precambrian. The rocks in the southern part of the map-area are similar to Mississippian strata in northern Cassiar Mountains. Hence the use of the term Yukon Group, with its connotation of Precambrian age, would do little to clarify the stratigraphic relationships of the rocks of map-units 6 and 7.

Although these rocks could be grouped under some name such as Little Salmon Complex or Little Salmon Terrane, this would seem only to introduce another ill-defined term. In the writer's opinion, the present information does not warrant setting up a name for these rocks.

The heterogeneity of rocks included within the two map-units reflects the many different original compositions and different degrees of metamorphism. Map-unit 7 consists mainly of metavolcanic rocks and has been mapped separately from the mainly metasedimentary rocks of map-unit 6. As each unit contains rocks more characteristic of the other and as they are closely associated spatially, the two units are discussed together in this section.

Distribution

The rocks of map-unit 7 outcrop in an irregular area stretching from near the southeast corner of the map-area, in the eastern part of Big Salmon Range, through the northeastern part of Little Salmon Range into the southeastern part of Tummel Hills. Strata of map-unit 6 underlie a huge area which extends diagonally across the map-area from near the southeastern to the northwestern corner. They are found in Big Salmon and Little Salmon Ranges, Tummel Hills, parts of Tatchun Hills and Tummel Basin, and in Pelmac Ridge and Macmillan Range. The lithologies of the rocks vary from place to place and there is no assurance that those in one place are stratigraphic equivalents of those in another. For these reasons, the map-unit has been divided into many sub-units so that the lithology in any part of the unit will be apparent, and description and correlation facilitated.

Lithology

Map-unit 6

Map-unit 6a. The rocks of map-unit 6a are confined to Big Salmon and Little Salmon Ranges and the extreme southwestern part of Tummel Hills. The most characteristic rock of this map-unit is thin-bedded, locally finely laminated, fine-grained to cherty, grey and greenish grey quartz-sericite-chlorite schist, which locally contains biotite, hornblende, epidote, and rarely small garnets. The rock generally has a well-developed schistosity parallel with the bedding; near the granitic stock on the north slopes of Snowcap Mountain and in the southern part of Tummel Hills it is almost gneissic. In the latter locality some of the rocks are granitic in appearance and composition though bedding is prominent. The metamorphic grade appears to increase slightly from east to west; garnets were seen only in the more western exposures. Many thin sections of these rocks reveal appreciable quantities of sodic plagioclase and much more epidote than would be expected from the appearance of hand specimens. The rocks vary from almost pure quartz to those with plagioclase, hornblende, biotite, epidote, chlorite, and sericite intermixed or interlaminated with quartz. In a few places a little calcite was noted. The rocks are all fine grained, commonly with no mineral exceeding 0.2mm in diameter. Quartz is all recrystallized and forms irregular interlocking grains with no trace of original sedimentary texture.

Scattered throughout the strata of map-unit 6a are greenstones which consist primarily of sodic plagioclase, epidote, and chlorite, with or without quartz, hornblende, and biotite. These rocks are perhaps most abundant on the eastern slopes of Snowcap Mountain.

Grey, finely crystalline limestone, mostly thin-bedded but locally massive, is found here and there among the quartzose rocks. Two bands, not shown on the map, the lower about 300 feet thick and the upper about 150 feet, cross Little Salmon Lake about midway along its length. These are separated by 3,000 feet or more of quartzose rocks. Rare, pale green, fine-grained, lime-silicate rocks consist of plagioclase, epidote, and calcite, and some contain hornblende, biotite, and quartz. A band of white sericitic quartzite extends southeasterly from the eastern ridge of Telegraph Mountain, and a similar rock outcrops on the western ridges of Snowcap Mountain.

Map-unit 6b. The rocks of map-unit 6b underlie the northwestern part of Tummel Hills and the southern part of Tummel Basin around Ess Lake. These rocks are similar to parts of map-unit 6a, but include few epidote-bearing rocks and no greenstone. The most abundant rock is quartz-plagioclase-sericite-chlorite-biotite schist which commonly contains small garnets. Characteristically these rocks are very fine grained, but so completely recrystallized that no trace remains of original sedimentary grains. Bedding is commonly distinct and parallel with the schistosity.

Map-unit 6b includes amphibolite which consists of hornblende, sodic plagioclase, epidote, and calcite, and it includes also a small quantity of grey and buff marble. Compared with the quartzose rocks of map-unit 6a, those of map-unit 6b are more noticeably schistose, glittering mica on the cleavage surfaces is more prominent, and the metamorphic grade apparently is slightly higher.

Map-unit 6c. This unit outcrops in small areas within and around the limits of the granitic batholith in Tatchun Hills and extends northwestward past Tadru Lake toward Tatlmain Lake.

Amphibolite is the main rock of map-unit 6c. Most of it has a schistosity shown by parallel orientation of platy and elongate minerals which in places are parallel with a vague compositional layering. The amphibolite consists of blue-green hornblende, sodic to medium plagioclase, biotite, epidote, quartz, chlorite, and, rarely, calcite and small garnets. Hornblende, plagioclase, biotite, and epidote are always present whereas the other minerals may be absent. Most of the constituents are less than 1 mm across though hornblende and plagioclase may be more. No recognizable bedding was seen in the amphibolite. Some fine-grained quartz-plagioclase-muscovite-chlorite-biotite schist, locally with calcite, occurs in relatively small quantities.

Map-unit 6d. The rocks of map-unit 6d form a strip along the northeast flank of Tummel Hills. The unit includes a heterogeneous group of rocks generally of very low metamorphic grade. Slaty argillite and very fine grained and cherty, grey, feldspathic, quartz-sericite-chlorite phyllite are perhaps dominant, but schistose greenstone is not uncommon, and a little dark grey, dense limestone was observed. Most of the phyllite and argillite is dark grey or black, but some is bright green, and some dull purple. Some, perhaps the bulk, of these rocks may be tuffaceous.

Map-unit 6e. A large area extending from Macmillan Range and Pelmac Ridge southeastward into Tummel Basin is underlain by rocks of map-unit 6e. These rocks resemble map-unit 6a. Probably the dominant type is phyllite or very fine grained, greenish grey or brownish grey, quartz-sericite-chlorite schist. Associated with this is both massive and schistose greenstone, dark grey phyllite, mica schist, and grey, finely crystalline limestone. The greenstone consists of sodic plagioclase, chlorite, and epidote with or without hornblende and quartz.

On the north bank of Pelly River, about 15 miles above the mouth of Macmillan River, are outcrops of brown, highly sheared, gritty-looking rock containing quartz, plagioclase, sericite, and a little biotite. Originally this rock was probably feldspathic quartz-pebble conglomerate.

White sericitic quartzite is prominent on the summit of the western part of Macmillan Range and in the central part of Pelmac Ridge, and may be continuous between these two occurrences.

Here again bedding and schistosity are parallel, but bedding is not as prominent as in the rocks of map-unit 6a. The grade of metamorphism appears to be slightly greater in the western part of Macmillan Range than elsewhere in map-unit 6e.

Map-unit 6f. Where it occurs in sufficiently large masses, limestone has been mapped separately from the previously described rocks of map-unit 6. These limestones no doubt represent several different carbonate units but the relation of one to another is not apparent.

The limestone is mainly a dark to medium grey, finely crystalline, grey weathering rock. It may be thin bedded or massive, and locally is irregularly sheared which causes it to break into platy fragments. In the northwestern part of Little Salmon Range limestone breccia was noted. The carbonate in the extreme northwest corner of the map-area, and on the ridge 6 miles west of Tadru Lake, is partly creamy or buff, and the former, particularly, weathers light grey or buff. Both of these limestones are finely crystalline and may contain some dolomitic zones. A few beds of quartzose rocks and amphibolite occur within them.

The limestone masses do not seem to be very continuous along strike. This may be because the carbonate was originally laid down in large lenticular deposits, or because of intense and largely unrecognized deformation.

Original composition. All the rocks of map-unit 6 described thus far have been metamorphosed. The metamorphism of all but the amphibolite and related rocks in Tatchun Hills and the western part of Tummel Basin (map-unit 6c) falls within the greenschist facies as defined by Fyfe, Turner, and Verhoogen (1958). Those not in the greenschist facies are included in the lower part of the almandine–amphibolite facies.

The greenstone and amphibolite represent metamorphosed, basic or intermediate volcanic rocks. These were evidently deposited as flows and tuffs.

The widespread quartz-albite-sericite chlorite rocks were originally shale and perhaps impure chert and siltstone; possibly some were calcareous. Similar rocks most common in map-unit 6a, and containing in addition epidote and amphibole, may represent transitions between the volcanic and sedimentary rocks, such as tuffaceous sediments, or sediments derived from the erosion of volcanic rocks. Some of these rocks might have been greywacke.

Within this assemblage of volcanic, pelitic, cherty, and impure psammitic rocks are some beds of nearly pure quartz sandstone now represented by white sericitic quartzite. Limestone was deposited in many parts of the section, perhaps as large lenticular masses as well as thin beds.

Map-unit 7

The rocks of map-unit 7 are primarily of volcanic origin though sedimentary rocks are interbedded with them. Most of the volcanic rocks were originally andesitic but some perhaps were basaltic. The rocks vary in colour from grey and brownish grey to more common shades of dull green. They are usually very fine grained and may be massive or schistose.

All these rocks have been affected by low grade metamorphism and the original volcanic minerals have been converted to a metamorphic assemblage. Perhaps the most common minerals are albite, epidote, and chlorite, but greenish brown hornblende, quartz, calcite, and sericite also are widespread. In the northwestern part of Little Salmon Range, some of these rocks contain feldspar phenocrysts now altered to albite, sericite, and epidote, and set in a very fine grained matrix of epidote, chlorite, sericite, quartz, and calcite.

In a few places in Little Salmon and Big Salmon Ranges, and on the north shore of Drury Lake, the greenstone is coarser than elsewhere, and resembles diorite. This apparently resulted from more intense metamorphism and recrystallization, perhaps with accompanying feldspathization, but may represent small dioritic intrusions or the coarse grained interiors of thick flows.

Thinly laminated greenstone, apparently more quartzose than other varieties, was probably originally tuffaceous rock. Such rocks are common on the north slope of Little Salmon Range above the head of Drury Lake. Associated with the laminated rocks are more massive greenstone layers which contain small masses of calcite and quartz thought to represent amygdules formed in volcanic flows.

Sedimentary rocks associated with the greenstone unit are similar to those found in map-units 6a and 6d. They consist of very fine grained quartz-chlorite-sericite phyllite or schist, dark argillite and phyllite, and minor, finely crystalline, grey and buff limestone.

A feature of the greenstones of map-unit 7 that is unique in Glenlyon map-area is their association with very fine grained, dark green, sheared serpentinite. The serpentinite occurs in many small bodies not mapped separately from the greenstone (map-unit 7b), south of Little Salmon Lake and in Little Salmon Range in a small mass shown on the map.

Structural Relations

Internal Structural Relations

Map-units 6 and 7. In a discussion of the structures of these rocks map-unit 7 may conveniently be grouped with map-units 6a to 6f. Although the structure is imperfectly understood, the sheared or schistose character of the rocks suggests that they are highly deformed. Similarly, minor folds, most commonly observed near Little Salmon Lake, imply that the rocks have been complexly folded. The axial planes of some of these folds have shallow dips that are commonly less steep than the general dip of beds in the area. The dips of the axial planes, however, vary abruptly over short distances, whereas the axes of minor folds have uniformly shallow to moderate plunges to the northwest. The strata are thus thought to have been deformed into isoclinal and perhaps recumbent folds upon which later folds have been superimposed but proof of such a hypothesis would require detailed study.

Two northwesterly trending fold axes can be traced far south of Little Salmon Lake; a synclinal axis crosses the lake near the east end, and an anticlinal axis toward the west end. Both bedding and cleavage are folded about these axes, and superficially the structures seem to be simple folds with steeply northeast-dipping axial planes. In detail, however, the situation is not simple as the minor folds show no clear relation to these structures other than having a roughly parallel axial trend, and the outcrop patterns of the few distinctive lithological units are irregular in relation to the fold axes. Near the southern boundary of the map-area greenstone is widespread between the fold axes. If the structure is a simple, gently plunging syncline and anticline the greenstone should extend across the anticlinal axis but does not do so. A prominent white quartzite extends southeasterly from the eastern ridge of Telegraph Mountain but does not continue to the northwest, nor extend over either of the fold axes. Similar quartzite outcrops on Snowcap Mountain where considerable small-scale structural complexity was observed, but here again it cannot be traced for any distance along strike.

The large mass of limestone north of the west end of Little Salmon Lake does not seem to extend easterly as might be expected from the attitudes of the rocks immediately to the east. The limestone seems to be involved in steeply east-plunging folds, but the evidence is not conclusive, and it may be that the limestone is continuous with one or both of two unmapped limestone layers that outcrop farther east. If folds in the limestone are easterly plunging, they are directly opposed to the plunge of all observed minor folds in the general area.

The apparent discontinuities and structural contradictions might be accounted for by faulting or by abrupt changes in thickness or lithology along strike. The erratic pattern of these rock units might also be attributed to unrecognized and intense first folding. Units involved in plunging isoclinal and possibly recumbent folds might easily show the described relationships to axes of a later folding. Discontinuities in other units such as the limestone in Macmillan Range and Pelmac Ridge suggest that similar structures may be suspected in that general area.

The greenstone of map-unit 7a extends northwesterly from Little Salmon Range into the southern part of Tummel Hills, where it is truncated by an inferred northerly trending fault. The abrupt change in the attitude of schistosity and stratification between the metasedimentary rocks of map-unit 6a and the greenstone of map-unit 7a in the southern part of Little Salmon Range is believed to result from displacement along a northwesterly trending fault. In Macmillan Range and Pelmac Ridge, rather vague and discontinuous lineaments are, locally, boundaries between areas of abruptly different structural attitudes and lithology. Some of these may represent faults.

External Structural Relations

Map-units 6 and 7. Between these rocks and those of Glenlyon Range block (granitic rocks and strata of the Harvey Group and Askin Group (?)) a major fault is thought to extend northwestward and southeastward from the lower part of Drury Lake valley. Although little is known about it, a large component of strike-slip movement is possible, and it may be related to the fault in Tintina Trench. Alternatively, the occurrence of westerly dipping thrusts in Pelly Mountains to the southeast (Roddick and Wheeler, report in preparation) suggests indirectly that it may be a folded thrust fault on which rocks from the west have been thrust over those of the Glenlyon Range block.

The evidence that some sort of fault exists is good. In the extreme southeastern part of the map-area, an abrupt change in lithology, degree of metamorphism, and structural trend takes place between the rocks of the Harvey Group and those of map-unit 7b. From the southeast corner northwestward to beyond Drury Lake none of the granitic rocks of Glenlyon Range break across to the southwest. Still farther north, a change in lithology and structural trend marks the boundary between the strata of the Harvey Group and Askin Group(?) and those of map-unit 6e.

The contact between the rocks of map-unit 6 and the Upper Triassic or earlier volcanic rocks (map-unit 16) to the west is not exposed and nothing is known about it. In adjoining map-areas also, where both groups of rocks are found, the relationship is unknown.

Two granitic batholiths, one in Tatchun Hills and the other east and north of Tatlmain Lake, as well as several small granitic and dioritic stocks, intrude the rocks of map-unit 6. The intrusive rocks are probably Mesozoic. A small, early

Tertiary, granitic porphyry mass cuts the rocks of map-unit 6e north of Macmillan River.

Age and Correlation

Map-units 6 and 7. Evidence as to the age of the rocks of map-units 6 and 7 is scarce in Glenlyon map-area. They are cut by granitic rocks, believed to be Mesozoic, and are metamorphosed in contrast with the unmetamorphosed Upper Triassic Lewes River Group.

Much of the limestone in the northwestern part of the map-area contains fossil fragments, but none collected were identifiable save crinoid columnals, indicating only that the rocks are probably Palaeozoic and certainly no older than Ordovician. Whether or not all rocks in map-unit 6 are about the same age as those that include the fossils is not known.

The lower Palaeozoic section is well established in Pelly Mountains (Roddick and Wheeler, in preparation) as well as farther to the southeast in northern Cassiar Mountains (Gabrielse, 1961, 1962a and b, and 1963). The section from Late Precambrian to Devonian is a miogeosynclinal assemblage and includes only minor quantities of volcanic rocks. In Glenlyon map-area, strata of the Harvey Group and Askin Group(?) are correlated with some of those to the south, and if the correlations are correct they encompass the section from Lower Cambrian to at least Middle Devonian. None of the sections of these rocks are more than incidentally similar to the eugeosynclinal suite under discussion (map-units 6 and 7). As fossil remains rule out the possibility of Precambrian age, the rocks of the eugeosynclinal suite probably were deposited between Middle Devonian and Upper Triassic time.

In the Laberge map-area to the south, Bostock and Lees (1938) described a thick succession of rocks that are generally similar to those of map-unit 6a and include much greenstone similar to that of map-unit 7. Some of these rocks, which the authors placed in the Yukon Group of Precambrian or later age, were traced for more than 50 miles to the south along the west face of Big Salmon Range.

Still farther southeast in Big Salmon Range, in Teslin map-area, Mulligan (1963) mapped an extensive area of metamorphic rocks which include much chloritic, epidotic, and amphibolitic schists in association with limestone and quartzose rocks. He assigned a Mississippian or older age to these rocks on the assumption that they are older than Mississippian strata found farther east in Thirtymile Range. The relationship, however, is uncertain, and the metamorphic rocks may be in part equivalent to rocks of known Mississippian age.

In Wolf Lake map-area, east of Teslin map-area, Poole, Roddick, and Green (1960) described an enormously thick section of rocks in Cassiar Mountains ranging from Upper Devonian to Middle Mississippian. These include greenstone, chlorite schist, phyllite, quartzite, chert, greywacke, limestone, and other rock types, and comprise an assemblage that closely resembles that in Glenlyon map-area.

In Cassiar Mountains in British Columbia, Gabrielse (1963) found similar rocks that he was able to date as post-Middle Devonian and pre-Upper Mississippian.

Thus, rocks similar to the strata of map-units 6 and 7 can be traced southeastward from Glenlyon map-area into exposures of rocks known to be Upper Devonian to Middle Mississippian in age.

To the west, in Carmacks map-area, Bostock (1936) found possible fossil remains in limestone associated with rocks similar to, but more highly metamorphosed than, those in Glenlyon map-area. On the same general northwestward trend through McQuesten and Ogilvie map-areas (Bostock, 1948, and 1942, respectively), metamorphic strata in which limestone- and hornblende-bearing rocks are prominent have been included in the Yukon Group.

From the foregoing it seems reasonable to assume that the volcanic and sedimentary rocks of map-units 6 and 7 in Glenlyon map-area are Upper Devonian to Middle Mississippian, and are part of a thick succession that extends for hundreds of miles from the Cassiar Mountains northwestward through Pelly Mountains and onward into Yukon Plateau where they become an important part of the Yukon Group. It is interesting to note that serpentinite bodies are scattered among these rocks and with but few exceptions are confined to them.

If these rocks lie unconformably beneath the rocks of the Upper Triassic Lewes River Group and Jurassic Laberge Group of the Whitehorse Trough (Wheeler, 1961), one may speculate that the original deformation and metamorphism took place prior to the Upper Triassic. This may be further refined if an unconformable relationship exists between the Upper Triassic or earlier volcanic rocks (map-unit 16) and the metamorphic rocks; the former may well be as old as Permian, thus the deformation and metamorphism may have taken place in the interval between Middle Mississippian and some time in the Permian.

Mississippian(?) or Earlier Rocks (Map-unit 8)

The rocks of map-unit 8 lie in a large re-entrant along Magundy River protruding into the granitic and metamorphic terrane of Glenlyon Range and its southward extension into Big Salmon Range. The relationship of the rocks in this re-entrant to the rocks of map-units 6 and 7 and to the granitic and metamorphic rocks of Glenlyon Range is not known with certainty.

The rocks of map-unit 8a consist of dark slate and argillite; light grey, rusty weathering quartzite; dark, cherty quartzite; grey, finely crystalline limestone; and a single exposure of greenstone. Finely laminated, cherty-looking, grey and green lime-silicate rocks outcrop in the western part of the hill (elevation 4,448 feet) about 2 miles north of the mouth of Railway Survey Creek.

The limestone of map-unit 8b is grey weathering, dark to medium grey, and finely crystalline. In some places it is massive and in others is prominently and thinly bedded.

North of Magundy River, the limestone (map-unit 8b) appears to be folded in a faulted anticline which plunges on a bearing a few degrees south of west. The limestone south of the river exhibits steep dips and northwesterly strikes with local, northwesterly plunging, minor folds.

On the basis of abrupt changes from schist and granitic rocks to low-grade metamorphic rocks, it is inferred that faults separate the "Magundy Re-entrant" from the Glenlyon Range block. This change can be observed along lower Railway Survey Creek and in several places south of Magundy River. Unfortunately, the contact is not exposed, but about 3 miles south of Magundy River schist and granitic rocks are found 100 feet from sheared sericitic quartzite associated with the grey limestone of map-unit 8b. Presumably the western extent of the "Magundy Re-entrant" is limited by the inferred fault through Drury Lake valley.

Whether or not faults isolate the rocks of map-unit 8, they appear to occupy an anomalous position that can be explained only through further work.

The age and correlation of the rocks in the "Magundy Re-entrant" cannot easily be resolved at present. The writer believes they should be correlated with the rocks of map-unit 6 but conclusive evidence is lacking. They may be equivalent to part of the lower Palaeozoic section of Pelly Mountains; thus possibly they should be included with the Harvey Group though they are much less metamorphosed. If such is the case, then the need for faults bounding the re-entrant disappears and the southwest boundary of the Glenlyon Range block would pass smoothly southeast from the valley of Drury Lake.

Mississippian(?) or Earlier Rocks (Map-unit 9)

Rocks grouped as map-unit 9 are found in two small areas in Glenlyon map-area, one of which includes scattered small outcrops (map-unit 9a) on either side of Tummel River about 10 miles above its mouth, and the other covers part of the ridge between Glenlyon Lake and Pelly River on the east boundary of the map-area (map-unit 9b).

The lithology of the rocks in these two areas is very different and they are unfossiliferous. They have been placed together as a single map-unit only because of a possible correlation with rocks found in Quiet Lake map-area to the southeast.

Lithology

Map-unit 9a

The characteristic rock of map-unit 9a is grey and brownish weathering, thick-bedded and massive, brown and black chert-conglomerate and sedimentary breccia. The rock contains black, brown, and light-coloured chert fragments ranging from little more than sand size to pebbles more than two inches in diameter. Most of the smaller grains are subangular whereas the larger are more rounded. The matrix of the conglomerate consists of sand-sized fragments of chert and quartz and local argillaceous material. Thin beds of grey and brown sandstone and dark slaty argillite are interbedded with the conglomerate. A few isolated outcrops of dark, bedded chert and one of greenstone evidently belong to the succession.

Map-unit 9b

In contrast with the above unit, the rocks of map-unit 9b, exposed on the ridge east of Glenlyon Lake, contain little chert-conglomerate. More abundant are greenish grey and locally purple andesite or greenstone and various, very fine grained, thin-bedded rocks. The andesite is aphanitic except for distinct feldspar laths. Much of it contains epidote and in places an interlacing network of epidote veinlets with a little calcite. The bedded rocks are mainly dark grey though some are light grey or white, and commonly are finely laminated. These rocks consist of combinations of extremely fine grained quartz, calcite, and clay minerals, with a little feldspar in some. The rocks vary from siliceous limy argillite, to limy chert, to siliceous argillaceous limestone. Some that may have been tuffs now contain epidote, actinolite, and calcite in an undetermined ultra fine grained matrix. A few beds of black, finely crystalline limestone and phyllite were observed here and there.

Many dykes of light brown quartz-feldspar porphyry cut the rocks of map-unit 9b. The matrix of the dyke rocks is aphanitic and phenocrysts are chalky, white, subhedral feldspar, up to one-quarter inch in diameter, and smaller, rounded, clear quartz. These dykes are believed to be related to a mass of chalky grey-white rhyolite of probable Tertiary age which outcrops near the crest of the ridge about one mile north of the high point (elevation 4,870 feet).

Structural Relations

The dominantly conglomeratic rocks of map-unit 9a on the west side of Tummel River generally exhibit shallow dips, ranging from 5 to 30°. Those east of the river dip more steeply. Although few data are available, their position relative to outcrops of the Harvey Group and Askin Group(?) suggests that they rest unconformably or disconformably on the older rocks.

The rocks of map-unit 9b near Glenlyon Lake are moderately to steeply dipping wherever observed, but no assessment of the nature of the folding can be made. Mesozoic granitic rocks, Tertiary rhyolitic dykes and plugs, and an overlying sequence of basaltic flows and sediments of Cretaceous or Tertiary age are the only rocks known to be in contact with those of map-unit 9b in the Glenlyon map-area.

Age and Correlation

In Quiet Lake map-area, Wheeler, Green, and Roddick (1960a) found rocks that they believed to be Mississippian or earlier. As these lie disconformably above the Askin, Lapie, and Armchair Groups, they are also presumably post-Middle Devonian. These rocks consist of a lower, dominantly clastic sedimentary unit (map-unit 5, op. cit.) which is partly interbedded with an overlying volcanic and sedimentary unit (map-unit 6, op. cit.).

Roddick and Wheeler (personal communication) believed that the rocks in Tay River map-area adjoining the ridge between Glenlyon Lake and Pelly River belong to the upper of the two map-units in Quiet Lake map-area, mentioned in the preceding paragraph. In the published map of Tay River map-area (Roddick and Green, 1961a) these rocks are included in a different group.

The strata of map-unit 9a, near Tummel River, can be correlated with the rocks of map-unit 5 in Quiet Lake map-area on the basis of lithological similarities and on the basis of the apparent disconformity or unconformity between map-unit

9a and the Askin Group(?) and Harvey Group. The most obvious similarity between the rocks of map-unit 9a and other rocks of Glenlyon map-area is the thick sequence of chert conglomerate of the Crystal Peak Formation which underlies Lower Mississippian limestone and is probably Upper Devonian and/or Lower Mississippian.

The volcanic and sedimentary rocks near Glenlyon Lake (map-unit 9b) have no distinctive characteristics that suggest a correlation with other rocks in Glenlyon map-area. In Quiet Lake map-area, however, their age is known to be post-Middle Devonian and they are thought to be Mississippian.

Map-unit 9 and similar rocks in Pelly Mountains to the southeast may be thin equivalents of the thick volcanic and sedimentary sequence of map-units 6 and 7 which lies along the western margin of Pelly Mountains. Presumably the latter was deposited in a deep basin, which may have shallowed rapidly east of the southwestern edge of Glenlyon Range and its extension south through Big Salmon Range.

Earn Group

The name Earn Group is proposed for a succession of upper Palaeozoic rocks in the general vicinity of Earn Lake in the northeastern part of the map-area. These rocks are exposed in a belt that extends easterly from Kalzas Range through Wilkinson Range and the northern part of Earn Hills to the eastern boundary of the map-area. The group has been divided into four units and formation names are proposed for two of these. Chert is characteristic of the group with the exception of a prominent carbonate unit. The bottom unit of the group (map-unit 10) is composed mainly of dark bedded chert and argillite. Above it is the Crystal Peak Formation of thick-bedded and massive chert conglomerate. The conglomerate is overlain by a Lower Mississippian limestone, the Kalzas Formation, and this in turn is succeeded by a thick sequence of bedded chert, argillite, and quartzite (map-unit 13).

The Crystal Peak Formation is named for Crystal Peak, the most prominent summit of the Wilkinson Range. The bulk of the mountain is composed of rocks of the formation and the exposures are better than elsewhere in the map-area. Crystal Peak is designated as the type locality of the Crystal Peak Formation.

The Kalzas Formation is named for the Kalzas Range where the unit is exposed. At the northern edge of the range fossils were found in this unit for the first time by Bostock (1947). The name Crystal Peak Formation would be equally appropriate for the Kalzas Formation, because the best exposures and best fossil localities of the Kalzas Formation are found on the south slopes of Crystal Peak which is regarded as the type locality of the formation.

Lithology

Map-unit 10

The strata of map-unit 10 are poorly exposed on the north slopes of Kalzas Range and in the central and northern parts of Wilkinson Range. Most of these rocks are dark grey, dull brownish grey, or black chert and siliceous or cherty argillite, which locally is slaty. A few exposures of grey, fine-grained quartzite, black, gritty conglomerate, and dark grey, finely crystalline limestone were noted. These rocks are characteristically thin bedded. The bedding planes in the chert may be marked by thin shaly partings.

The chert is extremely fine grained silica that grades to siliceous argillite as the content of clay minerals increases. The chert also grades, in a sense, into quartzite, as some of the quartzite is composed of sand-sized grains of both quartz and chert enclosed in a matrix of smaller, angular quartz grains, clay minerals, and sericite. A few grains of plagioclase were seen in thin sections of quartzite. The conglomerate of map-unit 10 contains pebble-sized fragments of chert and quartz and, apart from grain size, is similar to the quartzite.

Crystal Peak Formation (Map-unit 11)

The Crystal Peak Formation is exposed prominently in two parallel bands from Kalzas Range to the eastern boundary of the map-area. It underlies much of the crest of Kalzas Range and most of the high points in Wilkinson Range, of which the most prominent is Crystal Peak. The rocks were first mapped and described by Bostock (1947) in Mayo map-area.

The unit is characterized by thick-bedded and massive chert-pebble conglomerate. The rocks vary from quartzite to rare cobble conglomerate. They generally are light-coloured and may be brown or medium to light grey, though some are dark grey. The outcrops weather to shades of dull brown and grey.

Fragments in the conglomerate are mainly chert with smaller amounts of white quartz and minor black argillite. Most of the chert is varying shades of grey between black and white, but red and green pebbles were noted. The fragments may be subangular or sub-rounded; the larger tend to be more rounded. Few pebbles in the conglomerate exceed one-half inch in diameter and in many beds none exceeds one-quarter inch. Locally, however, cobbles are more than 3 inches long.

The matrix of the conglomerate has a sandy texture and consists of subangular grains of quartz and chert; the quartz grains commonly exhibit distinct overgrowths. In some rocks little or no cement is visible in thin section, but in others cement is formed by extremely fine grained silica and, to some extent, by argillaceous material, including very fine sericite. The quartzite is similar to the matrix of the conglomerate, and sand-sized grains within it vary from mainly quartz to 70 or 80 per cent chert. The dark colour of some of the rocks evidently originates from finely scattered magnetite and/or carbonaceous material. In a few places hematitic material colours the rocks reddish brown. Sparse spherical nodules of earthy hematite were noted in conglomerate on the north slope of Crystal Peak.

Near Earn Mountain, and in a few other places, thinly bedded chert appears to be interbedded with other rocks of the Crystal Peak Formation. Apart from these the entire section consists of conglomerate and quartzite. On Crystal Peak the thickness of the unit appears to be about 4,500 feet, but, as the rocks are massive, insufficient structural data could be obtained to eliminate the possibility of structural complications. At other places estimates of thickness are even less certain.

Kalzas Formation (Map-unit 12)

The Kalzas Formation occurs in several disconnected places and these are correlated on the basis of similar lithology and fossil content. A single small exposure was found in the valley north of Kalzas Range and similar rocks outcrop on the south slope near the eastern end of the range. The latter are apparently continuous with a line of exposures that extends southeasterly through Wilkinson Range. Other exposures of the same rocks occur east, south, and west of the west end of Earn Lake. The type locality and best exposures of the formation are on the south slopes of Crystal Peak.

The Kalzas Formation consists almost entirely of grey and buff weathering, dark grey to black, fetid limestone. The texture of the limestone varies from finely crystalline to cryptocrystalline; the former texture is found mainly in those places where fossils are most abundant and is a result, at least partly, of the accumulation of organic crystalline carbonate detritus rather than the result of metamorphism.

Some of the limestone is silty and contains fine grains of quartz; some is argillaceous and slaty. Where these varieties occur the rocks are, as a rule, thinly and prominently bedded, in contrast with the thick or unbedded character of the purer limestone. Beds of dark slaty argillite are found with the limestone in many places, especially in the eastern part of Kalzas Range.

The limestone is not well exposed in those areas of structural simplicity where its thickness might otherwise be readily measured. The approximate thickness of the unit, estimated from outcrop widths and the sparse structural data, is 1,000 feet; it is unlikely that it is more than 1,250 or less than 750 feet.

Map-unit 13

These rocks form the uppermost beds of the Earn Group and are best exposed on Kalzas and Dromedary Mountains and on the mountain south of Earn Lake. The unit includes chert, quartzite, and argillite with minor limestone and chert conglomerate.

The rocks of map-unit 13 appear to change along strike between the mountain south of Earn Lake and Kalzas Mountain. In the former place, the section is dominated by bedded, dark to light grey chert with black, slaty, siliceous cherty argillite and relatively minor light grey and buff quartzite and dark limestone. On Dromedary Mountain chert is much less prominent though it does occur on the eastern and northern slopes. The section there is mainly argillite and quartzite; much of the quartzite is a fine-grained, black, glassy rock. Chert was noted in the western part of Kalzas Range and on Kalzas Mountain, but there again fine-grained, dark quartzite and argillite are dominant.

Much of the quartzite on both Kalzas and Dromedary Mountains was described in the field as "cherty quartzite". Even though it is a clastic rock it has a cherty aspect, and in thin section it was found that part of the groundmass of many of these rocks is very fine grained silica with clay minerals and sericite, and that the sand-sized grains are composed of chert as well as quartz. Most of the grains are well rounded and, commonly, overgrowths have developed on the quartz. Some of the quartzite, particularly in the southern part of the exposures south of Earn Lake and less commonly on Kalzas Mountain, is light grey or buff and is made up almost entirely of quartz. Dark to medium grey, light grey weathering, fossiliferous limestone is interbedded with the quartzite in some places south of Earn Lake (e.g. 1 to 2 miles north of Menzie Creek).

Most of the limestone in map-unit 13 is thin bedded and dark grey, but on the ridge 3 miles directly north of the outlet of Earn Lake is an unusual limestone conglomerate. This rock is light grey-brown and cryptocrystalline, and contains flat pebbles of lighter coloured limestone; the flat pebbles are oriented parallel with bedding which is marked by interbeds of similar, though non-conglomeratic, thin-bedded limestone and minor, very fine grained, purplish brown quartzite. The limestone conglomerate is associated with argillite, quartzite, and chert. Some of the chert on the south side of the ridge is light brown and bright purple. Dark, slaty argillite is prominent on the northern side of the ridge and in the canyon of Dromedary Creek.

A few outcrops of brown chert-pebble conglomerate associated with bedded chert were noted near the eastern boundary of the map-area, south of the headwaters of Menzie Creek.

On Kalzas Mountain, the rocks of map-unit 13 have been metamorphosed around the periphery of the granitic body that extends southeastward from McArthur Range in Mayo map-area (Bostock, 1947). The quartzite and argillite are harder, tougher, and more vitreous, and extremely fine sericite and biotite add a sheen to the rocks. Argillite is converted to hornfels and here and there contains slender needles of andalusite up to one-quarter inch in length. Much of the dark quartzite on Kalzas Mountain contains extremely fine grained quartz suggesting that originally these rocks were bedded chert. On the northeast slope of the mountain fine conglomerate is associated with the quartzite. Light grey, flat granules occur in a dark grey matrix; both fragments and matrix are composed of extremely fine grained quartz which, in the latter, is accompanied by abundant, dusty, carbonaceous material. Similar hardening and recrystallization of the rocks may have taken place around the porphyry intrusion on Dromedary Mountain.

The thickness of strata of map-unit 13 is not known. The lack of good marker beds renders it difficult to determine the effects on the section of faulting and folding. On Dromedary Mountain and on the mountain south of Earn Lake, the thickness of the section may be in excess of 10,000 feet if there is no repetition by folding or faulting. The top of the section is not exposed.

Structural Relations

Internal Structural Relations

As with many of the other map-units in Glenlyon map-area, the structure of the rocks of the Earn Group is imperfectly understood. This is due primarily to the overall lack of good exposures. Though fairly large exposures are to be found, they are separated by broad areas of little or no outcrop and on many of the high ridges outcrops are small and scattered. This is true even of the resistant chert conglomerate of the Crystal Peak Formation.

It cannot be said with certainty that the rocks of the Earn Group are a conformable succession; on the contrary, the strata of map-unit 10 are possibly overlain disconformably by the thick chert conglomerate sequence (Crystal Peak Formation). No evidence for an unconformity exists in the section above the chert conglomerate (map-units 11, 12, and 13).

The Crystal Peak Formation either is repeated by faulting or folding or there are two essentially identical chert conglomerate sections in the Earn Group. Structural repetition by faulting is the more likely explanation although folding cannot be entirely disproved. If folding is involved it must be nearly isoclinal and strongly overturned toward the north to be consistent with the general southerly dip of the strata. The northerly chert conglomerate band extends westerly from Wilkinson Range into Mayo map-area (Bostock, 1947) where it outcrops prominently on Clarke Peak just to the north of Kalzas Range. Between the conglomerate on Clarke Peak and that in Kalzas Range is an exposure of the Lower Mississippian Kalzas Formation that lies stratigraphically above the conglomerate. The occurrence of limestone between the chert conglomerate bands could be brought about by folding only if the folds are nearly isoclinal and overturned toward the north. The chert conglomerate in Kalzas Range would have to occupy the anticlinal crest of one of these folds. A competent unit like the chert conglomerate is more likely to be deformed by faulting and fracturing than by isoclinal folding.

Minor folds in the Earn Group are not plentiful but those that were observed do not support the concept of isoclinal folds overturned toward the north. Most of the axial planes of the minor folds dip nearly vertically and some dip moderately to steeply to the north. None of the folds is isoclinal in form. Rocks in Mayo map-area that are at least partly equivalent to the Earn Group are deformed into upright, open folds according to Bostock (1947).

The repetition of the chert conglomerate unit can best be explained by faulting though no conclusive evidence of a fault was observed in the field. The nature and precise location of the assumed fault are not known.

Only one large-scale fold was recognized in the Earn Group. The axis of a westerly trending syncline lies on the south slope of the mountain south of Earn Lake. Unfortunately, little of the southern limb of the fold is exposed, hence its shape cannot be determined. Strata of the northern limb dip 40° to 70° to the south, and over a width of several hundred yards in the axial zone the dips are shallow.

Folding must be at least partly responsible for the outcrop pattern of the Kalzas Formation immediately west of the foot of Earn Lake, though little is known of its exact nature. The repetition of the limestone from the north to the south side of Earn Lake may be caused by either folding or faulting.

In the western part of Kalzas Range, rocks of the upper unit of the Earn Group (map-unit 13) have erratic attitudes and, commonly, northern dips. These attitudes may be caused by the intrusion of granitic rocks but they may also represent the limb of a fold not otherwise exposed. These rocks are evidently separated from those farther to the east by a fault.

The main part of the Earn Group in Glenlyon map-area apparently lies on the southern limb of a very large anticlinal structure that trends a few degrees north of west and is complicated by faults. The thick, competent, chert conglomerate unit evidently controlled the nature of the deformation and yielded mainly by faulting. Less competent rocks, both above and below the conglomerate, are relatively much more highly contorted.

External Structural Relations

The bottom unit of the Earn Group (map-unit 10) must lie unconformably on, or be in fault contact with, the probable Late Precambrian rocks of map-unit 1. The contact is not exposed and the bottom of the section does not occur elsewhere in the map-area.

The Earn Group apparently is unconformably overlain by rocks of the Anvil Range Group though the two are separated in places by a fault. A fault evidently separates the two groups on the west end of the mountain south of Earn Lake.

Three intrusive bodies are known to cut the strata of the Earn Group in Glenlyon map-area. A small granitic body of probable Mesozoic age was found on the mountain south of Earn Lake, and a larger mass underlies the northwest part of Kalzas Mountain. A Tertiary intrusion of porphyritic rhyolite is present on the southwest slope of Dromedary Mountain.

Age and Correlation

The Kalzas Formation is definitely dated as Lower Mississippian on the basis of marine invertebrate fossils. Many fossil localities were found. The faunal assemblages listed below are from those localities where determinable fossils were collected; all were identified by P. Harker of the Geological Survey.

Catalogue No. 20184
Two miles northwest of Earn Lake outlet
(62°48′N lat. 134°15′W long.)

Spirifer ex gp. *S. rowleyi*
Spirifer ex gp. *S. centronatus*
Spirifer sp. cf. *S. albertensis* Warren
Camarotoechia sp.
Spiriferina sp.
Platyceras sp.

Catalogue No. 20186
In valley north of central peak of Kalzas Range
(62°55′N lat. 135°05′W long.)

Camarotoechia sp.
Crinoid stems
Fish tooth
Spirifer fragments

Catalogue No. 20188
5,000 feet south of cairn on Crystal Peak
(62°53½′N lat. 134°30′W long.)

Schellwienella sp.
Spirifer sp.
Coral fragments

Catalogue No. 20190
Three miles east of Earn Lake outlet
(62°46½′N lat. 134°19′W long.)

Spirifer sp. ex gp. *S. rowleyi*
Platyrachella rutherfordi(?) Warren
Coral fragments

Catalogue No. 20191
1.3 miles N80°W of Earn Lake outlet
(62°47′N lat. 134°31′W long.)

Syringopora aculeata Girty
Coral fragments

Catalogue No. 20192
6.2 miles N22°E of Earn Lake outlet
(62°51′N lat. 134°22′W long.)

Syringopora sp. (larger form than 20191)

The locality of some of the collections containing indeterminable fossils is shown on the map.

Although neither the fossils nor the lithology of the Kalzas Formation suggests that more than one limestone is involved in the unit, limestone east and west of the foot of Earn Lake is not associated with the thick chert conglomerate unit as it is to the north and northwest. Cover by younger rocks, faulting, and, perhaps, rapid facies changes in the conglomerate may explain the apparent differences in stratigraphic relationships. In the writer's opinion, all the limestone shown as Kalzas Formation is probably part of a single carbonate unit though no definite proof of this is available.

On the east ridge of Crystal Peak close to the northern contact of the Crystal Peak Formation is a thin fossiliferous limestone associated with chert and quartzite. The forms present are listed below.

Catalogue No. 20187
1.5 miles east of Crystal Peak
(62°55′N lat. 134°27′W long.)

Spirifer sp. cf. *S. rowleyi*
Spirifer sp. cf. *S. centronatus*
Spirifer sp. cf. *S. cascadensis*(?) Warren

Cleiothyridina obmaxima McChesney
Hapsiphyllum sp.
Crinoid stems

These fossils are undoubtedly of Lower Mississippian age, and, according to E. W. Bamber of the Geological Survey (personal communication) who re-examined the collection, they are probably of early Osagean age. This limestone apparently underlies the chert conglomerate and is of essentially the same age as the limestone of the Kalzas Formation which overlies the conglomerate. Thus it seems that the chert conglomerate, up to 4,500 feet thick, was deposited in a very brief span of geological time, unless the limestone below the Crystal Peak Formation is actually part of the Kalzas Formation and was brought to its present position by faulting. Nothing observed in the field, however, supports this conclusion. The limestone is apparently thin and seems to be part of the section that extends upward into the chert conglomerate. Similar limestone was not found elsewhere along strike from this outcrop.

Though it is not proved, it seems that the Crystal Peak Formation is bracketed by Lower Mississippian rocks and that the entire section of conglomerate was deposited in a brief span of time.

Only one useful fossil collection was made from the upper part of the Earn Group (map-unit 13). It is in dark grey limestone interbedded with quartzite on the south side of the mountain south of Earn Lake. The forms from this locality identified by P. Harker are listed below:

Catalogue No. 21416
6.4 miles S55°E of outlet of Earn Lake
(62°43½′N lat. 134°16′W long.)
Neospirifer? sp.
Spirifer sp.
Derbyia? sp.
Chonetes sp.
Rugose coral fragment

Of these fossils Harker commented, "Collection from locality No. 21416 is believed to be Late Palaeozoic, possibly of Pennsylvanian equivalent, the fauna is, however, too scanty and ill preserved for anything but the most general inference of age." In a personal communication Bamber informed the writer that *Neospirifer* and *Derbyia* do not occur below the Pennsylvanian, and if the identification of these genera is correct then the rocks must be either Pennsylvanian or Permian. The stratigraphic position of these fossils, well above the Lower Mississippian limestone of the Kalzas Formation makes a Pennsylvanian age an attractive possibility.

Strata of the Earn Group extend east into Tay River map-area (Roddick and Green 1961a). Roddick and Green found Upper Devonian and probable Mississippian fossils in these rocks. Thus the Earn Group contains Upper Devonian and Lower Mississippian fossils and possible Pennsylvanian fossils. Neither the top nor bottom of the section is known but it seems unlikely that rocks of the Earn Group are older than Upper Devonian or younger than Pennsylvanian.

The known range, Upper Devonian to Lower Mississippian, of part of the Earn Group is similar to that proposed for the rocks southwest of Tintina Trench included in map-units 6, 7, 8, and 9. The sections generally seem to be very different; indeed volcanic rocks form an important part of the latter. The rocks in both places possibly rest unconformably upon older strata but the older rocks, particularly the Ordovician and Silurian rocks, in the two places are very different. Northeast of Tintina Trench in Tay River map-area (Roddick and Green, 1961a), the Ordovician and Silurian section contains abundant chert, whereas to the southeast rocks of this age are dominated by quartzite and dolomite.

Tintina Trench evidently marks a major geological discontinuity across which the sections of rocks from lower Palaeozoic to Mississippian are very different. Roddick (personal communication) has made a study of the Trench and has concluded that it may represent the locus of a transcurrent fault with more than 200 miles of right lateral displacement.

It is of speculative interest to note that a section of chert with chert conglomerate, called the Livengood chert and believed to be Mississippian by Mertie (1937), occurs in central Alaska southwest of the extension of Tintina Trench. The distance between this section and the rocks in Glenlyon map-area is about 370 miles along the Trench. The Mississippian and Devonian rocks associated with the Livengood chert include much volcanic material, and some of these may be equivalents of the Anvil Range Group in Glenlyon and Tay River map-areas.

A further interesting but speculative correlation can be made between the geology of northern Alaska and that of Glenlyon map-area. In the Brooks Range, north of the extension of the Tintina Trench, Bowsher and Dutro (1957) described a section of late Devonian chert conglomerate, at least 3,300 feet thick, that is overlain by 960 feet of Lower Mississippian shale, and that, in turn, by 1,230 feet of Lower Mississippian carbonate (partly dolomitic) and 970 feet of late Mississippian limestone. The chert conglomerate section is perhaps slightly older than that in the Earn Group but has a similar relationship to Lower Mississippian rocks. In other respects the two sections are widely different.

In northern Yukon Territory, Martin (1959) and Norris, Price, and Mountjoy (1963) described a widespread, Upper Devonian clastic, partly non-marine section which lies above a disconformity and is overlain by a Carboniferous section.

Gabrielse (1961) mapped clastic Devono-Mississippian rocks disconformably above Middle Devonian strata in the Rabbit River map-area of northern British Columbia east of the Rocky Mountain Trench.

The foregoing shows that Upper Devonian or Devono-Mississippian rocks in northern British Columbia and in Yukon Territory rest disconformably and, perhaps locally, unconformably on older rocks that are as young as Middle Devonian. This is true of the rocks on both sides of Tintina Trench and conforms well with the proposed ages and structural relations of rocks in Glenlyon map-area.

The problem of the origin of the immense quantity of chert fragments in the thick chert conglomerate of the Crystal Peak Formation is solved by the discovery by Roddick and Green (1961a and b) of an Ordovician and Silurian sequence, dominated by chert, in the area east of exposures of the Earn Group. If this is the source of the chert fragments, then uplift, erosion, and the development of a disconformity or unconformity between Middle Silurian and Upper Devonian time is obvious.

Anvil Range Group

The name Anvil Range Group applies to rocks exposed in a long narrow belt immediately northeast of Tintina Trench. It is taken from Anvil Range which extends southeasterly from Tay Mountain into Tay River map-area. The name was chosen in consultation with Roddick and Wheeler who are preparing a report on Pelly River area.

The Anvil Range Group is probably divisible into formations. No fossils were found in these rocks and exposures are so inadequate that neither the structure, stratigraphy, nor relation to the Earn Group could be determined in either Glenlyon or Tay River map-areas. A further complicating factor is the possibility that younger, Cretaceous volcanic rocks may be included with the Anvil Range Group in certain places.

Distribution

In Glenlyon map-area, the belt of Anvil Range Group rocks extends northwesterly from Tay Mountain to the southern slopes of Kalzas Mountain and beyond into Mayo map-area. The belt has a width of from 3 to 12 miles measured northeasterly from Tintina Trench. An extension northeast from this belt occurs near Earn Lake, where it protrudes into the southwestern part of Wilkinson Range. A long narrow series of exposures also lies south of Earn Lake.

Lithology

The Anvil Range Group includes a great diversity of rock types but two general categories of rocks are most common and are characteristic of the unit. These are grey and greenish grey andesitic and dioritic rocks, and dark grey argillite, slate, and phyllite. Tuffaceous rocks, which vary from greenish breccias and agglomerates to very fine grained, dark, finely laminated types, seem to bridge the gap between the volcanic and sedimentary parts of the group. The Anvil Range Group also includes minor dark grey shaly limestone, green and reddish argillite, pale green and grey chert, chlorite schist, dark grey and brown quartzite, and soft, carbonaceous shale. On the high ridges of Tay Mountain, equivalents of the phyllitic rocks are fine-grained quartz-biotite-sericite schist, and in one place in the canyon of Tay River the rocks contain biotite and very small garnets and actinolite.

The association of andesitic rocks with sedimentary strata is characteristic of the Anvil Range Group, except on the summit ridges of Tay Mountain and the southern slopes of McArthur Range north of Little Kalzas Lake where volcanic rocks were not found.

The andesitic rocks are mainly mottled, greenish grey, fine-grained rocks in which constituent minerals rarely can be identified in hand specimen though locally plagioclase laths and mafic minerals can be seen. The andesite grades into coarser grained material in which plagioclase and dark mafic minerals can be more easily discerned. In several places, the coarser rock was seen to grade both upwards and downwards into finer amygdaloidal material, indicating that in these places the dioritic rock forms the central parts of thick flows. In other places, where such evidence is lacking, these rocks could be intrusive. Amygdules are not abundant in the andesite but enough were observed to suggest that most of these rocks are extrusive. Calcite is the most common vesicle filling but quartz and chlorite amygdules were also observed.

Microscopic examination reveals that all of the andesitic and dioritic rocks have been affected by very low grade metamorphism. The rocks originally consisted of phenocrysts of plagioclase (An_{30} to An_{60}) and augite in a very fine grained matrix which was composed in part, at least, of plagioclase and pyroxene and may have been partly glassy. The metamorphism caused albitization and replacement by clay minerals, sericite, and carbonate of the plagioclase, and alteration of the pyroxene to chlorite and locally to fine-grained green biotite and amphibole. The matrix is a mass of chlorite, carbonate, fine plagioclase laths, and undetermined nearly opaque material which is pale brown in transmitted light.

The pyroclastic rocks are mainly very fine grained tuffs, but some are breccias or agglomerates. These rocks are similar in composition to the andesites and many are the same green colour. They are distinguished from flow rocks by delicately layered bedding and, in a few instances, by flattened and sheared oval fragments. Microscopic study revealed no conclusive evidence of a pyroclastic origin as these have apparently been obscured by the effects of metamorphism.

In several places, particularly just north of Tay River, relatively massive andesite and diorite grade into highly cleavable chloritic schist or greenschist. The schistose rock may represent the sheared margins of thick flows or possibly tuffaceous rocks intercalated with flows. Most of the greenschists, common throughout the group, are highly calcareous.

In the Anvil Range Group tuffs seem to grade imperceptibly into true sedimentary rocks. The dark grey, finely laminated rocks give little clear evidence of their origin. Some contain quartz, plagioclase, carbonate, and chlorite and seem to reflect partly at least a volcanic ancestry. The argillite, slate, and phyllite, which rarely show fine bedding, seem to be completely sedimentary. These rocks commonly have a well-developed fissility and crinkle lineation in contrast with those rocks believed to be tuffs. They consist of abundant quartz with sericite, clay minerals, and chlorite and a variable amount of carbonate. Many of the argillaceous rocks are limy and commonly associated with dark grey, finely crystalline limestone.

The best exposures of argillaceous rocks are high on Tay Mountain, on the southern slopes of McArthur Range, and along a northwesterly trending canyon about 2½ miles north of the mouth of Little Sheep Creek. On Tay Mountain these rocks are very fine grained quartz-biotite-sericite schist and phyllite. The highest grade of metamorphism is on the northwest face of the mountain. In the canyon of Tay River about one mile from Pelly River, phyllite and fine-grained schist are associated with rocks that consist of small garnets, actinolite, and quartz and are, locally, rich in pyrite with some copper stain.

Other rock types in the Anvil Range Group are of minor importance. Dark, fine-grained quartzite occurs in McArthur Range north of Little Kalzas Lake. Green and purple argillite was noted in several exposures along Pelly River above Harvey Creek, Black, friable, carbonaceaus shale outcrops near the mouth of Harvey Creek at Big Fishhook Rapids on Pelly River, and nearby on the west bank of Pelly River is a single exposure of thin-bedded, pale green chert.

Structural Relations

Internal Structural Relations

The general trend of strata in the Anvil Range Group ranges from west to N60°W. Foliation of the slates and phyllites is roughly parallel with bedding wherever it could be determined. The nature of the folding is not known, but crinkle lineation and foliation suggest that the rocks are highly deformed. If the foliation is parallel with the axial planes of the folds, then, in those areas of nearly flat foliation, folding must be recumbent; but in many places foliation is steeply dipping and the axial planes of the few observed minor folds are steep. Vertically dipping beds were observed locally.

At least some of the folds in the Anvil Range Group may have developed in response to movements along Tintina fault. Right lateral transcurrent movement along that fault might be accompanied by the development of folds trending within 15 or 20 degrees of west which is consistent with the attitude of bedding in much of the Anvil Range Group. In a group of rocks including thick massive flows and large sections of soft, incompetent argillaceous rocks, the fold pattern may differ greatly from place to place depending on the competency of the rocks involved. Under such conditions soft rocks may be sheared and foliated where they lie between thick competent members.

The most highly foliated rocks of the Anvil Range Group are found on Tay Mountain, along the valley sides of Tay River, and northwest from there in a narrowing band adjacent to Tintina Trench. The shearing and deformation of the rocks appear to be spatially related to Tintina fault and to the granitic rocks of Anvil Range which extend southeast from Tay Mountain. In general, the prominence of foliation appears to decrease toward the northeast where the Anvil Range Group is in contact with the Earn Group. This suggests that the deformation of the Anvil Range Group, and perhaps of the Earn Group as well, is at least partly related to movement along Tintina fault.

External Structural Relations

For its entire length in Glenlyon map-area the Tintina fault forms the southwestern boundary of the rocks of the Anvil Range Group. The contact between the Anvil Range and Earn Groups was not observed. A fault is indicated at the west end of the mountain immediately south of Earn Lake, where the contact cuts across the entire thickness of the upper unit (map-unit 13) of the Earn Group, and from Horsfall Creek south of Dromedary Mountain to the lower slopes of Kalzas Range, where a similar situation exists. In Wilkinson Range east of the head of Duo Creek and south of Earn Lake, rocks that are apparently part of the Anvil Range Group lie northeast of the proposed fault and seem to rest unconformably on the older strata. These rocks may belong to an altogether younger group of extrusive rocks that are widespread in Tay River map-area to the east (Roddick and Green, 1961a), or possibly to the Earn Group, though volcanic rocks have not been found elsewhere within that group. A third possibility is that the rocks in these two locations are intrusive. The andesitic rocks are, however, petrologically similar to those forming the bulk of the Anvil Range Group, and the associated rocks, which are mainly slates, also have counterparts in that group. In any event these rocks appear to rest unconformably upon the Earn Group; hence the relationship of the Anvil Range Group to the Earn Group is assumed to be a combination of fault and unconformity. Granitic intrusive rocks cut strata of the Anvil Range Group on Tay Mountain and in McArthur Range.

Age and Correlation

No fossils were found in the Anvil Range Group either in Glenlyon or Tay River map-areas; hence the age of the rocks is a matter of speculation. To the east of exposures of the Anvil Range Group, where the entire stratigraphic section from Late Precambrian to Mississippian has been investigated by Roddick and Green (1961a and b), volcanic rocks are absent or of minor importance. Immediately southwest of Tintina Trench, no significant amounts of volcanic rocks have been found in sections known to be older than Devono-Mississippian. The rocks of the Anvil Range Group are therefore either Mississippian or younger, or are Precambrian and older than any other rocks in the general area. A Precambrian age seems most unlikely as the tremendous thickness of late Proterozoic rocks to the east contains no volcanic rock; Mississippian or younger age is more probable. In the writer's view the Anvil Range Group is Carboniferous, Permian, or Permo-Triassic. If, as postulated, an unconformable relationship actually exists between the Earn and Anvil Range Groups, then a Permian or Permo-Triassic age seems most likely. Bostock (1947) assigned Triassic or older age to these rocks in Mayo map-area.

Although the Anvil Range Group cannot be correlated with other groups of rocks with any certainty, it may be equivalent to the dominantly volcanic assemblage in the southwestern part of Glenlyon map-area (map-unit 16) which is believed to be Permo-Triassic in age and which is thought to rest unconformably above the rocks of map-unit 6.

The age of the Anvil Range Group falls, with little doubt, between Lower Mississippian represented by the limestone of the Kalzas Formation and Jurassic or Cretaceous represented by intrusive granitic rocks. A complicating factor is that some of the volcanic rocks may be equivalents of the Cretaceous assemblage found to the east in Tay River map-area (Roddick and Green, 1961a), but these would constitute only a small part of the group and would not change the situation regarding the remainder.

Upper Triassic or Earlier Rocks (Map-unit 16)

The rocks of map-unit 16 are continuous with those of the Hutshi Group in Laberge map-area to the south (Bostock and Lees, 1938) and apparently are equivalent to the Mount Nansen Group as mapped by Bostock (1936) in Carmacks map-area. The use of one of the existing group names, Hutshi or Mount Nansen, would not be satisfactory in Glenlyon map-area because, in the writer's opinion, the age designated for those groups in the adjoining map-areas is questionable, and the meagre outcrops of the unit in Glenlyon map-area does not justify revision of the older names.

The rocks of map-unit 16 are confined to the southwestern part of Glenlyon map-area where they underlie the area along Little Salmon River west of the lake. They extend northwestward from the lower part of the river in a narrow belt, which includes Frenchman Ridge and Tatchun Mountain, to Kelly Creek.

Lithology

The rocks of map-unit 16 are mainly basic and intermediate volcanic rocks with a few scattered outcrops of grey, finely crystalline limestone (unit 16b). The lithology has been described by Cockfield (1929) in his early work along Little Salmon River, by Bostock and Lees (1938) in Laberge map-area, and in much more detail by Bostock (1936) in the Carmacks area.

The volcanic rocks included in unit 16a consist of flows, breccia, and tuff, most of which could be classed as dark green "greenstone" although some is comparatively fresh augite andesite and basalt. The rocks commonly contain phenocrysts of plagioclase and augite. Calcite and quartz amygdules were noted in several places. Very low grade metamorphism has more or less altered the original igneous minerals to chlorite, sericite, albite, and clay minerals.

Volcanic breccia occurs here and there. On the hill east of Yukon River on the south boundary of the map-area, a breccia consists of angular fragments up to 3 inches across of maroon, purple, grey, and green volcanic fragments in a dark green matrix. Well-layered tuffs are common, especially on the hill 5 miles south and 2 miles east of the foot of Little Salmon Lake. Light grey siliceous flows, tuffs, and breccias outcrop along the east-west part of the creek 2.5 miles south of the west end of Little Salmon Lake, and small quantities are interlayered with andesitic flows near the north end of Frenchman Ridge. The groundmass of these rocks is aphanitic and includes sparse, tiny grains of feldspar and quartz. Angular and rounded fragments in the breccia consist of greenstone, cherty quartzite, and porphyritic rhyolite and reach 2 feet in length.

Other rocks included in map-unit 16a are green and brown greywacke, grey to black slate, and grey chert-pebble conglomerate.

At the west end of Little Salmon Lake and along the contact of the batholith underlying Tatchun Hills, the rocks are more highly metamorphosed than elsewhere.

The metamorphism, evidently a contact phenomenon related to the emplacement of the batholith, has created fine-grained, epidote-bearing amphibolites from the basic and intermediate volcanic rocks. On Frenchman Ridge, these effects can be observed for several hundred feet from the contact.

Map-unit 16b represents mappable bodies of limestone associated with the rocks of unit 16a. Whether the limestone outcrops are exposures along a single carbonate horizon or along several is not known. The limestone probably occurs as discreet lenses within the volcanic assemblage. Most of the limestone in the western part of the area is massive, grey and buff, and finely crystalline. Some is thin bedded and some contains patches of breccia in which normal limestone fragments are cemented by ferruginous carbonate. The single exposure of this limestone south of Little Salmon Lake contains relatively abundant breccia and also includes chert lenses and pods.

Structural Relations

The mainly small and scattered exposures of this unit reveal little structural data. Dips as steep as 75 degrees were recorded on bedded rocks bearing evidence that the strata are strongly folded. No useful stratigraphic markers were observed.

Neither the upper nor lower contact of the unit is exposed, hence its relations to the rocks of map-unit 6 and to the Lewes River and Laberge Groups are not known. Bostock and Lees (1938) and Bostock (1936) suggested that, in adjoining areas, rocks equivalent to map-unit 16 rest unconformably upon the Laberge and Tantalus Groups; the evidence, however, is not strong.

The strata of map-unit 16 are intruded by granitic rocks and trachytic dykes and are overlain unconformably by flat-lying, Tertiary, vesicular basalt and trachyte.

Age and Correlation

The rocks of map-unit 16 are co-extensive with similar rocks in adjoining areas where they have been regarded as probably Cretaceous. In Laberge map-area they were placed, together with almost all the pre-Tertiary volcanic rocks, in the Hutshi Group (Bostock and Lees, 1938). Similar rocks in Carmacks map-area were named the Mount Nansen Group by Bostock (1936). Cockfield (1928) believed that the volcanic rocks along Little Salmon River were Jurassic or later and regarded the associated limestone as being altogether older. He found ill-preserved fossils at two localities in the limestone; one collection was regarded as Late Palaeozoic and the other as possibly Triassic.

Tozer (1958, p. 4) made a detailed study of the Upper Triassic Lewes River Group in part of Laberge map-area about 30 miles south of Glenlyon map-area, and cited good evidence that a succession of volcanic rocks underlies the lowest beds of the Lewes River Group. He suggested that volcanism was widespread in the region during and after the Late Palaeozoic and prior to the late Triassic.

Bostock and Lees (1938) reported fossils of Carboniferous or Permian age from an isolated limestone surrounded by "Hutshi" volcanic rocks. This limestone is 10 miles south of Glenlyon map-area and is roughly on trend with the string of carbonate outcrops east and southeast of Frenchman Lake. The authors suggested that many of the limestone masses east of Teslin and Yukon River may be Late Palaeozoic rather than Triassic as designated on their map.

Wheeler (personal communication) who, rather than the writer, did the mapping along Little Salmon valley, commented that the local steeply dipping beds, general degree of alteration, and association of clastic sedimentary rocks with volcanic rocks suggested to him that the rocks of map-unit 16 are not part of the Hutshi Group. Wheeler (1961) is familiar with the Hutshi Group from his work in Whitehorse map-area.

The Jurassic Laberge Group near Frenchman Lake and Yukon River contains basal sections of thick, coarse conglomerate in which the fragments are mainly volcanic rocks. Though the relationship between the volcanic rocks of map-unit 16 and the fragments is not known, an area of volcanic rocks was obviously available for erosion, close at hand, at the time of Laberge Group deposition. The rocks of map-unit 16 may have provided the source of the volcanic fragments in the Laberge Group conglomerate. As no extensive volcanic unit is known in the Upper Triassic Lewes River Group, a pre-Upper Triassic age for the rocks of map-unit 16 is possible.

The evidence, though not conclusive, favours the view that the rocks of map-unit 16 are Carboniferous, Permian, or Triassic as is suggested by fossil-bearing limestone from three separate localities. These rocks might be equivalent to the volcanic assemblage (map-unit 7) along the west side of Drury Lake, but they are of lower metamorphic grade and are apparently less intensely deformed. The rocks display a distinct similarity to those of the Anvil Range Group, both in degree of alteration and in the nature of the assemblage.

The evidence presented by Tozer (1958) and the association of Late Palaeozoic and possible Triassic fossiliferous limestone with the volcanic assemblage of map-unit 16, taken together with other points mentioned above, indicate that these rocks might best be assigned a Permo-Triassic age rather than a Cretaceous age as was done in adjoining areas.

Lewes River Group

Rocks assigned to the Lewes River Group occur in two small areas in the southwestern corner of Glenlyon map-area. Most of the field work on these rocks was done by Wheeler, and the following account is derived from his notes and impressions given to the writer shortly after the completion of the field work.

The Lewes River Group was named, originally, the Lewes River Series, by Cockfield, for Triassic rocks near Maunoir Butte in Laberge map-area (Lees, 1934). The name has since been applied to Upper Triassic rocks throughout the length of the Whitehorse Trough (Bostock, 1936; Bostock and Lees, 1938; Wheeler, 1961; and Tozer, 1958). Tozer's work established the faunal succession for the group.

Lithology

The only rocks that can be assigned to the Lewes River Group with assurance are the limestones represented by map-unit 17a. These are light and dark grey, and buff, very finely crystalline rocks. About 3 miles southwest of the north end of Frenchman Lake, a small amount of limestone conglomerate containing rounded grey limestone cobbles and pebbles in a reddish ferruginous carbonate matrix is exposed with normal limestone.

Rocks assigned to the Lewes River Group with much less certainty are those of map-unit 17b found in the extreme southwest corner of the map-area. There the rocks dip to the northeast and apparently underlie the Lewes River Group limestone on and south of Eagle's Nest Bluff. The rocks in this locality consist of conglomerate composed of boulders, up to 5 inches in diameter, of green and maroon volcanic rocks, interbedded with greyish green greywacke. No granitic fragments were noted in these conglomerates. Also in this area are grey-green and maroon, andesitic and basaltic tuffs and flows.

Structural Relations

Wherever data were obtained the strata dip moderately to steeply to the northeast and apparently lie on the southwesterly limb of a northwest trending syncline, a structure which also involves the overlying Laberge Group.

At Eagle's Nest Bluff, an apparent discordance between the Lewes River and Laberge Groups may be a fault or unconformity. Elsewhere in Glenlyon map-area and in adjoining areas, the contact does not seem to be discordant, hence a fault is probable, but, unfortunately, it is hidden in a drift-filled gully. The lower contact of the Lewes River Group is not exposed in the map-area.

Age and Correlation

Northeast of Lake Laberge, Tozer (1958) found Upper Triassic fossils in the Lewes River Group. The only fossils found in these rocks in Glenlyon map-area were from the west face of Eagle's Nest Bluff and are of Upper Triassic age. The collection (G.S.C. Cat. No. 28504) was examined by Tozer who reported that it contained *Monotis subcircularis* Gabb and the age is Norian, probably late Norian. All the limestone of map-unit 17a is certainly Upper Triassic; however the greywacke and volcanic rocks of map-unit 17b may be assigned to the Upper Triassic with much less certainty. These rocks have been shown as part of the Jurassic Laberge Group in Laberge map-area to the south (Bostock and Lees, 1938) and as part of the Mount Nansen Group of probable Cretaceous age by Bostock (1936) in the Carmacks map-area. If, as appears to be the case, they dip under the limestone along Yukon River, they can belong to neither of these groups but must be part of the Lewes River Group or of some older sequence. They may correspond to Formation B of Tozer (1958) which consists of greywacke, conglomerate, and andesite, and which lies several hundred feet below the *Monotis*-bearing strata. The correlation is highly speculative.

Laberge Group

The Jurassic Laberge Group is, like the Triassic Lewes River Group, restricted to the extreme southwestern part of the map-area. The group was first described by Cairnes (1910, p. 30) as the Jurassic or Cretaceous Laberge Series. Much of the field work on this group was done by Wheeler though the writer investigated the rocks near Frenchman Lake.

Lithology

The Laberge Group in Glenlyon map-area consists entirely of clastic sedimentary rocks dominated by conglomerate and arkose, with minor argillite.

Conglomerate, which evidently forms the basal beds of the group, is composed mainly of volcanic fragments which include dark green, dark maroon, and purple basalt and andesite, and feldspar porphyry. Clasts of quartz diorite and pink granite are common, though subordinate, and fragments of buff limestone, greywacke, and dark argillite are locally present. The matrix is sandy greywacke and arkose. Numerous interbeds of greyish brown greywacke and siltstone occur with the conglomerate. The lowest sections of conglomerate, near Eagle's Nest Bluff, form beds 6 to 10 feet thick and carry boulders up to 14 inches across. Stratigraphically higher, in the same locality, the fragments are pebbles 1 inch to 2 inches across.

The beds overlying the conglomerate are mainly grey and brown arkose, locally pebbly or gritty; there are a few beds of conglomerate, argillite, and possibly tuff. The arkose contains a high percentage of white and grey feldspar and quartz; the larger fragments in the pebbly and gritty beds are dominantly feldspar and quartz. Conglomerate interbedded with arkose east of the north part of Frenchman Lake contains cobbles in which granitic rocks are common. Near the south end of Frenchman Lake, fine pebble-conglomerate contains rather angular fragments of dark argillite.

Structural Relations

In a general way, the Laberge Group appears to lie in a broad syncline apparently complicated by small-scale folding and faulting. West of the foot of Frenchman Lake, Lewes River Group limestone occupies a faulted structural high extending southeast from Carmacks map-area (Bostock, 1936). The beds east of Frenchman Lake show various attitudes suggestive of small-scale folding.

Bostock (1936) estimated the Laberge Group to be 9,000 feet thick in Carmacks map-area, and Bostock and Lees (1938) suggested a possible thickness of 8,800 feet in Laberge map-area. In the Whitehorse district, Wheeler (1961) found the maximum thickness to be in excess of 9,500 feet. Insufficient structural and stratigraphic data preclude the possibility of estimating the thickness of the Laberge Group in Glenlyon map-area. In his work along Yukon River, Wheeler (personal communication) noted that sections of basal conglomerates are about 650 feet thick near Eagle's Nest Bluff and possibly 4,300 feet thick west of the mouth of Little Salmon River. The thickness of the finer clastics is not known, but seems to be great, and a total thickness of many thousands of feet for the group is quite probable.

The Laberge Group is overlain unconformably by Tertiary basaltic lavas (map-unit 22) and is cut by small bodies of granitic and andesitic rocks. The lower contact is not exposed. The group may rest with local disconformity on the Lewes

River Group and faults may separate these units in places. The contact of the Laberge Group with the rocks of map-unit 16 is covered either by Tertiary volcanic rocks or by wide drift-filled areas. If the rocks of map-unit 16 are indeed Triassic or older, then a fault contact would provide the best explanation for the failure of the Lewes River Group to outcrop between the Laberge Group and the older(?) rocks to the east.

Origin

Near Eagle's Nest Bluff, Wheeler (personal communication) found imbricated fragments in conglomerate indicating a western source. On the other hand the fact that conglomerate is thicker near Little Salmon village than it is to the west suggests an eastern source. The Laberge Group probably received detritus from both east and west and now underlies an area generally concordant with the original basin in which it was deposited (an idea consistent with Wheeler's (1961) concept of the Whitehorse Trough).

Granitic boulders and the enormous quantity of feldspar and quartz detritus in Laberge Group strata suggest that crystalline rocks provided part of the source material for the sediments. The prevalence of volcanic clasts provides proof that an area of volcanic rocks was also emergent during the deposition of the Laberge Group. The relatively coarse nature of the clastic rocks indicates nearby source areas, particularly for the very coarse basal conglomerates. It is interesting to note that crystalline and volcanic rocks outcrop near the area now underlain by the Laberge Group. One may speculate that the metamorphic rocks of map-units 6 and 7, together with those of the Yukon Group in Carmacks map-area (Bostock, 1936), the granitic rocks associated with this metamorphic complex, and the volcanic rocks of map-unit 16 are in much the same metamorphic condition as they were when exposed to erosion in the Jurassic period. There is no other obvious source for the combination of materials in the Laberge Group sediments.

Age

On the north bank of Yukon River about one mile northwest of Eagle's Nest Bluff a few indeterminate fossils were found in shaly Laberge Group strata. Workers in nearby areas have found the group to contain Lower and Middle Jurassic fossils, and it may extend into the Upper Jurassic.

Tantalus Group(?)

Conglomerate (map-unit 19a) tentatively assigned to the Tantalus Group is exposed in two small outcrops near the south boundary of the map-area south of the west end of Little Salmon Lake. Other clastic sedimentary rocks (map-unit 19b) that may be correlated with the Tantalus Group are found in Tintina Trench northwest of the mouth of Harvey Creek.

Lithology

The rocks near the south boundary of the map-area consist of pebble-conglomerate in which the well-rounded fragments are mainly chert and quartz. Just to the south, in Laberge map-area (Bostock and Lees, 1938), are large exposures of Tantalus Group rocks including conglomerate of similar texture and composition. These rocks are generally regarded as Lower Cretaceous though they may include Upper Jurassic beds (Bostock, 1936; Bostock and Lees, 1938; Wheeler, 1961).

Northwest from the mouth of Harvey Creek on Pelly River is a long thin line of outcrops of reddish brown weathering, grey and brown conglomerate and sandstone (map-unit 19b). Fragments in the conglomerate are mainly pebble-size, cobbles are common, and boulders are rare. The pebbles and cobbles are subangular to subrounded. They consist of grey and grey-white quartzite, grey and buff limestone and dolomite, and lesser amounts of white quartz, dark argillite, slate, and chert. The finer fractions and the sandstones are composed of smaller and more angular grains of similar material. The cement is calcareous.

Conglomerate beds may be more than 10 feet thick, whereas sandstone beds rarely are thicker than 3 feet and commonly only a few inches. Sandstone displays graded bedding and channelling but no decipherable crossbedding was observed. The beds are right side up.

The bulk of pebbles and cobbles in the conglomerate of map-unit 19b are lithologically identical to the rocks of the Askin Group(?) a few miles to the west. None of the fragments is granitic nor of a type that might have been derived from the Anvil Range Group, though these rocks may have been overlooked. Roddick and Green (1961a) mentioned the occurrence of granitic clasts in similar conglomerates in Pelly River valley farther to the southeast, but Kindle (1945) commented specifically that he did not find them. Johnston (1936) made no mention of granitic fragments in the conglomerate. Granitic rocks are certainly not a common constituent of the conglomerates in Pelly River valley.

Structural Relations

The Cretaceous or Tertiary sedimentary rocks in Pelly River valley rest unconformably on older rocks that border Tintina Trench. They are moderately deformed and beds dip in excess of 50° in places. They are overlain, apparently conformably in one place in the Tay River map-area (Roddick and Green, 1961a), by basaltic flows but otherwise are not overlain by any younger consolidated rocks.

The rocks are, no doubt, cut by faults in Tintina Trench and fault activity may be responsible for the tilting of the strata.

Age and Correlation

Other workers (Roddick and Green, 1961a; Kindle, 1945; and Johnston, 1936) found plant fossils of late Cretaceous or more probably of Paleocene age in conglomerate, sandstone, and shale sections in Tintina Trench, southeast of Glenlyon map-area. No fossils were found in similar rocks near Harvey Creek. Possibly they are of the same age as the rocks farther up the valley or they may be equivalent to the Lower Cretaceous Tantalus Group to which they bear a lithological resemblance.

The conglomerate northwest of Harvey Creek lies on the floor of Tintina Trench and above it, to the southwest, rises the great granitic face of Glenlyon Range. The scarcity or absence of granitic clasts in the sediments, coupled with the fact that material was evidently derived from rocks still farther to the southwest beyond the granite, suggests that the granitic rocks were not intruded or were not unroofed at the time the sediments were deposited. If the granite was emplaced at that time then it must have come to its present position at a later date through movements along faults. Such movements might be expected near the margins of Tintina Trench. Conversely it may be that the conglomerate and granitic rocks were brought into juxtaposition by Tintina fault itself. This would imply that the conglomerate rests unconformably upon the Anvil Range Group, and would not provide a reasonable explanation of the prevalence of pebbles and cobbles of Askin Group(?) rock types and the absence or scarcity of Anvil Range Group rock types in the conglomerate.

Logically, it would seem that the granitic rocks along the northeast face of Glenlyon Range were not in their present position relative to the conglomerate at the time the conglomerate was deposited. If the conglomerate formed prior to the intrusion of the granitic rocks then it probably is early Cretaceous or older.

Tertiary Volcanic Rocks

Tertiary volcanic rocks are found in two parts of Glenlyon map-area. They form scattered outcrops in a belt on either side of Little Salmon River and are also exposed on the hillside east of Glenlyon Lake. The rocks are basalt (map-unit 22a) and basalt and trachyte (map-unit 22b) with minor tuff and intercalated sediments. They were formed, no doubt, at different times from place to place.

Lithology

On the hillside east of Glenlyon Lake are outcrops of brown, grey, and dark purple basalt. Tiny laths of plagioclase are visible in an aphanitic matrix in some places; in others no phenocrysts can be seen. In thin section, the rock is seen to consist of very fine grains of labradorite showing a fluidal texture in a matrix of reddish brown indeterminate material which is probably devitrified glass. There are patches of fine carbonate. In many places the rock contains calcite amygdules and less commonly vesicles filled with chlorite(?) and epidote. No flow tops nor bottoms could be determined with certainty and little structural data was gathered from these rocks.

In the area 2 to 3 miles east of the southern part of Frenchman Lake are many outcrops of reddish brown weathering, dark blue-grey basalt in which tiny feldspar laths lie in an aphanitic groundmass. Calcite and silica form amygdules in this rock. In one place a 10-foot-thick bed of pale green tuff or shaly tuff lies between flows. Basaltic dykes containing phenocrysts of pyroxene cut limestone (map-unit 16b) in close proximity to the flows. Basalt was found on Bearfeed Creek about 2 miles above its mouth.

Fine-grained basaltic and trachytic rocks (map-unit 22b) with strong fluidal texture form a craggy ridge high in the hills, eight miles west and a little north of the outlet of Little Salmon Lake. The rocks vary from dark to light grey in colour; light grey plagioclase forms prominent, well-oriented laths. The rocks are highly vesicular and contain amygdules and veinlets of zeolites. Flow tops are oxidized and reddish brown in colour. Flows range from 10 to 20 feet in thickness.

A few small scattered outcrops of trachyte and basalt were noted south of Little Salmon River.

Structural Relations

The basaltic rocks east of Glenlyon Lake apparently overlie conformably clastic sedimentary strata of late Cretaceous or early Tertiary age which outcrop in Tay River map-area (Roddick and Green, 1961a). On the strata of map-unit 9b, however, flows may lie unconformably or the two may be in fault contact. A few observations suggest that the flows are tilted to 40 degrees or more, which is entirely consistent with the attitudes of the underlying sedimentary rocks.

The flows just east of Frenchman Lake are mainly flat lying though dips of 20 degrees were noted in one place. These flows rest unconformably upon part of the Laberge Group and strata of map-unit 16.

The ridge of basaltic and trachytic volcanic rocks about 8 miles west of Little Salmon Lake is a remnant of a volcanic cone that was built by the extrusion of flows from a central orifice. The flows exhibit initial dips of as much as 20 degrees. Trachytic rocks found in other localities may have been related to different centres of volcanic activity, but outcrops are too small and scattered to permit any certain conclusions regarding their origin. Some of them might be dykes.

Age and Correlation

The basalt near Glenlyon Lake is evidently Tertiary as it apparently overlies late Cretaceous or early Tertiary sedimentary strata. The degree of deformation and alteration of these flows suggests that they may be early Tertiary and that they are, perhaps, correlative with the Carmacks Volcanics (Bostock, 1936). The volcanic rocks in the southwestern part of the map-area are all glaciated and hence are Pleistocene or older. They might reasonably be considered to have formed in the general period of extrusion of the Selkirk Volcanics of Carmacks map-area (Bostock, 1936), which represents a period of volcanism that may have begun prior to Pleistocene time and continued into the Recent.

Surficial Deposits (Map-unit 23)

Much of Glenlyon map-area is heavily mantled by unconsolidated deposits of glacial origin which have been mentioned previously (Chapter II).

The larger streams have cut into the Pleistocene deposits and in many places have developed broad flood plains. The flood plains are floored mostly by deposits of gravel, sand, and silt but along much of Macmillan River they are mantled by silt and clay.

A thin layer of white volcanic ash varying from a fraction of an inch to several inches in thickness is exposed along the cut banks of Pelly River and other streams. The ash lies at or very near the surface except where covered by fine, wind-blown material which commonly forms extensive cliff-top dunes above active cut banks. Evidently the entire area was once blanketed by ash. Bostock (1952) has shown clearly that the source of the ash was an area of explosive volcanic activity in the White River district near the Yukon–Alaska boundary.

Intrusive Rocks

Ultramafic Rocks (Map-unit 14)

The only ultramafic rocks recognized are small bodies of serpentinite associated with greenstone and phyllites of map-unit 7. Of these bodies only one is large enough to be shown on the map (unit 14); the remainder are included in map-unit 7b.

The serpentinite body mapped is a small, narrow lens on the ridge about 8 miles northwest of the foot of Drury Lake. It was first noted by Cockfield (1929). The rock consists entirely of very fine grained serpentine and varies from nearly black to olive-green and grey. Much of it weathers to a reddish brown rough surface but some is shiny green. The rock contains veinlets of fibrous serpentine but no asbestos was seen, though sparse short fibre asbestos was reported by Cockfield. Although contacts are not exposed, the body is surrounded by and presumably intrudes greenschist and amphibolite.

The unmapped serpentinite included in map-unit 7b is generally similar to that described above. It occurs as pod-shaped bodies elongated parallel with the strike of the foliation of the enclosing rocks. Scattered patches of sparse, short asbestos fibre were noted in these rocks.

The serpentinite appears to have been deformed with the enclosing rocks and may have moved from its original position during such a period.

No direct evidence bears on the age of the serpentinite. Many workers in northern British Columbia and Yukon Territory have thought the ultramafic rocks to be of Late Palaeozoic age though they evidently intrude Mesozoic rocks in some places. It is true that the ultramafic rocks are generally associated with Late Palaeozoic greenstone though locally, as in Teslin map-area (Mulligan, 1963), they intrude younger rocks. Wheeler (1961, p. 91) suggested the possibility that the ultramafic rocks were first intruded in Late Palaeozoic time and subsequently moved during Mesozoic folding.

Granitic Rocks (Map-unit 20)

Granitic rocks form three large batholithic masses and many smaller intrusions in Glenlyon map-area. In aggregate they underlie nearly one-quarter of the area. Two of the batholiths are in the western part of the map-area; one underlies much of Tatchun Hills and extends for many miles northwestward into Carmacks map-area (Bostock, 1936); the other extends northwestward along Pelly River valley from the central part of Tummel Basin. These batholiths, in terms of composition, texture, and intruded rocks, have much in common. The third batholith underlies the bulk of Glenlyon Range and includes two large, distinct, and separate masses as well as numerous smaller bodies. It extends southward into Big Salmon Range near the eastern boundary of the map-area.

Substantial granitic batholiths occur northeast of Tintina Trench to the north (Bostock, 1947) and east (Roddick and Green, 1961a), but their extensions into Glenlyon map-area on and near Kalzas Mountain and on Tay Mountain are relatively small. A single small intrusion cuts rocks of the Earn Group on the mountain south of Earn Lake. Other small granitic intrusions occur in the western and southern parts of the map-area.

Granitic Rocks of Glenlyon Range

The granitic rocks of the northern part of Glenlyon Range were intensively studied by the writer during preparation of a doctorate dissertation at the California Institute of Technology (Campbell, 1959). As a result of this study, much more is known of these rocks than of granitic rocks elsewhere in the map-area. The detailed study involved exhaustive investigation of the textures, modes, and crystallization history of the rocks.

In Glenlyon Range, the granitic rocks are dominantly biotite granodiorite that grades, in places, to quartz monzonite, with relatively minor quantities of biotite-hornblende quartz diorite, leuco-quartz monzonite, and pegmatite.

Granodiorite and Quartz Monzonite

Biotite granodiorite forms two separate large masses and innumerable small bodies in Glenlyon Range. Similar rocks extend southward into Big Salmon Range. Granodiorite is essentially continuous in the southern half of the range and another generally homogeneous body forms a narrow intrusion along the northeastern margin of the range and extends beyond it to near the mouth of Tummel River. These masses are separated by the Harvey Group which, especially low in the section (map-unit 2), is cut by dykes and sills of similar granitic rocks.

The granodiorite is typically a medium grey and medium-grained rock of seriate texture which, where porphyritic, displays phenocrysts of potash feldspar and patches of granular quartz. Phenocrysts, however, generally are not prominent. Foliation is absent or shown only by a suggestion of parallel orientation of biotite flakes and not by any mineral segregation.

Throughout the two main masses of granodiorite the texture and composition are remarkably uniform. Greenish brown or olive-green biotite, usually the sole mafic mineral, forms fine to medium, shreddy, anhedral grains and relatively rare hexagonal books. Plagioclase forms anhedral and rarely euhedral medium grains, mostly of sodic andesine, with delicate oscillatory zoning. Somewhat more sodic, unzoned plagioclase commonly forms rims around, and replacements into, the zoned crystals. Plagioclase commonly forms clots of mutually interfering grains. Euhedral form is best displayed by plagioclase where it is in contact with quartz. Its contacts with potash feldspar may be highly irregular or they may be euhedral; in the latter case myrmekitic rims commonly mantle the plagioclase. In many places quartz forms complex mosaics of fine grains in patches that may exceed 5 mm across. All the quartz grains are anhedral. Perthitic potash feldspar occurs in various forms from tiny grains and veinlets to large inclusion-rich anhedral phenocrysts as much as 1 cm across. The grains enclose all the other minerals of the rock, clearly replace plagioclase, and may, locally, replace quartz and biotite. Potash feldspar, mostly untwinned, shows rare microcline twinning. Soda feldspar lamellae form a small proportion of the whole of the perthite.

Alteration of the granodiorite is not intense and varies from place to place. Where it is present, chlorite and epidote form from biotite, plagioclase is sericitized, and potash feldspar, which is rarely affected, may show a dusting of clay minerals.

The composition of the granodiorite is extraordinarily uniform; no significant variations could be detected in specimens taken from the contacts compared to those far from a contact. The average composition of forty-eight modal analyses (Appendix, Table II), made on specimens of the granodiorite body on the northeast flank of the range and from the mass south of Pass and Lyon Creeks, is 19 per cent potash feldspar, 41 per cent plagioclase, 30 per cent quartz, and 10 per cent biotite.

In only two localities were significant compositional variations noted in the mass adjacent to Tintina Trench. Low on the hillside above Pelly River about 3 miles southeast of the mouth of Harvey Creek, the rock appears to contain little if any quartz. This presumably represents the syenite mapped by Johnston (1936), but the writer noted these rocks only in the one locality and not in the long narrow strip indicated by Johnston. On the crest of the ridge about 5 miles northwest of the mouth of Jar Creek is a small body of pink and green hornblende syenite in which laths of partly chloritized hornblende are set in a matrix of pink potash feldspar.

In the central part of the range, north of a line through the headwaters of Pass and Lyon Creeks, the granitic rocks change slightly (see the results of thirty-eight modal analyses, Appendix, Table III). Potash feldspar averages 25 per cent, and plagioclase and biotite 35 and 8 per cent, respectively. Quartz remains constant at 30 per cent. The plagioclase is more sodic, biotite is red-brown rather than green, and biotite and quartz, particularly in small dykes and sills, form a fine-grained foliated matrix.

The contacts of the granodiorite intrusion on the northeast flank of Glenlyon Range are exposed only on the southwest side of the mass. This contact is extremely sharp and the granitic rock exhibits no significant compositional or textural change toward the contact. The invaded rocks, mainly the argillaceous upper unit of the Harvey Group (map-unit 4), are distorted and have been converted to andalusite-cordierite-biotite hornfels. Dykes or sills projecting from the intrusion along the regular contact were noted at one place only, but it may be that the large dyke of biotite granodiorite, about 6 miles southwest of the mouth of Harvey Creek, is directly connected to the main mass.

The granodiorite in the southern, southwestern, and central parts of Glenlyon Range has very complex contact relationships. These rocks invade medium-grade metamorphic rocks of the lower member of the Harvey Group. From the head of

Pass Creek, an essentially continuous mass of granodiorite lies to the south but to the north the volume of granitic rock decreases progressively until, toward the top of the lower member of the Harvey Group, the metamorphic strata are essentially granite-free. The granitic rocks in this zone are mainly quartz monzonite and they form intrusions of progressively smaller size toward the north. The small bodies of granitic rocks are mainly sills though dykes are common. They have sharp contacts with characteristic thin selvages of coarse-grained, potash feldspar-rich granite or pegmatite. Moderate to strong foliation in the smaller sills parallels the contacts and the foliation of the invaded rocks, and the entire assemblage may be folded to some degree. Disoriented blocks of metamorphic rocks are included in dykes and sills. Fingers of granitic rocks commonly are injected along metamorphic foliation planes. There is little doubt that the granitic rocks formed by the crystallization of intruded mobile material rather than by the transformation of rocks with which they are now associated.

Biotite-hornblende Quartz Diorite

Biotite-hornblende quartz diorite occurs as small bodies that pass gradationally into biotite granodiorite or quartz monzonite, and commonly, though not universally, it forms aureoles around large inclusions of limy metamorphic rocks. The quartz diorite is typically a fine-grained dark rock in which the average mode of twelve analyses (Appendix, Table IV) is 51 per cent plagioclase, 19 per cent hornblende, 17 per cent biotite, 11 per cent quartz, and 2 per cent accessory minerals. Strongly zoned subhedral and euhedral plagioclase probably averages about An_{45} but differs from core to rim between extremes of An_{74} and An_{30}. Yellowish green hornblende may be euhedral or subhedral and green biotite occurs as irregular shreddy grains. Anhedral quartz fits around the other minerals and commonly forms relatively large micro-inclusion-filled grains. Accessory minerals are sphene and apatite.

Quartz diorite seems to have developed as a result of reaction and assimilation between granodiorite magma and limy sedimentary rocks.

Leuco-quartz monzonite

Leuco-quartz monzonite forms dykes and sills that cut other granitic rocks and strata of the lower and middle units of the Harvey Group. Most of the dykes and sills are less than 10 feet thick but locally are much thicker, as on the ridge south of Harvey Creek about 8 miles from Pelly River, where a dyke of leuco-quartz monzonite is at least 6 miles long and about 500 feet thick.

The leuco-quartz monzonite weathers dull chalky white and is pale cream on the fresh surface. Most of it is medium grained with a seriate rather than porphyritic texture, although potash feldspar forms large grains. Locally the feldspars are sufficiently coarse for the rock to be termed pegmatite. Subhedral or anhedral, weakly zoned or unzoned plagioclase averages about An_{20} in composition. Quartz occurs as granular aggregates and as single grains whereas muscovite and biotite form fine flakes. Potash feldspar forms large irregular grains, commonly involved in micrographic intergrowths with quartz. The large dyke south of Harvey Creek cuts the limy and argillaceous rocks of the middle unit of the Harvey Group and, along the contact, has converted them to diopside-garnet skarn and andalusite hornfels.

Granitic Batholiths of the Western Part of the Map-area

Relatively little is known of the two batholithic masses in the western part of the map-area owing, primarily, to their poor exposure. The more southerly batholith extends from Little Salmon River northwesterly through Tatchun Hills into Carmacks map-area. It is more than 50 miles long and varies from 15 to 20 miles in width. The more northerly batholith underlies the western part of Tummel Basin and is present from there northwestward along Pelly River valley into Carmacks map-area. It is more than 30 miles long and 6 miles wide.

Lithology

The rocks of the two batholiths are similar. They vary from quartz diorite to granite, minor syenite, and mafic rocks. Most are medium grained, medium to dark grey, and roughly equigranular though in large areas, particularly just north of Little Salmon River, they contain coarse phenocrysts of potash feldspar up to 1 inch long. In most places, these rocks display a moderate to strong planar structure marked by the parallel orientation of mafic minerals, but layering by mineral segregation is rare or absent. Hornblende is the dominant mafic mineral though biotite is abundant.

Plagioclase forms fine, medium, and rarely coarse anhedral and subhedral grains varying from An_{10} to An_{30} (rarely more calcic, even in quartz diorite). Much of the hornblende, which is subhedral and fine grained, is seen to be bright blue-green in thin section. Fine-grained biotite is green or yellowish green. Anhedral quartz forms fine to medium-sized single grains and aggregates of fine grains. Potash feldspar crystals vary greatly in size and abundance, and constitute from 0 to as much as 50 per cent of the rock in forms ranging from tiny interstitial grains to very coarse phenocrysts which seem to replace both plagioclase and quartz. The bulk of the potash feldspar is perthitic microcline though in some thin sections no twinning was observed.

All the rocks in these batholiths are moderately to highly altered; plagioclase, particularly, has been affected and in many places consists of masses of sericite, epidote, and carbonate. The general sodic composition of the plagioclase may be a result of albitization but no good evidence of this was observed. Hornblende and biotite, locally, are heavily chloritized and epidotized. Some potash feldspar is rather turbid with clay minerals.

Coarse syenite consisting mainly of perthitic microcline, hornblende, and augite, with associated partly serpentinized mafic rocks, was noted along Needlerock Creek about 6 miles east and northeast of Tatlmain Lake.

The two batholiths in the western part of the area differ markedly from those of Glenlyon Range. The rocks in the former bodies vary from quartz diorite to granite and are locally coarsely porphyritic in contrast with the relatively uniform, medium-grained granodiorite of Glenlyon Range. Potash feldspar is mainly microcline as opposed to orthoclase, plagioclase is more sodic, hornblende is the dominant mafic mineral rather than biotite, and the rocks, generally, are more altered than those of Glenlyon Range. Furthermore, the associated rocks, which are mainly siliceous mica schists and argillaceous types in Glenlyon Range, are hornblende–epidote-rich schists around the western batholiths.

Granitic Rocks Northeast of Tintina Trench

Northeast of Tintina Trench granitic rocks are confined to Tay Mountain on the eastern boundary of the map-area and to the vicinity of Kalzas Mountain on the northern boundary, and to a small body near the crest of the west ridge of the mountain south of Earn Lake.

The granitic rocks on Tay Mountain are exposed in what appear to be four separate bodies but the contacts were not followed out and some may be connected. They consist of both equigranular and coarsely porphyritic biotite grandiorite and quartz monzonite. The equigranular rocks and the matrix of the porphyritic types are medium grained, medium to light grey rocks.

The intrusions on Tay Mountain are at the northwestern end of a group of larger granitic masses which lie to the southeast in Anvil Range (Roddick and Green, 1961a). The intruded strata of the Anvil Range Group in the vicinity of the granitic rocks on Tay Mountain are converted to fine-grained biotite schist and phyllite.

The main mass of granitic rocks in McArthur Range in Mayo map-area extends southeast across Kalzas River to the summit of Kalzas Mountain. A small satellitic intrusion lies on the south slopes of McArthur Range about 2 miles north of Little Kalzas Lake. These rocks are mainly biotite granodiorite and vary from fine-grained, particularly in the satellite, to medium-grained, equigranular, and, locally, coarsely porphyritic types in the main mass. These rocks intrude the Anvil Range and Earn Groups and cause narrow aureoles of contact metamorphism. Near the summit of Kalzas Mountain, long needle-like crystals of andalusite were formed in argillaceous rocks presumably by this metamorphism.

On the northeast edge of Tintina Trench, near Little Kalzas Lake and northwest of it, are several outcrops of uniformly coarse-grained muscovite–biotite granite which, on the north boundary of the map-area, are associated with kyanite-bearing schist. The relationship of these rocks to the Anvil Range Group and to other granitic rocks is not known.

A single large outcrop of medium- to coarse-grained, porphyritic hornblende-biotite granite with large phenocrysts of potash feldspar was noted on the mountain south of Earn Lake. Its contacts are not exposed but it is, presumably, intrusive into the Earn Group.

Miscellaneous Minor Granitic Intrusions

Sheared and altered diorite and granodiorite form small bodies in strata of map-unit 6e on the southeast side of Tintina Trench adjacent to Little Kalzas Lake. Exposures are limited and little is known of these rocks. Small exposures of hornblende diorite were noted in Tummel Basin between Pelly and Macmillan Rivers. This rock evidently intrudes quartzite of the Askin Group(?).

Three miles east of Ragged Lake in Tummel Basin are several isolated exposures of dark dioritic or gabbroic looking rock. In thin section, this rock was seen to be highly altered granodiorite in which the mafic minerals are entirely chloritized and plagioclase is much altered to clay minerals. These rocks evidently belong to a single body and may be intrusive into the Askin Group(?).

In the southern part of Tummel Hills a small granitic intrusion cuts rocks of map-unit 6b. It is a grey weathering, tan porphyritic granite which consists of as much as 50 per cent phenocrysts of rectangular, brown, potash feldspar and rounded, dark, glassy quartz set in a fine-grained matrix of quartz, feldspar, and biotite. An intrusion of similar rock, containing phenocrysts of biotite as well as quartz and feldspar, cuts strata of map-unit 6a. It is 6 miles south of the centre of Little Salmon Lake. These two bodies have textural and compositional similarities to intrusions of Tertiary age.

Equigranular, medium-grained biotite granodiorite forms two small bodies, one at the west end of Little Salmon Lake, and the other near the south boundary of the map-area close to Walsh Creek. Similar rock was noted in the body south of Little Salmon River about 8 miles east of the mouth. South of the east end of the lake is a small body of medium-grained hornblende diorite.

On Little Salmon River at the mouth of Bearfeed Creek, and farther north along the valley of the creek, are several small patches of sheared and altered diorite and syenite. Small grains of potash feldspar and, locally, a little quartz, lie in a sheared, almost schistose matrix of fine-grained material rich in chlorite. Small exposures of medium-grained hornblende syenite were found about 4 miles east of the northern part of Frenchman Lake. The contacts of this body are not exposed but Laberge Group rocks nearby may be intruded by it. The Laberge Group may also be intruded by small bodies and dykes of hornblende quartz diorite near Eagle's Nest Bluff, though there again contacts are not exposed. One such body is shown on the map.

On the ridge south of Needlerock Creek on the western boundary of the map-area, a body of gneissic biotite granodiorite (map-unit 20e) is separated from non-foliated granitic rocks to the north by a septum of limestone. This is the only occurrence of rocks of this nature noted in Glenlyon map-area although they are widespread in Carmacks map-area (Bostock, 1936). Bostock believed that the gneisses intrude the Yukon Group and are themselves intruded by non-foliated granitic rocks.

Age of Granitic Rocks

In Glenlyon map-area or in nearby areas, the Upper Jurassic Tantalus Formation and all older stratified rocks are intruded by granitic rocks. Furthermore, Wheeler (1961) and others have found that intrusions cut the Hutshi Group which overlies the Tantalus Formation. One cannot doubt that huge masses of granitic rocks in southwestern Yukon Territory were injected during or after the Lower Cretaceous.

Potassium-argon ages have been determined for biotites from granitic rocks well to the east and southeast of Glenlyon area (Lowden, *et al.*, 1960, 1961, 1963a, and

1963b). These generally confirm an age of about 100 million years for granitic rocks on either side of Tintina Trench. This corresponds to Upper Cretaceous time according to Kulp (1961) and is consistent with the geological evidence cited above.

The common occurrence of granitic fragments in conglomerates of the Lower and Middle Jurassic Laberge Group shows without question that granitic rocks were exposed at the surface near the margins of the Whitehorse Trough in early Jurassic time. This implies that some of the granitic rocks in Glenlyon map-area may have been emplaced long before the late Cretaceous, such as the batholith or part of the batholith in Tatchun Hills and some of the rocks farther north near Tatlmain Lake, which lie close to the Jurassic conglomerate.

Nothing is known to indicate that the granitic rocks in Glenlyon Range and northeast of Tintina Trench were exposed before the Upper Cretaceous. The youngest rocks cut by them are Late Palaeozoic.

Tertiary Intrusive Rocks (Map-unit 21)

Small intrusions of siliceous igneous rocks, varying from essentially aphanitic to highly porphyritic types, are widespread in southwestern Yukon Territory and are generally regarded to be of early Tertiary age (Bostock, 1936; Wheeler, 1961).

In Glenlyon map-area these rocks range from grey, aphanitic to finely porphyritic (quartz and feldspar) rhyolite to brown and grey varieties in which medium-grained phenocrysts of glassy grey quartz or chalky white feldspar, or both, are enclosed in an aphanitic to finely crystalline groundmass. Thin sections reveal phenocrysts of quartz, potash feldspar and albite, and rarely biotite, in a groundmass of the same minerals. Intergrowths of quartz and potash feldspar commonly form part of the groundmass. Feldspars, particularly plagioclase, are intensely altered to clay minerals and sericite, and biotite is heavily chloritized.

Small Tertiary intrusions occur on the southern flank of Macmillan Range and on the southwest side of Dromedary Mountain. Numerous dykes of quartz-feldspar porphyry and a single mass of chalky white-weathering rhyolite were noted on the east side of the ridge between Glenlyon Lake and Pelly River. A porphyry intrusion lies close by the lead–zinc deposit in the south end of Glenlyon Range. Trachytic rocks south of Little Salmon River have been mapped as extrusive rocks (map-unit 22b) but some may be intrusive.

In Glenlyon map-area, rhyolitic porphyry was not found cutting rocks known to be younger than Late Palaeozoic. They are assumed to be Tertiary because of their similarity to Tertiary intrusive rocks in other areas.

Chapter IV

STRUCTURAL GEOLOGY

Known details of the structure of the rocks of Glenlyon map-area are discussed in the previous section dealing with the individual map-units. In this section a few salient features are mentioned.

Unconformities

Although unconformities were not actually observed some may be inferred on reasonable grounds.

The thick Crystal Peak Formation chert conglomerate of Upper Devonian or Lower Mississippian age apparently rests unconformably on strata ranging in age from late Precambrian to Silurian. Evidence for this is found mainly in Tay River and Sheldon Lake map-areas (Roddick, personal communication). Thus in the area northeast of Tintina Trench, a period of deformation, uplift, and erosion during or before the Upper Devonian is indicated. An unconformity between the Earn and Anvil Range Groups is possible but cannot be confirmed.

Southwest of Tintina Trench, conglomerates and associated rocks (map-unit 9a) of probable Lower Mississippian or Upper Devonian age evidently rest unconformably upon strata of the Harvey and Askin(?) Groups. The relationship of map-units 6 and 7 to other rocks is very imperfectly known. The rocks of these groups, thought to be Mississippian or older, are much more highly deformed and metamorphosed than younger rocks to the southwest which presumably lie unconformably on them. They were apparently deformed before late Triassic and after early Mississippian, possibly in pre-Permian time.

Although far from conclusive, the evidence thus indicates at least two periods of deformation during the Palaeozoic: one during or prior to the Upper Devonian and one in the Carboniferous or Permian.

Folds

All the folds in the Harvey, Askin, Earn, and Anvil Range Groups trend between west and N60°W. Those in the rocks of map-units 6, 7, and 16 and in the Lewes River and Laberge Groups trend more nearly northwest.

Faults

The most prominent single structural feature of Glenlyon map-area is Tintina fault. This fault separates two distinct and different geological terranes in which the stratigraphic columns are dissimilar though they contain in part rocks of the same age. Roddick (personal communication) has made a study of the fault and has concluded, on the basis of correlations across it, that right lateral transcurrent movement may amount to 260 miles.

Other long, continuous faults in the map-area are mostly inferred as the most reasonable explanation of many features.

Chapter V

ECONOMIC GEOLOGY

Glenlyon map-area has provided little of interest regarding mineral deposits. To the writer's knowledge only a single deposit, the lead-zinc-silver showing in the southern end of Glenlyon Range, 6.5 miles due east of the northeast corner of Little Salmon Lake, has received more than passing attention. This showing was first mentioned by Cockfield (1929). The property was optioned by Prospectors Airways Ltd. in 1954, and in 1955 the company conducted geological, geophysical, and geochemical surveys, diamond drilling, and surface trenching. The writer visited the property briefly in 1955.

Known mineralization is restricted to two small showings close to the contact of a pink and greenish grey, quartz-feldspar felsite porphyry dyke. The dyke cuts a succession of grey and greenish grey, prominently laminated lime-silicate and cherty rocks which evidently represent alterations of the nearby limestone of map-unit 8b. The dyke is cut by a northeast-trending fault along which the northwest side has moved, relatively, about 1,000 feet to the southwest. South of the fault and close to the south contact of the dyke is a narrow zone of alteration. One showing is within this zone and consists of a replacement by magnetite, chalcopyrite, sphalerite, and galena. The other, just outside the zone, is a vein containing sphalerite and galena. The mineralization is erratic and silver values are generally low. The company subsequently dropped the property. More work had been proposed by another company at the time of writing.

Several narrow zones of pyrrhotite mineralization were noted in Glenlyon Range in the lower and middle units of the Harvey Group near the east branch of Little Sheep Creek and the headwaters of East Tummel River. Copper stain occurs at the base of the cliff of limestone (map-unit 8b) overlooking Magundy River from the north. A little copper mineralization is reported on the north shore of Little Salmon Lake but was not observed by the writer. Sparse and very short asbestos fibre was noted in serpentinite of map-unit 7b. The writer is not aware of any successful placer operations within the map-area.

Prospecting would be severely hampered by lack of exposures in all but a few parts of the map-area. Exploration might be aided by the use of geochemical techniques, although widespread glacial deposits may reduce the effectiveness of these methods.

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APPENDIX

Table II

Modal Analyses of Granitic Rocks of Glenlyon Range
(Granodiorite from batholith on northeast flank of range, from the central part of range south of Pass Creek, and from the southwest side near Moraine Mountain)

Specimen (%)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Potash feldspar	13.4	26.5	18.8	17.4	17.0	12.1	12.9	31.0	15.7	4.0	11.9	28.6	32.4	12.9	28.9	26.4	26.7	9.1	17.3	24.6	15.0	15.9	28.8	4.5
Plagioclase	42.2	34.2	37.7	44.3	37.1	34.2	39.0	34.9	43.8	41.3	31.2	33.3	49.8	49.3	58.7	45.9	41.6	46.8	32.3	40.7	49.1	55.5	31.7	53.5
Quartz	27.9		31.9	28.1	28.2	34.4	39.1	29.4	33.4	42.3	48.3	29.1	8.8	23.7	6.3	17.7	21.8	33.8	39.3	22.9	24.7	20.0	31.5	31.2
Biotite	16.5	7.0	12.7	9.9	11.5	14.4	8.5	4.7	7.1	12.4	8.6	9.0	9.0	14.1	6.1	10.0	9.8	9.1	8.8	10.5	10.1	7.8	7.2	10.1
Hornblende			2.4				1.6																	
Muscovite																								
Accessory minerals		0.4	2.7	0.2		0.3	0.5										0.1	1.2	2.3	1.3	1.1	0.8	0.8	0.7

Specimen (%	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Potash feldspar	32.9	26.8	13.0	13.6	10.3	30.9	19.1	17.5	28.9	21.8	26.7	22.1	16.2	22.8	22.3	19.6	18.4	22.7	24.9	4.1	14.6	20.2	17.3	21.7
Plagioclase	34.7	35.9	40.2	33.8	34.6	33.6	45.7	36.3	42.4	33.7	34.6	35.9	44.2	47.1	30.5	40.6	43.9	40.4	38.5	49.3	37.4	41.8	44.7	34.0
Quartz	23.0	25.2	37.8	40.2	44.6	24.9	27.7	36.3	21.1	33.4	28.8	33.4	25.2	20.9	39.1	31.1	27.3	29.3	27.7	32.2	35.8	26.8	26.3	32.8
Biotite	8.6	11.7	8.1	9.9	10.4	9.8	7.0	9.1	5.0	9.4	8.8	7.3	12.4	8.7	6.8	7.5	10.1	6.5	8.1	13.7	11.5	10.6	11.5	9.6
Hornblende																								
Muscovite																								
Accessory minerals	0.8	0.4	0.9	2.5	0.1	0.8	0.5	0.8	2.6	1.7	1.1	1.3	2.0	0.5	1.3	1.2	0.3	1.1	0.8	0.7	0.7	0.6	0.2	1.9

Table III

Modal Analyses of Granitic Rocks of Glenlyon Range
(From central part of range north of headwaters of Pass and Lyon Creeks)

Specimen (%)	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67
Potash feldspar	12.0	20.9	31.9	35.0	38.3	26.7	40.7	31.2	23.5	37.7	30.9	14.3	24.2	17.8	21.5	34.6	26.8	14.8	29.6
Plagioclase	40.7	35.4	32.0	29.2	33.2	32.0	25.6	34.7	37.4	25.0	32.2	38.9	38.9	38.5	37.9	30.2	33.8	42.0	36.2
Quartz	34.6	37.2	30.6	33.2	18.7	33.3	30.0	27.3	30.0	34.6	31.5	32.6	20.5	31.7	29.4	28.3	32.7	33.5	24.3
Biotite	11.6	5.7	4.9	2.4	8.6	7.5	3.3	5.9	8.3	1.7	4.1	13.1	15.3	11.3	10.1	5.6	5.8	7.9	9.0
Hornblende																			
Muscovite																			
Accessory minerals	1.1	0.8	0.6	0.2	1.2	0.5	0.4	0.9	0.8	1.0	1.3	1.1	1.1	0.7	1.1	1.3	0.9	1.8	0.9
Specimen (%)	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Potash feldspar	14.6	35.1	27.6	27.5	30.7	22.2	35.2	26.6	34.0	27.0	12.3	13.7	22.0	17.0	24.3	20.3	23.2	16.4	25.0
Plagioclase	37.8	25.1	39.1	30.3	36.1	36.1	31.0	28.8	34.9	26.8	35.5	35.5	40.5	39.8	32.8	40.5	38.3	37.6	35.0
Quartz	35.4	30.2	28.6	34.3	27.1	29.2	28.6	35.5	26.0	35.1	35.7	40.0	27.4	30.1	34.4	29.3	29.3	34.8	30.2
Biotite	11.4	7.1	4.3	7.1	5.8	11.3	4.2	6.2	2.2	6.8	15.3	10.0	9.8	12.5	7.8	3.9	5.9	10.4	9.0
Hornblende																			
Muscovite																5.2	3.2		
Accessory minerals	0.8	2.5	0.4	0.8	0.3	1.2	1.0	2.9	2.9	4.3	1.2	0.8	0.3	0.6	0.7	0.8	0.1	0.8	0.8

Table IV

Modal Analyses of Granitic Rocks of Glenlyon Range
(Scattered small masses of hornblende-biotite quartz diorite)

Specimen(%)	87	88	89	90	91	92	93	94	95	96	97	98
Potash feldspar					1.4					2.1		
Plagioclase	42.2	48.4	48.6	57.0	47.5	50.5	52.4	54.1	54.6	53.0	51.5	51.2
Quartz	9.3	10.9	14.6	17.8	7.5	9.9	11.3	19.9	20.1	14.0	10.5	0.4
Biotite	19.3	11.2	18.9	14.9	18.3	14.2	17.9	18.2	16.3	16.1	19.3	2.3
Hornblende	27.8	27.9	16.7	7.4	22.3	21.4	17.4	6.3	6.6	13.7	18.5	45.2
Muscovite												
Accessory minerals	1.4	1.6	1.2	2.9	3.0	4.0	1.0	1.5	2.4	1.1	0.2	0.9

Table V

Modal Analyses of Amphibolite of Glenlyon Range (Map-unit 2)

Specimen(%)	99	100	101	102
Potash feldspar				5.8
Plagioclase	44.8	27.9	49.1	25.4
Quartz		0.5		0.4
Biotite				
Hornblende	54.4	71.1	16.1	66.6
Diopside			29.1	
Accessory minerals	0.8	0.5	4.9	1.8

Table VI

Modal Analyses of Quartz-mica Schist of Glenlyon Range (Map-unit 2)

Specimen (%)	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119
Potash feldspar	1.3			4.4	1.6	1.4	0.6	0.2	0.6	13.6	5.8				10.2	12.5	36.1
Plagioclase	28.0	6.6	12.5	29.3	15.6	16.4	1.1	22.5	10.9	19.1	37.4	17.7	17.6	40.2	23.8	30.1	23.0
Quartz	47.6	37.4	47.1	58.3	40.3	17.6	44.8	66.5	73.5	52.6	36.7	62.1	68.7	54.6	49.0	41.3	2.9
Biotite	19.8	36.3	24.1	7.9	28.8	62.2	38.5	5.6	13.1	13.8	19.2	19.1	12.3	4.9	16.5	16.1	37.0
Hornblende																	
Muscovite	2.7	18.0	15.1	0.1	12.0	2.4	15.0	5.2	0.6		0.7	0.6	1.0		0.5		0.1
Accessory minerals	0.6	1.7	1.2		1.7				1.3	0.9	0.2	0.4	0.4	0.3			0.9

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