GEOLOGICAL SURVEY OF CANADA · 1842 ·

MEMOIR 348

WILLBOB LAKE and THOMPSON LAKE MAP-AREAS, QUEBEC and NEWFOUNDLAND

(23 O/1 and 23 O/8)

M. J. Frarey

1967

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2,000—1966—5484

98943—1½

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Printed on No. 1 OFFSET ENAMEL
Set in Times Roman with
20th Century captions by
CANADIAN GOVERNMENT PRINTING BUREAU
Artwork by CARTOGRAPHIC UNIT, GSC

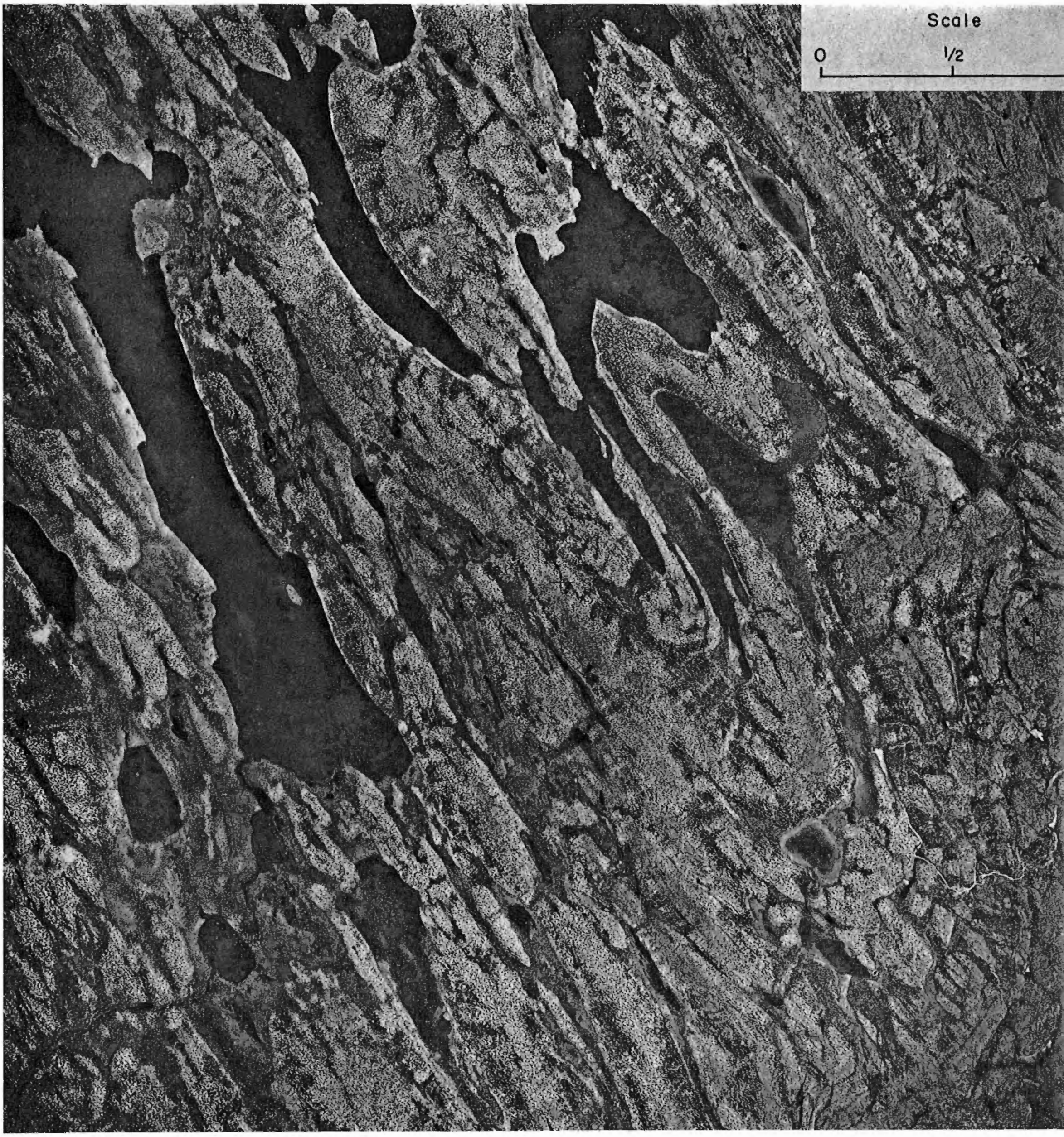

PLATE I. Aerial photograph of terrain, Willbob Lake map-area, showing low ground with forest-tundra vegetation underlain by metamorphic and sedimentary rocks (left and centre), and barren uplands of igneous rocks exhibiting strong topographic expression of structure (right). (RCAF A11512-66)

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WILLBOB LAKE AND THOMPSON LAKE MAP-AREAS, QUEBEC AND NEWFOUNDLAND (23 0/1 and 23 0/8)

By
M. J. Frarey

DEPARTMENT OF
ENERGY, MINES AND RESOURCES
CANADA

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Price: $2.25 Catalogue No. M46-348

Price subject to change without notice

ROGER DUHAMEL, F.R.S.C.
Queen's Printer and Controller of Stationery
Ottawa, Canada
1967

PREFACE

Although emphasis on the geology of the Labrador Trough has naturally centred about the important iron ore deposits of Schefferville, considerable geological and prospecting effort has also been devoted to the northeastern or 'outer' side of that belt. The Geological Survey of Canada commenced work there in 1950 as part of a program to map a section across the Trough. This memoir gives an account of two map-areas (1 inch to 1 mile) lying in that terrain, the geology of which contrasts sharply with that of the Schefferville iron district.

J. M. HARRISON,
Director, Geological Survey of Canada

OTTAWA, April 16, 1964

MEMOIR 348 — Kartenblätter Willbob Lake und Thompson Lake in Quebec und Neufundland. Von M. J. Frarey

Eine Beschreibung der Stratigraphie der proterozoischen Gesteine, die zu der Eisen führenden Schichtfolge in der Geosynklinale von Labrador gehören.

ТРУД 348 — Уиллбоб Лейк и Томпсон Лейк листы геологической карты, Квебек и Ньюфаунленд. М. Й. Фрэрий

Описывает стратиграфию протерозоиских пород слагающих часть железосодержащей серии Лабрадорской геосинклинали.

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WILLBOB LAKE AND THOMPSON LAKE MAP-AREAS, QUEBEC AND NEWFOUNDLAND

Abstract

This report describes the geology of two contiguous map-areas along the east side of the Labrador Trough, slightly north of the latitude of Schefferville, Quebec. It embodies the results of four seasons' systematic mapping (at one inch to half a mile), and of subsequent laboratory investigations.

The rocks of the mapped area are entirely Precambrian and all are probably Proterozoic in age. The various formations of the known Proterozoic groups (Knob Lake and Doublet) of this part of the Trough are successively described, as well as the more metamorphosed Laporte rocks, of probable Proterozoic age, in fault contact with them to the northeast. Pre- or syn-orogenic basic sills profusely intrude the Proterozoic sequence (Kaniapiskau Supergroup), particularly the sedimentary units; a more restricted but persistent group of ultrabasic sills invades the Doublet Group; glomeroporphyritic gabbroic sills of special interest are prominent in the Knob Lake Group, in the southwestern part of the mapped area. No major unconformities are recognized.

Metamorphism in the strata of the Kaniapiskau Supergroup ranges erratically from almost negligible to greenschist levels. The best developed greenschists are represented by pyroclastic rocks adjacent to the Walsh Lake fault. Laporte metasediments in the northeast attain almandine–amphibolite rank.

Three structural blocks of contrasting style are present. In order northeastward they are: a generally homoclinal, northeast-dipping block lacking apparent important faults; a central block containing prominent, open, southeasterly-plunging folds and several conspicuous strike faults and shear zones; and the metamorphic Laporte block northeast of the Trough, lacking definable folds and, with few exceptions, definite faults.

The mapped area comprises the deeper 'eugeosynclinal' part of the Labrador geosyncline and is dominated by the basic and ultrabasic igneous rocks. A relatively brief and simple tectonic history is indicated. While the major deformation of the Labrador Trough is generally believed to belong to the Hudsonian orogeny (1700 m.y.), a single age determination of 1375 m.y., from the Murdoch Formation, possibly indicates a post-Hudsonian disturbance.

Sulphide mineralization is common, particularly in dark shales and gabbroic rocks, but no workable deposits have so far been discovered. Iron sulphides are particularly widespread in the shales. From regional considerations, all the sulphide mineralization is believed to be related to the basic and ultrabasic igneous rocks.

Résumé

Le présent rapport donne la description géologique de deux régions contiguës situées le long du flanc est de la fosse du Labrador un peu au nord de la latitude de Schefferville (Québec). Il renferme les résultats de quatre saisons de travaux systématiques de cartographie (à l'échelle d'un demi-pouce au mille) et de recherches subséquentes en laboratoire.

Toutes les roches de la région sont du Précambrien et remontent probablement au Protérozoïque. L'auteur décrit successivement les diverses formations des groupes protérozoïques connus de cette partie de la fosse (lac Knob et Doublet), de même que les roches plus métamorphisées de la formation de Laporte, probablement du Protérozoïque, qui sont en contact faillé avec les premières au nord-est. Des filons-couches basiques préorogéniques ou synorogéniques présentent de nombreuses intrusions dans la succession protérozoïque (surgroupe Kaniapiskau) et surtout dans les unités sédimentaires. Un groupe de filons-couches ultrabasiques plus réduit mais persistant a envahi le groupe de Doublet. Des filons-couches à gabbro gloméroporphyritiques d'un intérêt particulier sont en évidence dans le groupe du lac Knob, dans la partie sud-ouest de la région. On n'a relevé aucune discordance importante.

Le métamorphisme dans les strates du surgroupe Kaniapiskau varie quelque peu au hasard: à peu près négligeable par endroits, il a donné ailleurs des schistes verts. Les schistes verts les mieux formés sont représentés par des roches pyroclastiques adjacentes à la faille du lac Walsh. Les métasédiments Laporte au nord-est ont atteint l'étape d'amphibolite à almandine.

Dans la région se trouvent trois ensembles structuraux d'aspect contrastant. Ce sont, par ordre, en direction nord-est: un ensemble à pendage nord-est généralement homoclinal qui ne semble pas comporter de failles importantes; un ensemble central qui présente des plis ouverts, bien visibles, à pendage sud-est de même que plusieurs faibles longitudinales et des zones de cisaillement bien visibles; enfin, l'ensemble métamorphique Laporte, au nord-est de la fosse, qui ne présente aucun plissement reconnaissable ni, sauf quelques exceptions, aucune faille définie.

La région comprend la partie eugéosynclinale la plus profonde du géosynclinal du Labrador et elle est caractérisée par des roches ignées basiques et ultrabasiques. L'histoire tectonique de la région est donnée de façon brève et simple. Quoique l'on croit que la déformation majeure de la fosse du Labrador remonte à l'orogenèse hudsonienne (1,700 millions d'années) une datation de 1,375 millions d'années faite à l'égard de la formation de Murdoch laisse entrevoir la possibilité d'une perturbation antérieure.

Les minéralisations sulfurées sont communes surtout dans les schistes noirs et les roches à gabbro, mais on n'a pas encore trouvé de gisements exploitables. Les sulfures de fer sont très répandus dans les schistes. On croit, d'après des considérations d'ordre régional, que les minéralisations sulfurées sont apparentées aux roches ignées basiques et ultrabasiques.

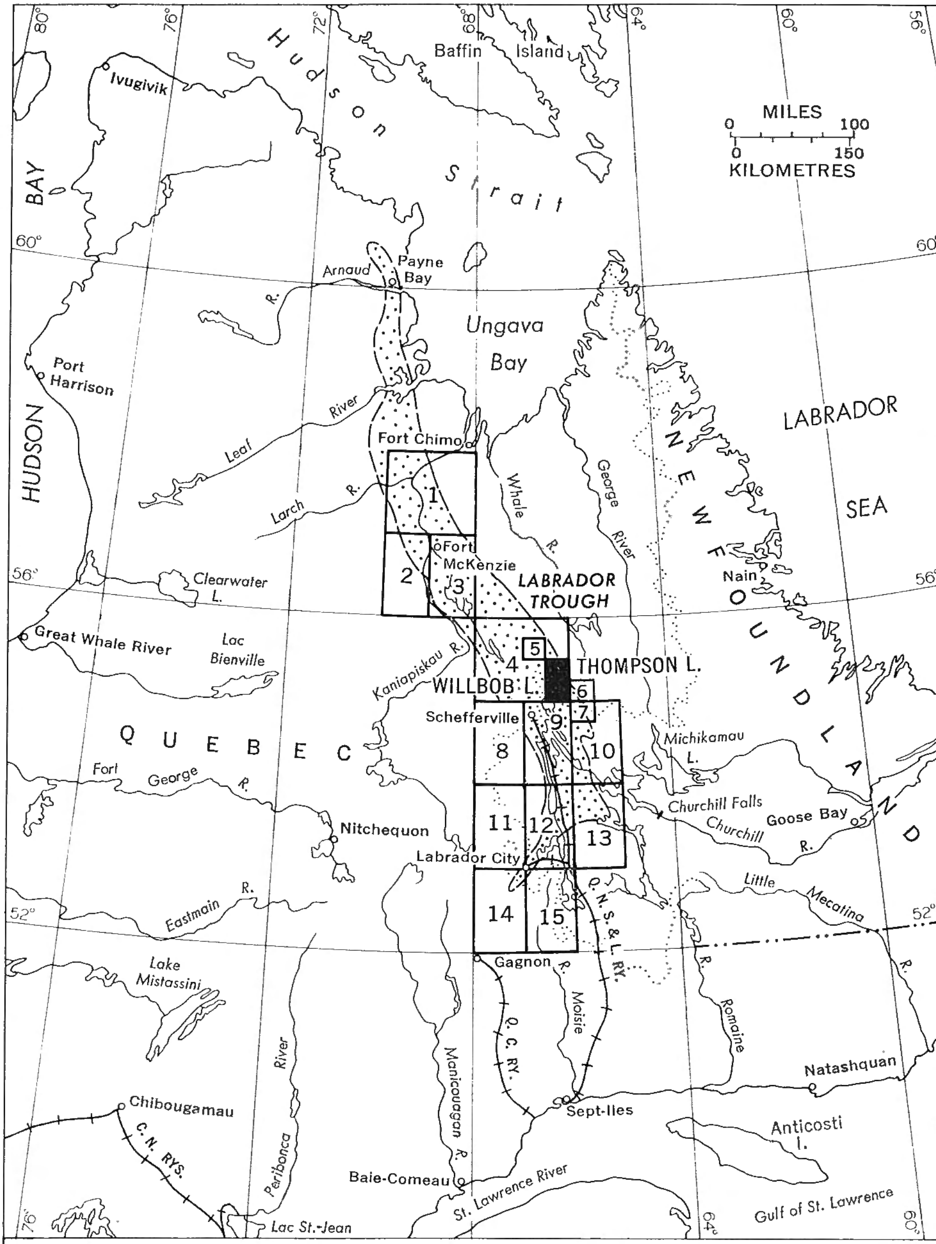

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FIGURE 1. Geographical location of the Willbob Lake and Thompson Lake map-areas and Geological Survey mapping in the Labrador Trough.

Chapter I

INTRODUCTION

Location, Extent and Access

Willbob Lake and Thompson Lake are two contiguous map-areas in the central Quebec–Labrador Plateau, covering about 700 square miles along the eastern side of the Labrador geosyncline or Trough (Fig. 1). The centre of Willbob Lake map-area lies about 35 miles northeast of the iron mining town of Schefferville, Quebec, which is about 360 miles by rail from the port of Seven Islands, on the north shore of the St. Lawrence River. The map-areas are located well east of the Knob Lake iron ore range, between latitudes 55°00′ and 55°30′, and longitudes 66°00′ and 66°30′.

Schefferville can be reached by rail from Seven Islands, Quebec, or, more conveniently, by air, on regular flights from several points on the north and south shores of the St. Lawrence River. The only practicable means of access into and travel within the map-areas is by float-equipped aircraft, although canoes can be used on the larger lakes.

Previous Work

The map-areas lie entirely within two former large mineral concessions granted by the governments of Newfoundland and Quebec, in 1936 and 1942, respectively, to the Labrador Mining and Exploration Company and Hollinger North Shore Exploration Company, and were explored jointly by the former company. The earliest geological work in the vicinity of the map-areas, done by geologists of the company in 1942, consisted of preliminary mapping of the territory and exploration for mineral deposits. In the next several years, the company mapped a number of areas in this and other parts of the concessions, in the course of which the important stratigraphic and structural elements of this sector of the Labrador Trough were recognized, named, and briefly described, providing an invaluable framework for subsequent work. Considering the total lack of previous geological work, topographic maps, and aerial photographs, together with the problems of logistics, this represented a notable achievement (Moss, 1955, p. 160). Geological investigations in the vicinity of mineral showings were continued by the company, intermittently, until 1949, when a narrow strip southwest of Connolly and Walsh Lakes in Willbob Lake map-area was mapped on the scale of 1 inch to 1,000 feet, and a

Ms. received 26 February, 1964.

small area southwest of Lac Faute was similarly mapped (Labrador Mining and Exploration Company, private reports). In 1953, P. M. Kavanagh mapped for the company, on the same scale, a strip up to seven miles wide, extending from southwest of Willbob Lake some twenty miles northwestward to Keating, Kalko, and Hansen Lakes in Thompson Lake map-area (Kavanagh, 1954).

Work in this district by the Geological Survey of Canada began in 1949, with a reconnaissance by J. M. Harrison which included a traverse across the southern part of Willbob Lake map-area and adjacent areas to the west, east, and south. The two map-areas were mapped in the four years from 1950 to 1953, inclusive. The mapping was done on the scale of 1 inch to half a mile, and, for publication, 1 inch to 1 mile. Preliminary papers covering this and other Survey investigations nearby have been published previously (Fahrig, 1951; Frarey, 1952; Harrison, 1952; Baragar, 1958, 1963; Donaldson, 1959; Wynne-Edwards, 1960) (*see* Fig. 1).

Acknowledgments

Special thanks are due the Labrador Mining and Exploration Company, which, through the generous cooperation of Dr. R. D. MacDonald, Mr. G. M. Hogg, and the late Dr. J. A. Retty, supplied various private reports and maps pertaining to the map-areas, and extended many other courtesies. Similarly, the Iron Ore Company of Canada, through Dr. A. E. Moss, Dr. C. Dufresne, and the geological staff, provided valuable assistance through the use of their facilities in the area. It is no exaggeration to say that the feasibility of carrying out the required field work in these areas depended to a great extent on the cooperation and assistance of these organizations and individuals. The writer also wishes to thank his field assistants, who included the following: in 1950, A. M. Syme, F. G. Savard, and D. C. MacLean; in 1951, C. W. Weeks, J. T. Jenkins, and R. J. W. Kelly; in 1952, W. K. Liddicoat, J. Gittins, and H. C. Evans; and in 1953, E. J. Olsen, E. G. Nicolle, and T. W. Calvin. Field work in Willbob Lake map-area provided material for a Ph.D. thesis at the University of Michigan, and, for valuable assistance and advice, the writer thanks Prof. F. S. Turneaure and the thesis committee.

Physical Features

Drainage

The map-areas lie at the headwaters of two large drainage systems, that of the Churchill River, which flows southeastward through Labrador into Goose Bay on the Atlantic Ocean, and that of the northward-flowing George, Kaniapiskau, and Whale Rivers, which run through Quebec into Ungava Bay (*see* Fig. 1). The divide between these two systems passes through the west half of Willbob Lake map-area from a point near Fox Lake, northwestward along the southwest side of Butt Lake and the northeast side of Howse Lake, intersecting the west boundary of the map-area just southwest of Diorite Lake. Southwest of this line, the drainage is generally southerly into Attikamagen Lake and thence by connecting waters into upper Churchill River. Northeast of the height of land, there are two sub-systems. One drains to the southeast from Walsh, Willbob, Connolly, Frederickson, Faute, and Doublet Lakes, of the Willbob Lake map-area, into the upper reaches of the Rivière de Pas, and thence northward to Ungava Bay via George River, while the other runs more directly north to Ungava Bay via Wheeler and Whale Rivers, draining the lakes of Thompson Lake map-area and the northeast part of Willbob Lake map-area.

The drainage is imperfectly developed, and there are many isolated ponds and swamps. An estimated 20 per cent of the surface is covered by water. The lakes fall into two categories: firstly, those lying at relatively low elevation and characterized by drift-covered shores and islands, broad widths with numerous islands, and brownish, warm water; secondly, those lying on higher ground on bedrock, and characterized by narrower widths with fewer islands and clearer, colder water.

The streams are, in general, narrow, straight, and shallow, usually strewn with boulders, and flowing on or close to bedrock. Rapids are numerous and generally impassable, making canoe travel impractical. The larger streams commonly parallel the general northwest trend of the rock formations. They are joined by a few short tributaries entering at right angles from flanking ridges, thus imparting an imperfect trellis drainage pattern. Drainage evolution is extremely slow because of the low rate of erosion, and the character of the streams emphasizes the youthful stage of the drainage as a whole.

Swamps are numerous but are generally narrow and rarely a serious obstacle to foot travel. Numerous examples of 'festooned' bogs occur. These are described in the following section.

Physiography

The map-areas lie within the vast Labrador–Quebec interior plateau. This great upland region is considered to be an ancient peneplane repeatedly modified by epeirogenic movements since late Ordovician time. The three major events leading to the development of the existing regional physiographic features were the strong uplift that occurred in late Pliocene time, Pleistocene glaciation, and subsequent renewed uplift (Cooke, 1929, 1930, 1931). Observations at widely separated points in the region have indicated that the post-glacial uplift has ranged from 200 to 1,500 feet (Tanner, 1944). That this uplift is still continuing in coastal areas rather rapidly is indicated by the presence of raised beaches, as yet free of vegetation (Tanner, 1944; Harrison, personal communication).

The Quebec–Labrador Peninsula has been divided into major physiographic units by Douglas and Drummond (1955), and Hare (1959), mainly through the study of aerial photographs. Of these units, the Lake Plateau, previously mentioned by Hind (1863), Tanner (1944), and Kimble and Good (1955), is outlined as a broad, crescentic, largely drift-covered belt about 550 miles long, trending roughly east and west through the southern interior of the peninsula. Its northeast extremity extends to the great belt of lakes south of Schefferville, including Petitsikapau, Dyke, and Menihek Lakes (Hare, 1959, p. 55). Attikamagen Lake and the extreme southwestern part of Willbob Lake map-area may be considered the northern extension of the Lake Plateau in this vicinity. The remainder of the report area falls within Hare's Labrador Trough upland subdivision, which is characterized by ridge-and-valley topography. Within the map-areas, this surface is partly rolling, but commonly is sharply dissected, with local relief of as much as 750 feet. In general, the high ground consists of long ridges with rounded to flat tops and steep sides, whose slopes commonly attain 35 degrees. Bedrock is abundantly exposed on the upper parts of the ridges. Many ridges are asymmetrical in section, in that one flank is steep, cutting across the underlying strata sharply, whereas the other is gentler, in places approximating a dip-slope. The approximate attitude of strata is thus discernible from aerial photographs. The ground between the ridges is occupied by shallow lakes and streams and by flat wooded or swampy areas where outcrops are sparse. Elevations in the map-areas range from about 1,490 feet above sea-level on McNeill Lake, in the southeast, to 2,350 feet at a point about three miles north of Willbob Lake.

The most prominent regional topographic feature in this part of the Labrador Trough upland is a linear element, roughly 90 miles long, extending from Andre Lake, 30 miles southeast of Willbob Lake map-area, northwestward beyond the map-areas to Murdoch River, at about latitude 55°50′. Particularly conspicuous in Willbob Lake map-area, it follows Lac Faute, Frederickson Lake, Connolly Lake, Walsh Lake, and Dobbin Lake and continues across the southwest corner of Thompson Lake map-area from Dobbin to Benjamin Lake. In the Frederickson Lake–Walsh Lake sector, this linear element is marked by a prominent line of hills up to 300 feet high. In the map-areas under consideration and to the southeast (Donaldson, 1959), it is known to mark a fault, referred to herein as the Walsh Lake fault.

A consistent relationship exists between the topography and the bedrock lithology and structure. The hills and ridges of the upland area are underlain almost exclusively by basic or ultrabasic igneous rocks. Of these, basic volcanic rocks are the most resistant, forming the highest hills, such as those southwest and northeast of Retty Lake and north of Thompson Lake. The next highest ground is generally underlain by gabbro and ultrabasic rocks, and the lowest, by sediments and schists. The long, relatively narrow ridges consistently follow the trends of the basic volcanic flows and sills, and, as a result, many folds are strikingly reflected topographically (Pls. I and XVI). In general, outcrops are abundant in the upland, but vary considerably with lithology, depending on the degree of resistance to erosion. Areas of sedimentary, metasedimentary, or pyroclastic rocks, for example, are generally characterized by small scattered outcrops, whereas basaltic and gabbroic igneous rocks form extensive outcrop areas.

The lower parts of the map-areas are noteworthy for the development, in places, of 'festooned' and palsa bogs. The former are generally elongate, grassy, wet areas, divided transversely by sinuous bands or 'festoons' a few feet wide, and composed of woody organic matter and supporting shrubs. Some bogs also have one or more longitudinal 'festoons' close to the edges. The 'festoons' appear to be the result of solifluction movements associated with the process of in-filling of the bogs. The 'festooned' bogs of these quadrangles apparently closely correspond to the 'string bogs' described from the vicinity of Knob Lake (Allington, 1959, 1961). The palsa

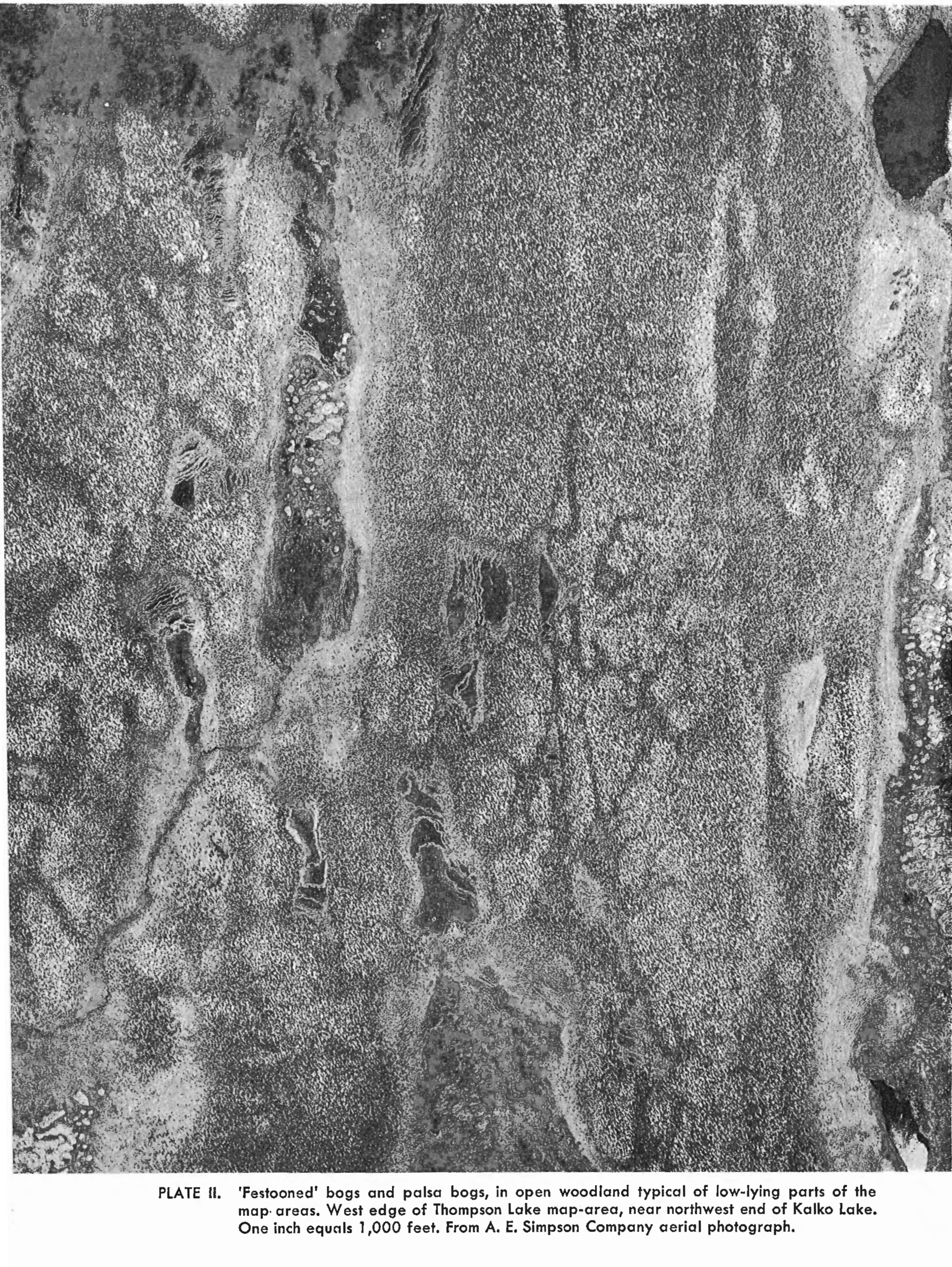

PLATE II. 'Festooned' bogs and palsa bogs, in open woodland typical of low-lying parts of the map-areas. West edge of Thompson Lake map-area, near northwest end of Kalko Lake. One inch equals 1,000 feet. From A. E. Simpson Company aerial photograph.

bogs are swamps distinguished by rudely circular to elongate mounds, covered by organic matter and measuring a few feet in height. Larger mounds exceed a hundred feet in width or in length, and tend to coalesce to form compound features. In some cases, tree stumps and roots were observed on the surface of mounds, indicating an encroachment of bogs into wooded areas. The mounds form conspicuous white areas on aerial photographs (Pl. II). Some palsa bogs also have 'festooned' borders. Time did not permit an investigation of the internal composition or structure of the mounds.

Glaciation

Observations regarding glaciation were only made incidentally to the bedrock study, but sufficient data were obtained to permit a general summary. The subject of glaciation in this general region has been treated by Henderson (1959).

Glacial Erosion

Glacial erosional features are common in the map-area. Striae and grooves are abundant on the bedrock surfaces, especially those underlain by basic igneous rocks. Rounded outcrops, *roches moutonnées*, and plucking effects are fairly numerous, but chatter marks and friction cracks less so. None of the valleys showed evidence of shaping by ice, and the total amount of glacial erosion appears to have been moderate.

Glacial Deposition

The map-areas are covered with a thin mantle of till, consisting of clay and a moderate number of rock fragments. The clay is usually greenish, reflecting the widespread distribution of basic igneous rocks in the region. The fragments are mostly basalt and gabbro; relatively few foreign to the area were seen. Over much of the area the till is only a few inches thick, and is nowhere believed to be more than a few feet deep.

Other types of drift are almost totally absent from the report area. Sand and gravel deposits of any sort apparently are totally lacking, and only a few surface accumulations of glacial or fluvial-glacial origin were seen. Most of the glacially transported boulders were of small to moderate size, but, in one restricted area, near the northeast corner of Willbob Lake map-area, numerous blocks of volcanic breccia up to 30 feet long were noted. As outcrops of these rocks occur in the vicinity, it is believed that these blocks are of local origin and have not travelled far.

If one assumes that the present climatic warming has been continuous in recent geological time, it would appear that the area has not long ceased to be a locus of ice accumulation, as the higher parts of the upland are now free of snow for only a few weeks of the year.

Ice Movement

Three directions of ice movement are indicated by glacial striae and other features. The chief glacial trend is northwest, and, as a rule, large-scale erosional features, such as *roches moutonnées*, indicate flow toward the southeast. At some localities, however, similar evidence clearly points to a northwestward movement. A second, clearly marked glacial trend strikes about N35° E. Intersecting striae on numerous outcrops indicate that this is a later flow than the northwest-southeast movements. In a few places along the eastern side of the map-areas, erratics from the southwest deposited by this flow were observed. This late flow is significant in that it crossed the topographic grain of the country almost at right angles, and its regional importance is shown by reported occurrences at such widely scattered localities as George River, 75 miles to the northeast (Ives, 1960), the Knob Lake area 40 miles to the southwest (Harrison, 1952), the Eclipse Lake area 40 miles to the west, the Menihek Lakes–McPhadyen River area 65 miles to the south-southwest (Henderson, 1959), and near Lobstick Lake, about 65 miles to the southeast (Wynne-Edwards, 1960).

Climate, Vegetation, and Wild Life

Tanner (1944), Montgomery (1949), Hare (1959), Barry (1959), and Allington (1961) have discussed the climate of the region. The main features are the long, cold winters of the northern continental type, and the short cool summers with unstable weather conditions. The intervening spring and fall seasons are very short. In summer, conditions are highly variable, with rapidly shifting but constant winds, low overcast skies, numerous squalls and rainy periods of irregular duration, and interspersed periods of sunshine. The mean daily temperature for the map-areas is about 23 degrees Fahrenheit, the average high temperature, generally reached in early July, is about 85 degrees, and the average low, in January or February, −55 degrees. The average total precipitation, predominantly snow, is about 27 inches at Schefferville, spread over an average of 167 days. Frosts normally continue into June, resume in late August or early September, and may occur in the interim. Between 1955 and 1960, the average number of days with precipitation from June to September, at Schefferville was 75 (Shaw, 1962). As the normal length of the field season is about 100 days, beginning with breakup in mid-June, it can readily be appreciated that geological field work in the district is seriously hampered by the weather.

The map-areas lie within the forest–tundra vegetation zone (Hustich, 1949). The trees are mostly confined to low ground, where open stands, mainly of black spruce, with some tamarack, follow the valleys. Some of the upland lakes are similarly fringed with stunted spruce and tamarack. Balsam fir occurs sparsely. The most conspicuous form of vegetation, however, is the luxuriant growth of white lichens ('caribou moss') found at all elevations. Dense thickets of dwarf birch and other shrubs occur on many slopes immediately above tree line, and the banks of many streams are fringed with willow and alder. Various wildflowers are abundant.

Game animals are scarce and restricted to a small number of caribou, black bear, fox, muskrat, otter, rabbit, and red squirrel. Fish are only locally plentiful. Porcupines and chipmunks are fairly abundant, as, periodically, are lemmings. Spruce partridge and ptarmigan, in moderate numbers, are the chief game birds, although Canada geese and various ducks nest in the area and are locally numerous.

Chapter II

GENERAL GEOLOGY

Both map-areas are entirely underlain by Precambrian rocks of sedimentary, volcanic, and intrusive origin. All but those in the northeastern corner of Thompson Lake map-area are known to be Proterozoic deposits of the Labrador Trough.

The expression "Labrador Trough" has been criticized on the ground that it designates neither a topographical depression nor a structural syncline. Basically referring to the geosyncline in which the rocks concerned were deposited, the expression is widely used and well entrenched in the literature as a combined geographical–geological term designating the present established distribution of these geosynclinal rocks, and is so employed in this report. The alternative term "Labrador Geosyncline" has been favoured by some writers (Bergeron, 1957) to designate this Proterozoic belt. The belt as mapped to date does not define the actual geosyncline, however, as the northeastern limit of these Proterozoic rocks in western Labrador and northern Quebec is as yet not known, for the most part. The full extension of the geosyncline along strike to the south and southwest in central Quebec is also uncertain.

The rocks of the Trough form a belt known to extend for over 600 miles from near Dry Bay, on the west shore of Ungava Bay at latitude 60°30′, southeastward through northern Quebec and western Labrador and thence southwestward into central Quebec (Fig. 1), where they have been traced into the Grenville Province for over 200 miles (Stockwell, 1963). The geosyncline itself may have extended much farther southwestward but has been masked by metamorphism and intense deformation. The western basal margin of this great Proterozoic belt is clearly marked over most of its length by a major unconformity, but a corresponding demarcation has not been defined on the opposite side, except at and near the northern end (Auger, 1954; Bergeron, 1957; Beall and Sauve, 1960), and possibly in relatively small areas northeast of Lac Romanet about 50 miles northwest of the map-areas (Morgan, 1963), and near Wade Lake, a similar distance to the southeast (Wynne-Edwards, 1960). Elsewhere, the northeast boundary of the geosynclinal rocks is obscured by metamorphism and faulting.

At the latitude of the map-areas in the central part of the Trough, Proterozoic strata have been traced continuously northeastward across the strike, for about 60 miles, as far as the northeast corner of Thompson Lake map-area. There and in adjacent areas they are in fault contact with the Laporte Group, a metamorphic assemblage contrasting sharply with the strata to the southwest. In this district, *Table of Formations*

Era	Supergroup	Group	Formation and Thickness (feet)	Lithology and Remarks
Proterozoic	Kaniapiskau	Montagnais	Retty Peridotite	Serpentinized peridotite and tremolite–actinolite rock, intruding Willbob and Thompson Lake Formations
			Wakuach Gabbro	Glomeroporphyritic gabbro, porphyritic gabbro; sills invading Knob Lake Group; 'normal', medium- to coarse-grained gabbro, in part porphyritic, sills and multiple sills in Knob Lake Group; meta-gabbro, meta-diorite, in minor part gradational with ultrabasic rocks, probably in part extrusive; sills in Doublet Group
		Intrusive Contact		
		Doublet	Willbob 15,000 + (?)	Meta-basalt, basalt, flow breccia, pyroclastic breccia, and tuff; minor sedimentary intercalations
			Thompson Lake 2,000 (?)	Quartzite, argillite, greywacke, slate; minor basic flows and conglomerate
			Murdoch	Agglomerate, volcanic breccia and tuff; minor sedimentary beds and massive basic flows
		Fault Contact		
		Knob Lake	Menihek 2,000 +	Shale, argillite slate, greywacke, chert, and quartzite; intercalated volcanic breccia and flows
			Sokoman 250 (?)	Jaspilite, shale
			Wishart	Quartzite, shale
			Denault 2,000 + (?)	Siliceous dolomite, dolomite breccia
			Attikamagen	Shale, argillite
Proterozoic (?)		Laporte		Biotite schist in part garnetiferous; graphitic schist; stratigraphic position uncertain.

therefore, it has been customary to consider this contact as the northeastern limit of the Trough rocks. From its maximum width there, the Trough tapers in either direction, especially toward the northwest end, where it is only 10 miles wide.

The Labrador Trough can be longitudinally divided over much of its length into two fairly distinct lithological belts: a southwestern zone of almost exclusively sedimentary rocks, and a broader northeastern zone dominated by basic igneous rocks. The sedimentary zone lies on a group of basement gneisses and intrusive rocks termed the Ashuanipi Group. Near the boundary at least, the latter comprises, for the most part, extensively deformed and metamorphosed paragneiss, intruded by granite, gabbro, and anorthosite (Labrador Mining and Exploration Company, private reports). Age determinations from micas of the rocks of this group with few exceptions yield minimum ages for the rock of from 2,350 to 2,500 million years (Stockwell, 1961, 1963a, 1963b; Beall and Sauve, 1960). As mentioned, the relationship with the overlying Proterozoic strata is that of a major unconformity (Harrison, 1952) disturbed only by relatively minor cross-faulting (Frarey, 1961).

Since the first systematic investigations, the Trough rocks of the sedimentary and basic igneous zones have been subdivided into series, groups, and formations, subject to modification as new work was done. To conform to approved practices of stratigraphic nomenclature, the various sedimentary and volcanic units recognizable within the Trough sequence have been included under the comparatively new rock-stratigraphic term "Kaniapiskau Supergroup" (Frarey and Duffell, 1964), which supersedes the former terms "Kaniapiskau Group" and "Kaniapiskau System". A supergroup has been defined by the American Commission of Stratigraphic Nomenclature (1961) as "a formal assemblage of related groups or of formations and groups" not separated by a major unconformity; associated intrusive rocks are excluded.

At the latitude of the map-areas, the assemblage forming the Kaniapiskau Supergroup had already been divided by Survey geologists into subordinate groups, following for the most part the usage of the Labrador Mining and Exploration Company (Frarey, 1952; Harrison, 1952). In order of occurrence and succession northeastward from the basal unconformity of the Trough, these were the Knob Lake, Howse, Murdoch, and Doublet Groups. The Laporte Group, adjoining the Doublet Group in turn, may also be part of the Proterozoic sequence (Fahrig, 1957) and of the Supergroup, but its relationship has not definitely been established. Of the groups listed, only the Knob Lake Group was subdivided into formal units in preliminary Survey reports. Subsequent revisions of the stratigraphic nomenclature proposed by Frarey and Duffell (1964) are followed here, with the result that the Howse Group has been eliminated, and the Murdoch Group has been relegated to formational rank and included in the Doublet Group, which is further subdivided.

Contrary to previous ideas of the depositional and tectonic histories of the Labrador geosyncline (Gastil *et al.*, 1960), Survey investigators to date have recognized no angular or other major unconformity indicative of an orogenic episode during the period of deposition of Kaniapiskau rocks. No satisfactory evidence of such an interval was observed in these map-areas. However, considerable evidence exists in the sedimentary formations to indicate a number of erosional unconformities of appreciable extent and duration.

The Knob Lake Group, in the type district near Schefferville, consists of seven sedimentary formations including shale (or slate), dolomite, chert breccia, quartzite, and iron-formation (Harrison, 1952). This group, variable in that some of these formations may be absent in places, and that additional units, including volcanic strata, may occur, forms a belt up to 40 miles wide that underlies much of the Labrador Trough south of latitude 56°. The sedimentary formations occupy the whole of the 'main ore zone', an area some 60 miles long and up to 12 miles wide that includes the more than forty commercial deposits of direct-shipping iron ore of the Knob Lake Range. A representative stratigraphic and structural section was studied in detail by Harrison (1952) and Howell (1954), who mapped on the scale of 1 inch to 500 feet, a transverse strip 2 to 3 miles wide and about 12 miles long, passing through Schefferville. The component formations of the group were found to thicken northeastward to a maximum total estimated by Harrison at about 3,900 feet. Other estimates of the maximum thickness of this group are 4,500 feet by Dufresne (1952), who studied a larger area extending farther northwestward, and 5,000 to 6,000 feet by Choubersky (1957), for the ore zone generally. The geology of the group, particularly the origin of the contained iron deposits, has also been described by Stubbins, Blais, and Zajac (1961).

As originally described (Harrison, 1952; Frarey, 1952), the Knob Lake Group at this latitude extended northeastward across the Trough for about 30 miles to Attikamagen Lake, in the southwest corner of Willbob Lake map-area, where it was bounded by intrusive rocks and succeeded by the Howse Group. In this report, however, the Knob Lake Group, following the previous reorganization (Frarey and Duffell, 1964), includes the strata of the former Howse Group, i.e., those occurring in a zone about 7 miles wide, composed mostly of gabbro sills, between Limestone Bay of Attikamagen Lake and the Walsh Lake fault. In this reorganization, the jaspilite iron-formation of the former Howse Group is correlated with the Sokoman Formation of the Knob Lake Group, the strata beneath it with the Wishart and Denault Formations, and those above it with the Menihek Formation. Thus, the Knob Lake Group here is extended another 7 miles northeastward, and the Howse Group is dropped as a stratigraphic unit.

In the type area, the Knob Lake Group lacks volcanic components and is almost devoid of intrusions. It has been intensely folded and faulted, except for a narrow fringe marginal to the basement. Narrow folds overturned to the southwest and sliced by closely spaced thrust faults are characteristic of the Knob Lake iron range, where the structural complexity is probably not matched in any other part of the Trough. Nevertheless, the degree of metamorphism remains low, primary structures are preserved, and synorogenic igneous rocks are absent. The group has been mildly affected by post-Cretaceous normal faulting (Stubbins *et al.*, 1961). Southeast and northeast of the type area, however, basic volcanic and intrusive rocks enter the section, and the extent of deformation decreases (Frarey, 1961). Within the map-areas described, the group contains volcanic rocks, and the gabbroic intrusions are profuse, obscuring the structure of the group to a considerable degree; metamorphism remains low.

The Doublet Group is a dominantly volcanic assemblage of regional importance, extending along the northeast side of the Trough for at least 110 miles. Underlying most of the report area, it consists of a lower dominantly pyroclastic unit, the Murdoch Formation, a middle sedimentary unit, the Thompson Lake Formation, and an upper assemblage of basic flows, the Willbob Formation. The two upper formations, in particular the Thompson Lake Formation, have been intruded by numerous gabbroic sills; ultrabasic sills also invade these two formations, notably near their contact. The Doublet Group and its associated sills have been folded into fairly gentle, upright to northeasterly inclined structures plunging moderately southeastward. It is bounded on either side by major faults, and is cut by numerous lesser faults and shear zones.

The Knob Lake and Doublet Groups of the Labrador Trough and their contained intrusions appear to be notably similar to the Povungnituk and Chukotat Groups, respectively, of the Cape Smith–Wakeham Bay Belt of northern Ungava (Bergeron, 1959; Beall, 1959), and may eventually prove to be correlative. The latter differ chiefly in their more extensive metamorphism, and, reportedly, by the presence of an angular unconformity between them (Bergeron, 1957b).

The Laporte rocks in the northeast corner of Thompson Lake map-area are an extension along strike from the Griffis Lake map-area, some 15 miles to the southeast, which includes the type area east of Lac Laporte. In Thompson Lake map-area, the Laporte Group is almost entirely composed of fine-grained biotitic sedimentary schists, and is evidently not invaded by intrusions. In Griffis Lake map-area, however, metamorphic equivalents of basic and ultrabasic igneous rocks were reported (Fahrig, 1957), and farther to the southeast, areas of amphibolite were mapped within the Laporte Group (Donaldson, 1959). The foliation and, presumably, the bedding are generally inclined at 30° or less. The trend of foliation varies from east to northwest. No folds could be defined, but a few small faults appear to cut the schists. The Laporte rocks are poorly exposed.

Except for the Laporte Group, the rocks of the map-areas show incipient to low-rank metamorphism. Greenschists are best developed in the incompetent Murdoch Formation. The Laporte strata of Thompson Lake map-area have been converted to metamorphic assemblages of medium grade, and also show cataclastic effects.

The Willbob Lake and Thompson Lake map-areas, in common with others along the northeastern flank of the Trough, are characterized by widespread sulphide mineralization. Among the more abundant and widely distributed occurrences of barren iron sulphides are a few concentrations of lead, zinc, and copper sulphides, but none of these has so far proved to be of workable size and grade. Iron sulphides are particularly persistent in black shales of the Menihek and Thompson Lake Formations, and a syngenetic origin has previously been assigned these deposits; however, the black shale deposits are closely related regionally to the Wakuach gabbro belt, which may be the primary control over mineralization.

Knob Lake Group

Attikamagen Formation

Distribution and Lithology

This formation is limited to the extreme southwest corner of Willbob Lake map-area, where a few outcrops and frost-heaved fragments are exposed on islands in Attikamagen Lake. A short distance south of the map-area, it is more extensively exposed on the shores of that and adjacent lakes (Frarey, 1961). It is widely distributed over most of the southwest half of the Trough at this latitude, where it forms the lowermost unit of the Knob Lake Group (Harrison, 1952).

The exposures in the southwest corner of Willbob Lake map-area consist of intercalations of thin, grey to black beds and laminae of shale and argillite. The rock is evenly bedded and fissile.

Structural Relations

Little information could be obtained on the stratigraphic and structural relationship of these isolated beds with other formations. They had tentatively been assigned to the Menihek Formation, which contains many similar beds (Frarey, 1952). The previous correlation depended in large part on the acceptance of the Howse Group northeast of Attikamagen Lake as a separate stratigraphic entity, younger than, and conformably overlying, the Knob Lake Group. Subsequent work, however, in Menihek Lakes map-area (Frarey, 1961), Ahr Lake map-area (Baragar, 1958), Marion Lake map-area (Donaldson, 1959), and Wakuach Lake map-area (Baragar, 1963), has indicated the equivalence of the Knob Lake and Howse Groups. The resultant correlation of the iron-formation of the former Howse Group, occurring just northeast of Attikamagen Lake, with the Sokoman Formation of the Knob Lake Group, is the primary factor in reassigning the argillaceous beds under discussion to the Attikamagen Formation, which also accords with their designation in contiguous areas (Frarey, 1961; Baragar, 1963).

Denault Formation

Distribution

The rocks assigned to the Denault Formation are on the northeast shore of Attikamagen Lake, Willbob Lake map-area, some three miles northeast of the Attikamagen beds discussed above, and separated from the latter by water and drift-covered tracts. The formation is possibly 2,000 feet thick there, but exposures are limited to a few localities.

Lithology

The exposures at Limestone Bay, Attikamagen Lake, and those about 2½ miles to the northwest, near the west edge of the map-area, consist of massive to thin-bedded siliceous dolomite grading into calcareous quartzite. Fresh surfaces of the rock are grey, but it weathers a distinctive buff colour, and is flecked with small quartz 'eyes', the abundance of which imparts a distinct grittiness to the rock. Numerous intersecting fractures result in a cover of small loose blocks on parts of the outcrops. The only other observed exposures of the formation are restricted to the shore of Attikamagen Lake, about half a mile west of the north tip of Limestone Bay, and consist of highly irregular breccia, composed of resistant, angular to rounded fragments of carbonate-rich quartzite, up to several inches long, cemented by a softer matrix of similar but less siliceous material. Irregular lenses of dark quartzite and black chert lie within the breccia, which is cut by numerous fractures filled with chert and quartz.

Under the microscope, the siliceous carbonate matrix of the breccia is seen to be composed, at least in part, of angular to subrounded quartz grains, with subordinate plagioclase and chert, together with larger, angular to subangular grains of carbonate which themselves contain numerous small chips of quartz. Thus, the matrix appears to be a type of calcarenite. Elsewhere, it consists of small quartz grains cemented by dolomite. The siliceous dolomite–quartzite outcrops, like the breccia, are composed essentially of mixtures of dolomite, quartz, and chert, but here the carbonate, in some places at least, constitutes less than 50 per cent of the rock. Plagioclase accounts for up to 10 per cent. Angular to rounded grains of clear, poorly sorted quartz and plagioclase are irregularly distributed in a matrix of carbonate, chlorite, and possibly chert. In places, a mosaic is formed by clusters of larger quartz grains and dolomite grains of evidently detrital origin. This quartz–dolomite rock may be classified as a calcarenaceous orthoquartzite (Pettijohn, 1957). The prominence here in the Denault Formation of detrital carbonate is in keeping with similar observations elsewhere (Harrison, 1952; Donaldson, 1960), indicating that over a broad area the formation is in large part the product of reworking of pre-existing beds.

Structural Relations

Because of the separation from one another by water and surficial deposits, the structural relation of the Denault beds to the underlying Attikamagen Formation cannot be observed in this area. It is assumed, however, that the two are gradational here as in other parts of the Labrador Trough (Harrison, 1952). The upper Denault contact is likewise not visible in this area.

Wishart Formation

Distribution and Thickness

The Wishart Formation, in the type iron ore district to the southwest, is a thin but persistent unit overlying various older formations of the Knob Lake Group. In the most complete sections, it is separated from the Denault Formation by the Fleming Formation, which has not been recognized in the map-areas described here. Rocks thought to represent the Wishart Formation in the map-areas are confined to a few scattered exposures adjacent to outcrops of the Denault Formation, in Willbob Lake map-area. They extend from the west boundary southeast to Limestone Bay, Attikamagen Lake. The thickness is roughly estimated as a few hundred feet.

Lithology

The observed outcrops consist of dark cherty shale, chert, and quartzite. At one locality, shale occurs in close proximity to the overlying iron-formation, and may constitute the top of the formation. Poorly exposed pale quartzite occurs along the inlet of Attikamagen Lake, near the west edge of Willbob Lake map-area, where it has been brecciated, altered, and cut by quartz stringers, so that its original nature is obscured.

The Wishart Formation in this map-area evidently contains a large proportion of shale, in contrast with its almost exclusively arenaceous character in the type area (Harrison, 1952). However, a general lithological change in the formation northeastward from the latter, resulting in a more mixed character has previously been noted (Frarey, 1961). Slate and greywacke, for example, are present in the formation on the southwest side of Attikamagen Lake (Labrador Mining and Exploration Company, private reports).

Structural Relations

No contacts with other formations were visible in the few exposures observed so that no direct evidence bearing on structural relations is available. The formation is assumed to be conformable with those above and below. According to Dufresne (1952) and Harrison (1952), the Wishart Formation in the main iron ore zone to the southwest overlies successively older formations without angular discordance, from Schefferville southwest to the margin of the Trough, its base evidently marking a distinct disconformity. The Wishart Formation has also been described near Marion Lake, about 25 miles southeast of Attikamagen Lake, where it is reported to contain angular detritus from older formations of the Knob Lake Group (Donaldson, 1960), suggesting the further possibility of a disconformity in this general part of the Trough. As indicated, however, no evidence concerning such a disconformity is available in the report area.

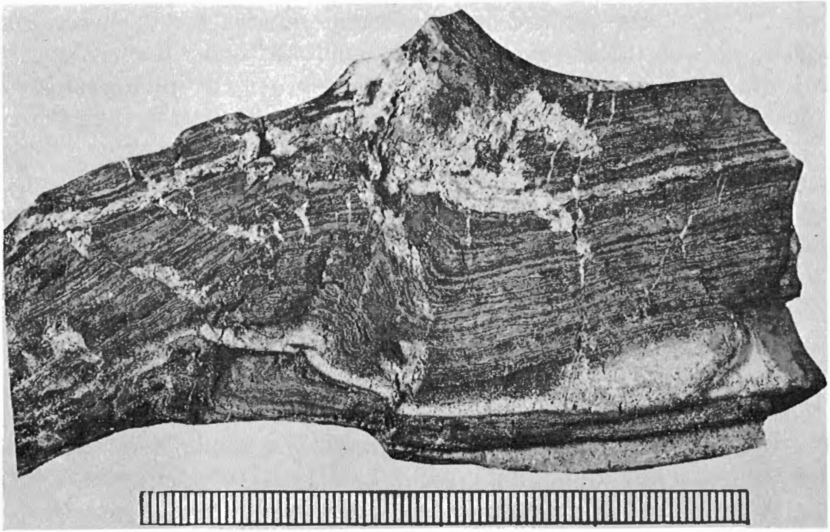

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PLATE III. Jaspilite of Sokoman Formation near Attikamagen Lake, Willbob Lake map-area, cut by quartz-filled gash fractures (millimetre scale).

Sokoman Formation

Distribution and Thickness

The Sokoman Formation outcrops in a narrow band parallel with, and just northeast of, the formations discussed above. Like the three preceding formations, it is poorly exposed. A rough estimate of the thickness is 250 feet.

Lithology

The outcrops consist of jaspilite and red shale. The former is a banded rock composed of thin layers of jasper, bluish hematite, and some white chert (Pl. III). This type of iron-formation is common in the main ore zone of the Knob Lake range, where it occupies a middle stratigraphic position in the formation (Harrison, 1952). Some of the red shale underlies jaspilite, and therefore might represent an equivalent of the Ruth Formation, which is an iron-rich slate consistently underlying the iron-formation in the Knob Lake iron range (Harrison, 1952).

Structural Relations and Correlation

The iron-formation and the adjacent Wishart beds appear to be inclined at the same attitude, and the two are considered to be conformable and in normal stratigraphic order. As mentioned previously, the correlation of this iron-formation unit with the Sokoman Formation of the Knob Lake district is important, in that it permits the reassignment of adjacent strata to other units of the Knob Lake Group and the elimination of the Howse Group. Heretofore the Howse Group was retained in Willbob Lake map-area because the paucity of outcrops near Attikamagen Lake, and the ~~very extensive gabbro intrusions northeast of it throughout~~ the entire Howse belt, resulted in insufficient grounds for this reorganization. Subsequent work in the surrounding areas mentioned under the heading "Attikamagen Formation", however, together with the similarity in lithological succession, amply justifies, in the opinion of the writer, the revised classification (Frarey and Duffell, 1964) and correlation of the two groups. Differences in the succession near Attikamagen Lake from that of the type district for the Knob Lake Group (shale, dolomite, chert breccia, quartzite, slate, iron-formation, and shale, in ascending order) may be attributed to a modified depositional history, resulting from a different geosynclinal site and environment.

Menihek Formation

Distribution and Thickness

The Menihek Formation stretches over a broad area about 7 miles wide, extending from the Sokoman Formation to the Walsh Lake fault. It forms isolated northwest-trending sedimentary and volcanic bands, separated by sills or groups of sills of Wakuach gabbro up to 5,000 feet across. No reliable estimate of the thickness of the formation is possible. Along a section through the north end of Butt Lake, there is an apparent total thickness of about 4,000 feet, but this is almost certainly too great a figure because of unexposed intrusions, reversals in attitude, and overturning. A minimum thickness of 2,000 feet is postulated.

Lithology

The formation is a mixed assemblage, consisting of various sedimentary rocks and lesser amounts of volcanic rocks. Shale and argillite, and to a lesser extent, greywacke, account for 75 per cent or more of observed outcrops. Minor amounts of chert, cherty quartzite, and quartzite are also present. Volcanic intercalations, in part pyroclastic, are present from Howse Lake northeastward.

The shales of the formation include black, reddish black, brownish, greenish grey, and grey varieties, but by far the most common are black carbonaceous beds. These consist of thin layers up to two inches thick; in some places a marked fissility is shown, in others the rock is fairly compact and slightly indurated to form argillite. Weathered surfaces are buff to white. Black shale or argillite laminae are commonly replaced by sulphide minerals or silica, and in places such sulphide concentrations are of economic interest. Likewise, where the black shales have been fractured, veinlets of sulphides or cherty quartz have commonly formed. Grey shale is also prevalent in the formation.

Brownish, reddish, grey-green, and green shales are restricted to a few localities, occurring mostly as variegated series of thin beds, each up to a few inches thick. The best observed exposures of this type are in the valley of the outlet creek a mile southeast of Howse Lake.

Under the microscope, the black shale and argillite is seen, for the most part, to be a mass of semi-opaque, isotropic or submicroscopic material whose exact composition is obscure. In it are numerous blebs of quartz, apparently of secondary origin, and a few clastic quartz grains. Sericite and chlorite, in patches and individual flakes, are common, and lines of pyrite grains, in places accompanied by pyrrhotite, are abundant parallel with the bedding. Spherulitic growths were observed in brownish argillite.

The chert, cherty quartzite, and quartzite occur as interbeds with black shale and argillite. In outcrops, the chert and cherty quartzite are closely associated. The chert is well stratified and made up of grey and black layers up to a few inches thick. Bedding in the quartzite is likewise well defined and regular. Sporadic small-scale crossbedding provides the direction of tops of beds in some outcrops. Ripple-marks were also observed in a few places. The quartzite bedding planes are marked by chlorite and biotite, and, in the case of the finer grained varieties, the same minerals form numerous clusters within the beds, as well as filling many narrow fractures. The coarser grained quartzite is normally made up of beds one foot to several feet thick, and it is characterized by glassy quartz 'eyes' up to an eighth of an inch across, set in a matrix of dull white quartz.

Microscopically, the cherty quartzite is seen to be composed of strained quartz grains accompanied erratically by up to 15 per cent chert. The siliceous matrix contains chlorite, and, to a lesser extent, sericite and biotite. The chert

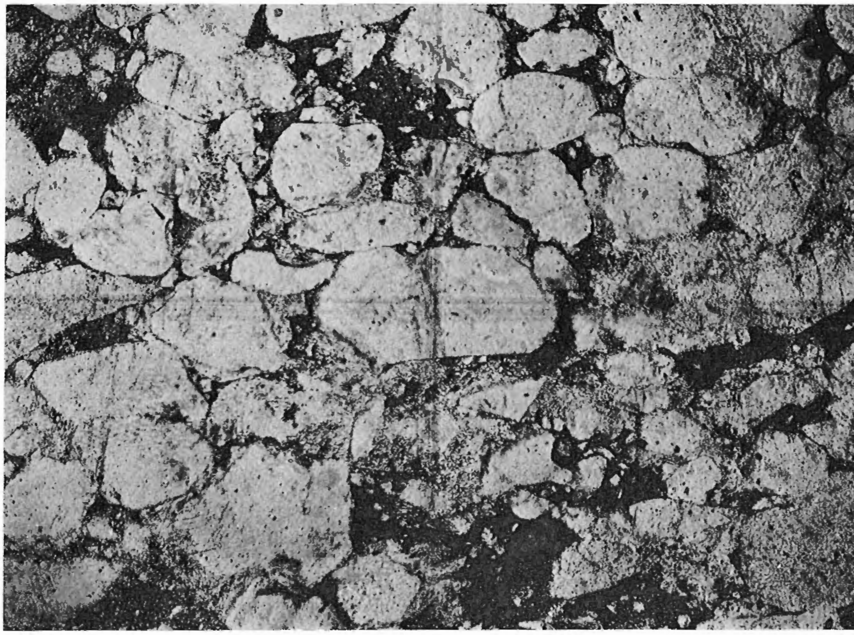

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PLATE IV. Photomicrograph of cherty quartzite, Menihek Formation, near Frederickson Lake, Willbob Lake map-area. Aligned, rounded to subangular grains of quartz and chert (dappled white and grey) in matrix of chert and chlorite. One nicol x 50 (Specimen F-67-50).

of some slides is clearly detrital, possibly indicating a second cycle of erosion (Pl. IV). In places, the quartzites show considerable recrystallization (Pl. V). A more argillaceous variety has an abundant sericitic matrix and a high chlorite content in the form of elongate clusters and streaks. The coarser grained quartzite lacks the chlorite, sericite, and chert of the finer members. Some sandstone is arkosic, containing as much as 30 per cent feldspar. Plagioclase, in variable amounts, and accessory zircon and pyrite are found in all the arenites of this group.

Extrusive rocks in this part of the former Howse Group were previously reported by Moss and Griffis (Labrador Mining and Exploration Company, private reports). Within the map-areas, these rocks appear to lie in two zones, one between Howse and Butt Lakes, the other just west of Walsh and Connolly Lakes. In the first zone, exposures on the shores of Howse Lake and a small lake northwest of Butt Lake consist of pyroclastic material intimately, although irregularly, mingled with greywacke and shale. Pyroclastic deposits and greywacke are intergradational, and small irregular beds of dark shale are interbedded with the volcanic breccia and greywacke. The breccia is composed of pebble-sized, grey volcanic fragments in a greenish chloritic matrix.

A thin section taken from the gradational material shows it to consist of rock fragments of volcanic origin (75 per cent), large clastic quartz grains (15 per cent), and a sparse matrix. Among the fragments can be recognized:

(a) pilotaxitic, highly feldspathic material, carrying blotches of chlorite and carbonate replacing feldspar; these are gradational to:
(b) fragments completely altered to carbonate and chlorite, with much leucoxene and only remnants of feldspars;
(c) fragments composed mainly of black isotropic amorphous dusty material (glass) in which are slivers and needles of plagioclase and patches of chlorite.

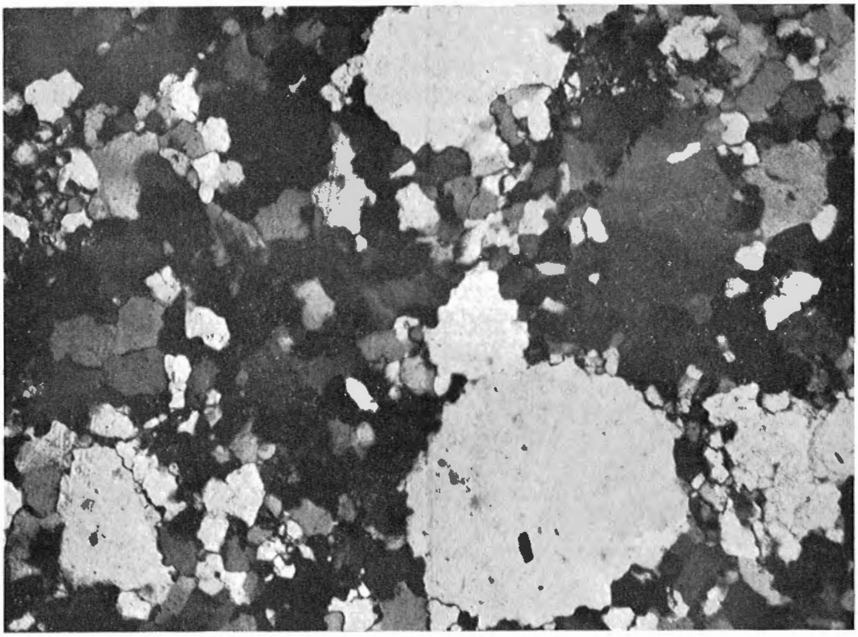

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PLATE V. Photomicrograph, Menihek quartzite, showing intergrown grain boundaries and poor sorting, near Lac Servais, Willbob Lake map-area. Crossed nicols x 80 (Specimen F-51-99-2).

Such mixed material may be entirely detrital, but if so, would be derived mainly from nearby deposits of volcanic breccia.

The main volcanic deposits near Walsh and Connolly Lakes consist of fine- to medium-grained, massive, non-porphyritic basaltic rocks. Weathered surfaces are cream to light brown, broken surfaces grey to black. In addition, basic amygdaloidal flow breccia occurs west of the outlet of Walsh Lake. Isolated exposures of fine-grained basic rock of possible volcanic origin occur between Lacs Philippe and Servais and the Walsh Lake fault, and extrusions at several horizons may exist in this area.

Microscopically, the coarser grained basalt is composed of a holocrystalline mass of subhedral laths and granules of augite, together with virtually interstitial calcic plagioclase. Minor clinozoisite and titanite appear, the former replacing plagioclase.

Structural Relations

The lower contact of the Menihek Formation was not observed, but the formation is assumed to be structurally conformable with the underlying Sokoman Formation. On the southwest side of the Trough, the Menihek overlaps several older formations, and may be separated from them by a disconformity (Dufresne, 1952; Harrison, 1952). In Willbob Lake map-area, although no evidence was seen within the Menihek to suggest a depositional break, jasper-bearing conglomerate in the succeeding Murdoch Formation at Walsh Lake strongly indicates erosion of the Sokoman iron-formation within the source area of the conglomerate. This probable erosion, the occurrence of jasper-bearing 'volcanic conglomerate', probably Menihek, near Point Lake, south of the map-area (Harrison, 1952; Frarey, 1961), and the apparent absence of the Sokoman Formation in Marion Lake map-area (Donaldson, 1959) suggest a pre-Menihek period of erosion in the eastern Labrador Trough at this general latitude.

The upper limit of the Menihek Formation is marked in these map-areas by the Walsh Lake fault, so that direct evidence regarding its stratigraphic relation with the adjacent Murdoch Formation is lacking. In the Ahr Lake map-area, however, about 15 miles beyond the northwest limit of the contact zone in Thompson Lake map-area, the two formations appear to be conformable (Baragar, 1958).

Doublet Group

Murdoch Formation

Name, Distribution, and Thickness

The Murdoch Formation, formerly the Murdoch Group, was so named as a result of early mapping of the unit near Murdoch Lake, about six miles west of the northwest corner of Thompson Lake map-area. Its known regional extent stretches from latitude 56°, about 50 miles northwest of Thompson Lake map-area, southeastward for 100 miles or more to Andre Lake, at about latitude 54°30′. Within the map-areas, the formation occupies a zone as much as two miles wide immediately northeast of the Walsh Lake lineament, diagonally crossing the Willbob Lake map-area and the southwest quarter of Thompson Lake map-area. Because of poor exposure and lack of structural data, no reliable estimate of the thickness can be made; it is probably at least 2,000 feet thick, and possibly as much as 5,000. For the same reasons, and because of lithological complexity, detailed study of the formation, particularly its internal stratigraphy, is practically impossible in the map-areas.

Lithology

The Murdoch Formation consists predominantly of basic pyroclastic rocks, together with minor basaltic flows and local sedimentary strata. Agglomerate and breccia are the dominant members of the pyroclastic assemblage, and consist of angular to rounded, light to dark grey fragments up to several inches across, in a fine-grained, dark matrix. The fragments commonly weather a lighter colour than does the matrix, but on fresh surfaces they are generally darker. In most exposures, the matrix is converted to well-foliated schist, and the agglomerate and breccia are strongly sheared. Clusters of biotite and rims of biotite about the fragments are prominent. The fragments are, in many instances, elongated and otherwise deformed. East of Connolly Lake and elsewhere, the breccia contains fragments that are small and well-rounded, so that it resembles conglomerate.

Tuff of the Murdoch Formation is well exemplified by outcrops of fine-grained, greenish grey, regularly laminated rock along the east side of Walsh Lake, particularly near the southeast end, and near the west side of Kalko Lake in Thompson Lake map-area. Most of the tuffs have been converted to well foliated, greenish, chloritic schist, commonly containing abundant magnetite.

Basaltic components of the formation are not common, but good exposures were mapped along and near Dobbin Lake, Willbob Lake map-area. They are fine to medium grained, and relatively massive, lacking both primary volcanic structures of any kind and secondary foliation.

A narrow fringe of sediments lying along part of the western boundary of the formation may constitute a thin basal member. Polymictic conglomerate exposed in a restricted area on the northeast side of Walsh Lake is composed of pebbles of quartzite, quartz, argillite, grey chert, jasper, and a few dioritic and felsitic fragments, closely packed in a quartzitic matrix. Just north of Walsh Lake along the creek are outcrops of argillite and badly weathered or sheared arkosic quartzite. In the same general area, highly carbonatized sediments have been described (Kavanagh, 1954). Exposures of the conglomerate and quartzite have also been reported along strike just south of the map-area (Labrador Mining and Exploration Company, private reports).

As mentioned earlier, attempts to map separately the various rocks of the formation were mostly unsuccessful, mainly because of lack of outcrops and distinctive horizon markers. In general, tuffaceous rocks appear to be most abundant in a zone along Walsh Lake and to the southeast, and possibly also near the top of the formation in Thompson Lake map-area. In detail, however, the components are closely interstratified, and probably are also discontinuous laterally.

The Murdoch volcanic rocks have been almost completely transformed into mineral assemblages of the greenschist facies. Tuffaceous schists consist of well oriented aggregates of actinolite, epidote, albite, chlorite, magnetite, and biotite. Coarser pyroclastic rocks are composed of plagioclase-rich fragments, some of which have a pilotaxitic texture, in a matrix of albite–epidote–biotite–chlorite schist.

Structural Relations

For reasons outlined above, the internal structure and stratigraphy of the Murdoch Formation are difficult to determine. From the limited evidence provided by the distribution of the formation, the attitudes of foliation, bedding in the tuffs, and rare occurrences of crossbedding, the formation appears to maintain the same general attitude as that shown by neighbouring formations of the Kaniapiskau Supergroup, i.e., a dominant northwest strike and moderately steep northeast dip.

The relationship of the Murdoch Formation with the Menihek Formation of the Knob Lake Group is, as indicated previously, obscured by the intervening fault in these map-areas, but the presence of the polymictic conglomerate at Walsh Lake suggests that the former is disconformably younger. That no major interval occurred, however, is indicated by the apparently local distribution of the conglomerate and the lack of included fragments definitely identified as foreign to the Trough. Aside from the occurrence in the Walsh Lake locality and the ones just south of Willbob Lake map-area mentioned previously, no such conglomerate is reported from neighbouring map-areas (Baragar, 1958; Donaldson, 1959). In fact, as pointed out above, the Murdoch not far northwest of the map-areas apparently lies on the Menihek Formation without any stratigraphic or structural interruption.

The upper contact of the Murdoch Formation was not observed because of lack of outcrops. General structural conformity and contemporaneous folding with overlying strata, however, is indicated by the distribution of the formations and the configuration of the competent gabbroic sill within the Murdoch Formation west of Kalko Lake, Thompson Lake map-area, which reflects the folding in the younger Doublet rocks east and south of that lake.

A pre-Menihek age for the Murdoch Formation and a correlation between the Menihek and post-Murdoch sediments of the Doublet Group have been postulated by Kavanagh (1954). There appears to be no definite evidence reported to date to support this interpretation, and indeed, Baragar's work (1958) north of the map-areas contradicts it.

Thompson Lake Formation

Name and Distribution

The dominantly sedimentary assemblage between the Murdoch Formation and a second volcanic unit above, has been termed the Thompson Lake Formation (Frarey and Duffell, 1964). These sediments and the overlying flows formerly constituted the Doublet Group. The name is derived from occurrences on and near Thompson Lake, one of several sizable lakes formed within this unit in the two map-areas. The formation extends the length of the map-areas and has also been described in other areas underlain by the Doublet Group (Baragar, 1958; Donaldson, 1959). It normally occupies relatively low ground, and in places only frost-heaved fragments are exposed. It is doubtful whether the maximum thickness exceeds 2,000 feet. Numerous gabbroic sills intrude the formation, and some of the smaller ones are grouped with the sediments on the map.

Lithology

The formation consists of beds of quartzite, shale, argillite, greywacke, siltstone, pebble-conglomerate, and basic flows. No regular stratigraphic succession was defined, but near Lac Marbrelle, and reportedly east of Lac Faute (Labrador Mining

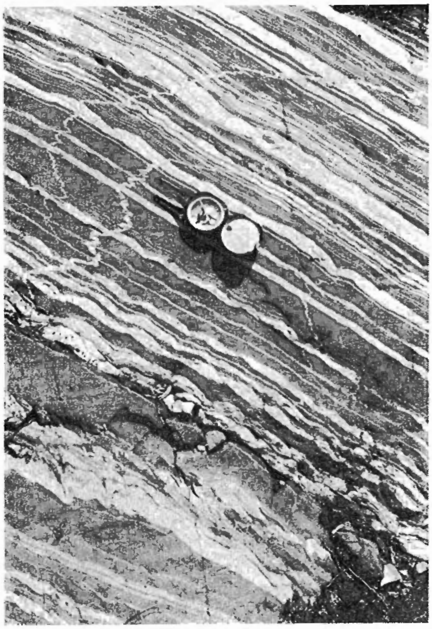

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PLATE VI
Outcrop of intercalated argillite and silty quartzite of Thompson Lake Formation. Southwest arm of Doublet Lake. Willbob Lake map-area. Note discontinuous fractures oblique to bedding and transcurrent quartz stringers with crenulations following bedding plane cleavage.

and Exploration Company, private report), Willbob Lake map-area, pebble-conglomerate and quartzite form the base, and argillite beds commonly occur at the top. Argillite or shale, quartzite, and greywacke commonly occur in close association. East of Lac Marbrelle and south of the west arm of Doublet Lake, Willbob Lake map-area, argillite and silty quartzite form alternating sequences of layers less than 3 inches thick (Pl. VI). At the second locality, this assemblage overlies quartzose greywacke and massively bedded quartzite. The pebble-conglomerate northwest of Lac Marbrelle is composed of numerous, well-rounded quartzite pebbles in a sandy, friable matrix that is less resistant to weathering, resulting in a conspicuously knobby surface. The exposures are broken into large and small, white or pinkish white blocks, and are extensively carbonatized. Pinkish, carbonatized quartzite accompanies the conglomerate. Neither is visibly bedded. Beds of black argillite at or near the top of the Thompson Lake Formation are commonly replaced selectively by sulphide minerals; a number of such mineral occurrences have been prospected for base metals.

The volcanic component of the formation is most conspicuous in Thompson Lake map-area, where a persistent extrusive band, possibly up to 500 feet thick, occurs. Commonly well-pillowed, the flows closely resemble those of the overlying Willbob Formation. Some intrusive bodies in the formation shown as individual sills include basaltic layers that also may be extrusive.

The quartzite is sugary in texture, white weathering, and generally thick bedded. Locally it is crossbedded, more abundantly so where it is in alternating sequence with argillite. The pure quartzite grades into impure grey varieties and subgreywacke. Greywacke forms strata a few feet thick and is grey to black on weathered surfaces.

It too is interbedded with argillite and slate. These arenaceous rocks are characterized by the presence of dark, glassy 'eyes' or angular grains of quartz.

Under the microscope, the quartzite is seen to be composed largely (75–90 per cent) of poorly sorted quartz grains up to 2.5 mm across, separated by a sparse matrix of sericite, with some fine-grained quartz and minor chlorite and biotite; chert and carbonate may also be present. Most of the matrix is authigenic. Plagioclase is absent or a minor constituent in the slides examined. In places, recrystallization has produced a mosaic of quartz, and elsewhere the quartz grains are typically frayed as a result of encroachment by the matrix. The quartzite is shown in Plate VII.

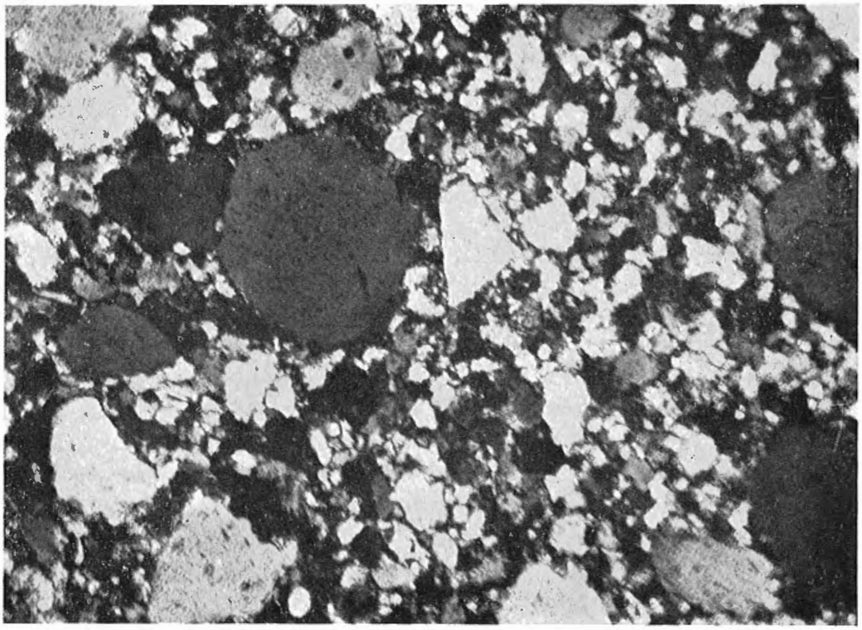

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PLATE VII. Photomicrograph of poorly sorted Thompson Lake quartzite, Doublet Lake, Willbob Lake map-area. Large, rounded to subangular quartz grains in partly intergrown matrix of angular quartz and plagioclase, minor chlorite. Crossed nicols x 50 (Specimen S-2-50).

In subgreywacke or low-rank greywacke, the matrix is more abundant, constituting up to 30 per cent of the rock. Plagioclase increases to 10 or 15 per cent, occurring chiefly in the matrix. Chlorite and biotite also appear in it (Pl. VIII). Greywacke contains much clay-sized material and many slate fragments, and the matrix accounts for more than 50 per cent of the rock. Feldspar is still subordinate to quartz in the coarse fraction, and the matrix is dominantly sericite, biotite, and chlorite, which replace the edges of the quartz grains.

The argillite–shale is composed of dense submicroscopic material, in which appear, locally, small grains of quartz or micaceous minerals.

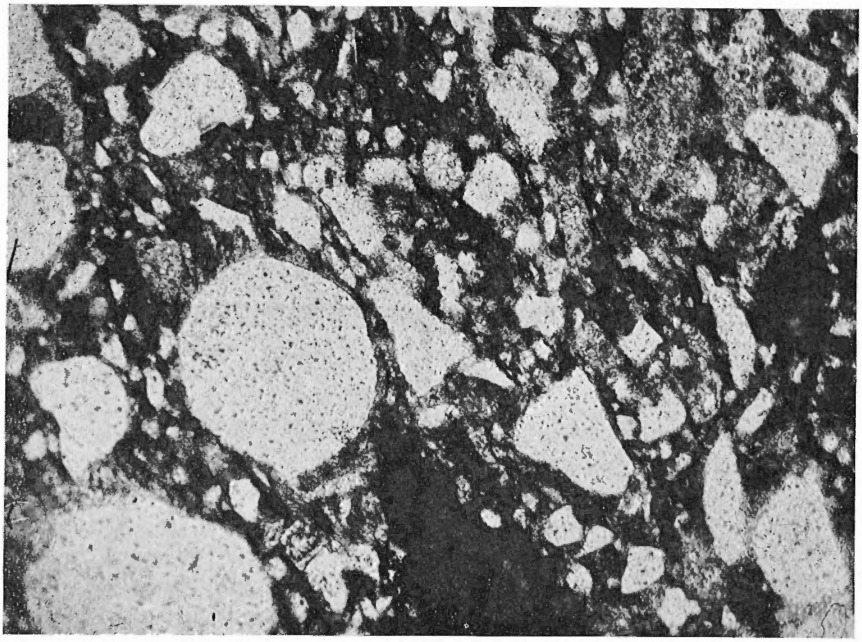

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PLATE VIII. Photomicrograph of subgreywacke, Thompson Lake Formation near Doublet Lake, Willbob Lake map-area. Rounded to angular, dusty quartz grains and slate fragments (black) in chloritic matrix. One nicol x 50 (Specimen F-50-50-2).

Structural Relations

As indicated previously, the poor exposure of the contact zone between the Thompson Lake and Murdoch Formations prevents direct observation of the contact relations. However, the lowest Thompson Lake strata are generally parallel with the nearest foliation (and possibly bedding) in the underlying unit. Southwest of Kalko Lake in Thompson Lake map-area, conformity of the two formations is indicated by similar attitudes of stratification and by the trend and dip of the nearest meta-gabbro sill in the Murdoch Formation. From this and owing to lack of evidence to the contrary, the formations are believed to be structurally conformable.

Willbob Formation

Name, Distribution, and Thickness

This unit comprises the upper volcanic part of the Doublet Group. Formerly known, in general, as the 'Doublet volcanics', these strata required a new formal name when the present classification was adopted (Frarey and Duffell, 1964) to avoid duplication of the term 'Doublet'. While a name of more regional significance would be preferable, the present designation seems suitable because of the wide distribution of these rocks near Willbob Lake and in Willbob Lake map-area.

The Willbob Formation is the thickest and most widely distributed formation in the eastern part of the Trough at the latitude of the map-areas. It is known to extend more than 100 miles, from latitude 56° southeastward to Andre Lake at about 54°30′. Within the map-areas, the formation occupies a belt up to 12 miles wide, forming most of the east half of Willbob Lake map-area and the northeast half of Thompson Lake map-area. Based on a limited number of attitude determinations, and neglecting possible effects of faulting, 15,000 feet or more of these strata appears to be exposed in Thompson Lake map-area north of Thompson Lake. As the top of the formation is not exposed, the original thickness may have considerably exceeded that figure.

Lithology

The formation consists mainly of an assemblage of pillowed and massive basic flows, accompanied by tuff and flow breccia bands and a few thin argillite interlayers. Continuously pillowed sections hundreds of feet thick were observed. The volcanic members are all of basic composition, but variations in colour from pale grey to black may reflect, in some at least, small chemical changes. Basic sills similar to coarser phases of the flows intrude the formation; medium- to coarse-grained basaltic rock of undetermined origin was mostly mapped with the flows.

Pillow lava is dominant throughout the formation. These flows are light grey, green, or buff on weathered surfaces, and grey to black on fresh surfaces. They are normally aphanitic to fine grained, in places grading to medium grained. Subporphyritic to porphyritic flows are common, and have a typically blotchy appearance, due to the clustering of cream-coloured feldspar into scattered irregular aggregates. Only in restricted areas were the porphyritic lavas mapped separately. The pillow structure of all these flows is well formed and strikingly displayed in many individual layers, which are as much as several hundred feet thick southeast of Retty Lake and north of Willbob Lake. Measurement of the attitude of pillows clearly delineates the structure in this part of the area. Individual pillows of all types, but generally bun-shaped, range from a few inches to 25 feet in length, and are separated by chloritic rims, commonly about an inch thick. Ovoid cavities occur in the upper central area of numerous pillows, oriented parallel with them. These and the cusps between pillows are in many cases filled or partly filled with quartz. These dense, fine-grained flows are the most erosion-resistant rocks in the map-areas, and as a result form the highest and most persistent ridges.

Thin pyroclastic bands, including tuff and coarse to fine breccia of ejection origin, are intercalated with the other volcanic strata. They are commonly only 25 to 50 feet thick and limited in lateral extent, lensing out within a few hundred feet. In contrast with them is a band up to 500 feet thick, mostly breccia, in the northeastern corner of Willbob Lake map-area. This mapped band has been followed for several miles; it passes about two miles south of the most southerly tip of Retty Lake, where it is well layered and composed of fragments up to 8 inches across, some of which are vesicular or amygdaloidal. Along either shore of the same bay of Retty Lake, near the common boundary of the two map-areas, are scattered outcrops of a highly schistose fragmental rock thought to be of pyroclastic origin. It consists of rounded, pebble-sized fragments, highly chloritic, in a matrix dominantly composed of chlorite and biotite.

Bands of massive basaltic to gabbroic material are numerous throughout the volcanic assemblage. Some are almost entirely medium to coarse grained and are, in all probability, sills or lenticular intrusions associated temporally and genetically with the lavas. Other finer grained structureless masses of considerable extent, however, are taken to be extrusive, and are included in the Willbob Formation. These basalt bodies are darker, in general, and relatively unaltered, in contrast with the more extensively altered pillow lavas. One body appears to form a stratigraphic marker around the major syncline southwest of Retty Lake and elsewhere. Similar relatively unaltered basalt in the formation has been reported from Griffis Lake map-area (Fahrig, 1951) and Marion Lake map-area (Donaldson, 1959).

Intercalated with the volcanic strata of the Willbob Formation are a few beds of black shale and argillite, probably nowhere exceeding 150 feet. In many places the bands are replaced in part by sulphide minerals, notably pyrite, marcasite, and pyrrhotite.

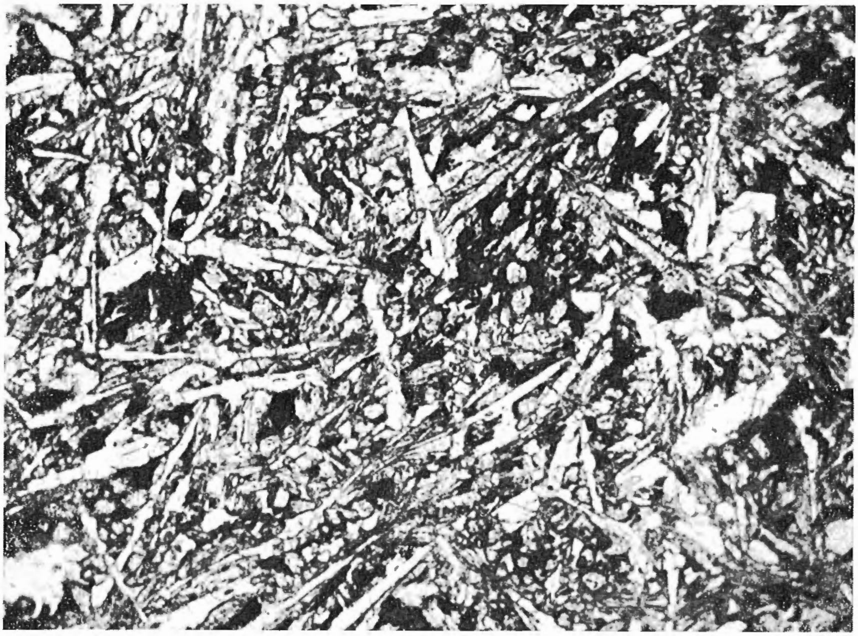

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PLATE IX. Photomicrograph of fresh holocrystalline basalt, Willbob Formation, near Retty Lake, Willbob Lake map-area. Labradorite laths of random orientation, augite granules (grey), and chlorite. One nicol x 50 (Specimen F-144-50).

The Willbob flows present a varied appearance under the microscope. The groundmass of the aphanitic to fine-grained lava is a brownish mass difficult to resolve, containing euhedral, microlitic, plagioclase feldspar crystals, randomly oriented. The larger of these crystals proved to be mainly andesine, with some secondary albite. The porphyritic flows are characterized by clusters of plagioclase highly altered to clinozoisite. Massive, dark, fresh basalt comprises a mat of long slender feldspar laths with interstitial, granular pale augite, derived amphibole and chlorite, and iron oxide (Pl. IX). The plagioclase is mostly labradorite (An_{60}), and constitutes about 30 per cent of the rock. Much of it is dusty and nearly opaque, though retaining its euhedral habit. Secondary plagioclase is sodic oligoclase (Ab_{88}). Ilmenite–leucoxene, sphene, and iron sulphide are accessory minerals.

The breccia fragments are composed mainly of a mass of dense, semi-opaque material, although in one slide, they are seen to consist of a felt of actinolite blades intergrown with pyroxene grains. The groundmass varies from one specimen to another, but pyroxene is usually present, as are small scattered laths of plagioclase. In some instances, layers of chlorite surround the fragments, and chlorite veinlets cut and irregularly replace the matrix.

Classification

Table I lists the chemical composition of a composite sample of meta-basalt and samples of a porphyritic meta-basalt from the Willbob Lake Formation in the neighbouring Griffis Lake map-area (Fahrig, 1953). Shown also are average compositions for tholeiitic basalt, alkaline olivine basalt, high-alumina basalt, and calc-alkaline basalt, the chief basaltic magma types recognized by various authors.

Table I

Chemical Composition of Willbob Lake Meta-basalts, and of Tholeiitic Alkaline, Calc-alkaline, and High-alumina Basalt Types (recalculated to 100 per cent, water free)

	I	II	III	IV	V	VI
SiO_2	51.8	48.3	51.6	46.9	48.10	54.0
TiO_2	0.6	0.9	1.6	2.8	0.89	0.9
Al_2O_3	15.7	18.7	14.5	15.3	18.22	18.1
Fe_2O_3	2.5	3.7	2.1	4.3	1.04	2.5
FeO	10.0	7.9	9.9	8.3	8.31	5.8
MnO	0.4	0.1	0.1	0.2	0.17	0.1
MgO	6.6	6.4	6.5	7.3	8.96	5.5
CaO	10.0	11.6	10.1	9.8	11.30	8.4
Na_2O	1.8	1.7	2.5	3.2	2.80	3.4
K_2O	0.4	0.5	0.7	1.3	0.14	1.1
P_2O_5	0.2	0.2	0.2	0.4	0.07	0.2

I. Composite sample Willbob Lake meta-basalt. Analyst R. J. C. Fabry, Geol. Surv. Can.
II. Porphyritic Willbob Lake meta-basalt. Analyst, R. J. C. Fabry, Geol. Surv. Can.
III. Tholeiitic basalt type; average of 12 published analyses (Turner and Verhoogen, 1960; Nockolds and Allen, 1956 *in* Baragar, 1960).
IV. Alkaline olivine basalts; average of 16 published average analyses (Turner and Verhoogen, 1960; Nockolds and Allen, 1954 *in* Baragar, 1960).
V. High-alumina basalts (*after* Yoder and Tilley, 1957, *in* Baragar, 1960).
VI. Calc-alkaline basalts (*after* Nockolds and Allen, 1953, *in* Baragar, 1960).

Table II

Partial Analyses of Some Flows of the Willbob Formation

SiO_2	52.0	55.4	52.5	49.9	49.4	50.2
Al_2O_3	13.3	13.0	13.7	15.2	13.1	14.4

Analyst R. Beaulne, Geol. Surv. Can.

Considering all the gabbroic and basaltic rocks of this part of the Labrador Trough to have formed from a single magma series, Baragar (1960) concluded, from their chemical characteristics, that the Trough rocks represent a tholeiitic magma. The composite meta-basalt analysis listed in Table I shows a general agreement with the average tholeiite listed for comparison. The porphyritic meta-basalt, however, is in some respects similar to the high alumina type of Yoder and Tilley (1957 *in* Baragar, 1960). It will be noted that both of the Labrador Trough samples in Table I are appreciably lower in soda and potash than all the recognized 'parental' types. The water content of the two samples is not shown in the table, but it totalled 3.52 and 2.42 per cent for the composite and porphyritic samples, respectively. The Willbob lavas are not considered to represent the parental magma of the basaltic suite.

That the lavas of the Willbob Formation have an appreciable range in acidity is indicated in Table II, which lists partial analyses of more leucocratic flows from various localities, and suggests that some of these approach the andesite class in SiO_2 content. In this connection, significant amounts of andesitic volcanic rocks are said to occur in the Doublet Group about 30 miles northwest of Thompson Lake map-area (Findlay, 1958, pp. 25, 28).

Further, it is noteworthy that, with respect to minor elements, Baragar's results (1960) show these Labrador Trough basaltic rocks, at 83 p.p.m., to be the lowest, in average strontium content, of all known basaltic provinces (Turekian, 1963). Baragar's analyses also show the rocks to be notably low in rubidium and barium.

The rocks under discussion are also of interest in providing a prominent example of a non-spilitic, basaltic geosynclinal suite in the Canadian Shield.

Structural Relations

The lower strata of the Willbob Formation are conformable with those of the underlying Thompson Lake Formation; its top has nowhere been defined. In Thompson Lake map-area, the northeastern boundary of the Willbob Formation, apparently also its uppermost limit, is marked by the Elsie Lake fault, beyond which are the metamorphic sedimentary rocks of the Laporte Group, of uncertain age relative to this formation.

Laporte Group

Name and Distribution

The term "Laporte Series" was applied by early geologists (Labrador Mining and Exploration Company, private reports) to metamorphic–sedimentary rocks near Lac Laporte, Griffis Lake map-area (Fahrig, 1952, 1964) about 15 miles east of Doublet Lake, Willbob Lake map-area. There, biotite-rich paragneiss and schist of the Laporte Group abruptly appear in fault contact with basic volcanic flows of the Willbob Lake Formation, Doublet Group, on the west. Subsequently, hornblendic gneisses of possible igneous origin were included in the group in that area (Fahrig, 1964).

The metasediments and the fault boundary with the Doublet Group have been mapped southward from the type area for some 30 miles, beyond which the fault has not been traced and the paragneisses not distinguished from similar rocks farther west that form the pre-Kaniapiskau basement (Wynne-Edwards, 1960).

The Laporte rocks of the report area occupy a belt some 5 miles wide in the northeast corner, separated along strike from their northern limit in Griffis Lake map-area by about 15 miles of unmapped ground. They continue northwest and northeast for an undetermined distance.

Lithology

This group consists almost entirely of light to dark grey, fine-grained metasediments. The foliation is typically well developed, but here and there bedding has been preserved to varying degrees. Subordinate black slate and argillite beds are interbedded with the grey layers, and, in places, notably along the fault boundary with the Willbob Formation, abundant graphite with or without pyrite has formed in these. Occasional chloritic layers occur, but for the most part the gneiss and schist consist essentially of feldspar, quartz, and biotite. In the extreme northeast corner of the area mapped, small garnets appear in some outcrops. Very little admixed quartzo-feldspathic material accompanies these foliated rocks, although some layers are separated or cut obliquely by thin, fine-grained, quartz-rich seams, pods, or irregular lenses, less than an inch across; a few such pods carry abundant hornblende crystals up to 5 mm long. No intrusive rocks were seen to cut the group.

From microscopic examination, the rocks appear to consist of between 50 and 75 per cent combined quartz and plagioclase, with the remainder composed of biotite, chlorite, and accessory epidote, apatite, and ilmenite. In less foliated specimens, equidimensional porphyroblastic biotite lies in a rudely aligned mosaic of plagioclase and quartz, and, in schistose types, elongate biotite is arranged in layers in the foliated matrix. Some of the porphyroblasts are oriented across the foliation. The biotite contains numerous pleochroic haloes. Oriented inclusions of quartz and biotite are present in some of the larger plates of ilmenite. Biotite, possibly of a second generation, may form blade-like porphyroblasts, up to 3 mm long, superimposed on smaller flakes. Chlorite is not abundant, but commonly forms larger and evidently younger flakes than the biotite, trending across the length of the latter. Strain shadows, heavy fracturing, mortar structure, and mylonitic areas of quartz and plagioclase show that these minerals underwent a cataclastic stage. Some of the biotite, at least, probably formed subsequent to this. Plagioclase in the schist, whose composition is oligoclase (An_{20}), is commonly elongated normal to the 010 twinning.

Structural Relations

As in the type area, the Laporte Group is separated from the Willbob Formation of the Doublet Group by a well-marked fault, here termed the Elsie Lake fault. The relationship is most apparent at the southeast end of Elsie Lake, Thompson Lake map-area, where a shallow linear depression a couple of hundred feet wide lies between exposures of metasedimentary biotite and graphite schists and chloritic, schistose Willbob basalt. Elsewhere, a broader drift-covered zone intervenes between the two units, although the position of the fault can be followed on aerial photographs. Because of this fault, no evidence regarding the age relationship of the two groups is available from their contact zone.

Correlation, Origin, and Age

In the early years of mapping and exploration, it was thought likely that the fault between the Laporte and Doublet rocks was a major tectonic feature along which the pre-Kaniapiskau Laporte rocks had been thrust against rocks of the geosyncline. Later, as mapping progressed to other parts of the Trough, it became apparent that, throughout most of its length, the geosynclinal rocks pass eastwards into metamorphic rocks of uncertain age and relationship; the eastern basement rocks were recognized only at the extreme northern end (Bergeron, 1957) and along restricted parts of the boundary farther south (Beall and Sauve, 1960; Morgan, 1963; Wynne-Edwards, 1960). Known geosynclinal rocks over considerable areas in the northern and southern parts of the Trough have been converted to schists and gneisses, and the suggestion has been made that the adjoining rocks of dubious age, including the Laporte Group, are also metamorphosed Trough rocks (Fahrig, 1957). The eastern limit of recognized or postulated areas of such metamorphosed Trough strata is presumably obscured by increasingly intense metamorphism, and has nowhere been defined.

In Thompson Lake map-area, while it is clear from their lithology, remnant structures, and texture that the Laporte rocks were derived from pelitic beds such as occur in the Kaniapiskau Supergroup, no direct connection with the latter can be established because of the intervening fault and the lack of distinctive identifying markers. However, the relatively low grade of metamorphism, with attendant incomplete preservation of primary features, in contrast with known higher grade Archaean basement rocks flanking the Trough, and the presence of carbonaceous intercalations in the Laporte assemblage support the suggested Proterozoic age for these foliates. However, actual correlation with strata of the Doublet or Knob Lake Groups to the west is difficult. The Laporte Group of Thompson Lake map-area is exclusively metasedimentary, although subordinate amounts of hornblendic rocks classed as basic igneous derivatives have been mapped in the Laporte Group of Griffis Lake map-area to the southeast (Fahrig, 1964) and in the schists of Wakuach Lake map-area to the northwest (Baragar, 1963). Although it may contain some flows elsewhere, the group appears to consist dominantly of a thick sequence of pelitic sediments. The Thompson Lake Formation, suggested as a possible correlative to the Laporte Group (Gastil *et al.*, 1960), is probably much thinner, and contains persistent and well-defined intercalations of basalt, meta-gabbro, and quartzite that should remain evident through moderate metamorphism. No metamorphosed equivalents of iron-formation or dolomite have been reported from the Laporte Group, thus apparently restricting possible correlatives in the Knob Lake Group to the Menihek and Attikamagen Formations. As the Menihek of Willbob Lake map-area contains basic flows, greywacke, and quartzite, as well as the prevalent black shale or slate, and farther west is composed dominantly of the latter, its correlation with the Laporte rocks is dubious. The Attikamagen Formation typically carries numerous carbonate interbeds and lenses (Harrison, 1952) and in the medial part of the Trough has a prominent basic volcanic component (Baragar, 1963).

The possibility remains that the metasediments of the Laporte Group are not direct equivalents of any of the units established to the west, but were deposited independently either in pre-Doublet or post-Doublet time. A stratigraphic position above the Doublet Group would conform to the general structural pattern of most of the Labrador Trough, which, as pointed out previously (Auger, 1954), has an overall eastward-facing monoclinal aspect, modified by folding and faulting, but in general presenting successively younger groups and formations eastward. A post-Doublet (or post-volcanic), metamorphosed, geosynclinal Proterozoic group along the east side of the Trough may explain relationships in some areas to the north where no fault can be recognized between known Kaniapiskau strata and schists and gneisses of uncertain origin.

A Proterozoic age for the Laporte Group obviates the assumption that its fault boundary represents a major thrust between eastern basement rocks and the geosynclinal blocks, and shifts any such boundary thrust farther east.

Intrusive Rocks (Montagnais Group)

In keeping with the original usage, the name Montagnais Group is applied to the profuse intrusions invading strata of the Kaniapiskau Supergroup in the central and eastern parts of the Labrador Trough (Frarey and Duffell, 1964). The intrusive rocks underlie a large proportion of this district (more than 50 per cent in Willbob Lake map-area) and together with related volcanic rocks they represent a major igneous assemblage.

Within the map-areas, the Montagnais Group ranges from quartz diorite to peridotite, but is predominantly gabbroic. All the gabbroic intrusions are believed to be consanguinous, although not necessarily contemporaneous, and all intrusions appear to be sheet-like or lenticular bodies essentially concordant with the invaded strata, as no post-orogenic dykes have been recognized. Ultrabasic rocks, except for a few thin bands associated with, and possibly differentiates of, gabbroic sills intruding the Menihek Formation, are confined to the Doublet Group, mostly within a restricted stratigraphic zone. Meta-gabbro likewise is confined to this group and favours the same zone. In contrast, relatively unaltered gabbro that has generally been referred to as 'normal' gabbro (Baragar, 1960), together with glomeroporphyritic, commonly anorthositic gabbro ('leopard rock') and various related phases, is restricted to the Knob Lake Group, southwest of the Walsh Lake fault.

Wakuach Gabbro

Name and Distribution

Sills of basic composition dominate the Montagnais intrusive belt in these map-areas, as is the case elsewhere. For this part of the Labrador Trough, they have been named the Wakuach Gabbro (Frarey and Duffell, 1964) from their extensive distribution over a broad area east and southeast of Wakuach Lake, a major topographic feature about 40 miles northwest of Schefferville (Baragar, 1963). A detailed petrological study of these basic intrusions in Ahr Lake map-area east of Wakuach Lake was previously presented (Baragar, 1960).

In the vicinity of the map-areas, the Wakuach Gabbro intrusions occupy a belt some 40 miles wide, covering more than half the breadth of the Labrador Trough from the northeastern limit southwestward. From regional maps (Gross, 1960) it appears that the belt has an overall minimum length of more than 350 miles, extending from the vicinity of Andre Lake in the southeast to Leaf Basin near Ungava Bay in the northwest. The belt narrows appreciably, as does the Trough, north of latitude 56°30′, and its southward termination near Andre Lake is abrupt (Wynne-Edwards, 1960). The Wakuach Gabbros and their presumed volcanic equivalents in the Knob Lake and Doublet Groups constitute an important regional igneous province.

The two map-areas cover most of the total width of the gabbro belt, and the three main types, normal gabbro, glomeroporphyritic gabbro (leopard rock), and meta-gabbro (Baragar, 1960) are all well represented. The latter is sharply delimited from the other two, geographically at least, in that it occurs only northeast of the Walsh Lake fault. There, the intrusions are fewer, readily recognizable individually, and appear to favour a particular stratigraphic zone. Normal gabbro and glomeroporphyritic gabbro bodies in Willbob Lake map-area, on the other hand, are profusely crowded together, occupying 80 per cent or more of the terrain between the Walsh Lake fault and Attikamagen Lake. The gabbroic rocks throughout the map-area typically form broad continuous ridges up to about 400 feet high, in considerable part covered with a thin mantle of till. The narrow intervening valleys are almost entirely covered with drift and linear lakes and ponds.

Meta-gabbro

Distribution and Occurrence

These rocks are restricted to the Doublet Group, and within it they appear to be concentrated in the sedimentary strata of the Thompson Lake Formation and the adjacent part of the Willbob Formation. In the northern part of Willbob Lake map-area and the southern part of Thompson Lake map-area, Kavanagh found about fifteen meta-gabbro layers in this zone, each separated by sedimentary and volcanic strata. Meta-gabbro bodies may be less abundant higher in the Willbob

Formation, but this impression could result from the fact that they are lenticular and less distinctive there because they resemble the adjacent volcanic rocks. In places, medium-grained gabbroic rock was seen to grade into fine-grained basaltic masses considered to be extrusive. Thus the origin of many of the gabbroic masses within the Willbob Formation is doubtful where contacts were not observed. However, there is little doubt that most meta-gabbro in the map-areas is intrusive, forming sills whose maximum thickness is of the order of one thousand feet and which can be traced individually for several miles or more.

Lithology

The meta-gabbro bodies are tough, mostly fine to medium grained rocks, weathering greenish grey and, less commonly, brown. With few exceptions the meta-gabbro sills are massive and homogeneous, and lack banding, layering, and foliation. While in general little vertical variation in composition was observed in these map-areas, in a few places a distinctly feldspar-poor basal zone a few feet thick is visible. More prominent examples of differentiation in the Ahr Lake map-area have been reported (Baragar, 1960). Sheet and columnar joints are commonly well developed (Plates X and XI). The rock can megascopically be seen to consist

M.J.F. 2-1-50

PLATE X

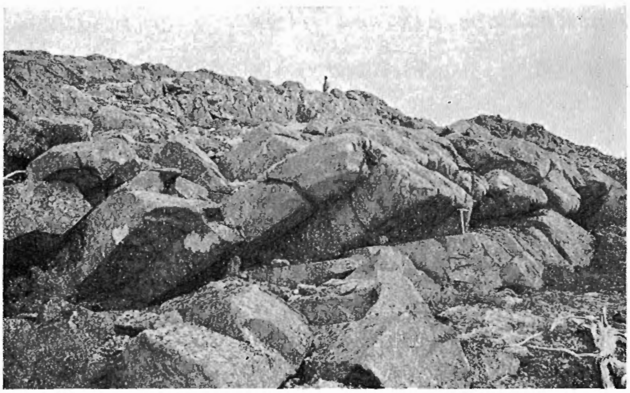
Well-developed sheet jointing in meta-gabbro near Retty Lake, Willbob Lake map-area.

dominantly of plagioclase and amphibole that typically present a speckled appearance. In places, the feldspars are large or clustered, and the rock is semi-porphyritic. Some sills, as for example those near the northeast shores of Lac Eracourcie and Willbob Lake, contain numerous prominent grains of bluish quartz. Small amounts of disseminated pyrite and pyrrhotite occur sporadically.

In Thompson Lake map-area, two distinctive, pale-weathering, mafic-spotted intrusions are present, one about 4 miles northeast of Thompson Lake and the other just north and west of Elsie Lake in the northeast corner of the map-area. These large sills may be related to leucometa-gabbro bodies at similar stratigraphic levels in Ahr Lake map-area about 10 miles to the northwest (Baragar, 1958, 1960).

In both map-areas, other sills differing in character occur in the Murdoch Formation. These are noteworthy in that they are wholly or partly more acidic in composition than common meta-gabbro, and have been referred to as meta-diorite.

In addition to more abundant feldspar and the presence of quartz, the megascopic contrast with common meta-gabbro is accentuated by the development of weak to strong gneissic structure produced during the deformation of the surrounding incompetent chloritic rocks, which also resulted in the contorted outlines of these sills. This deformation has in places also produced an aggregation of the amphibole into conspicuous dark patches, particularly in the intrusion near Walsh Lake, Willbob Lake map-area. This intrusion, according to Kavanagh (1954), is markedly acidic in its terminal offshoots or tongues. Prominent splotches and disseminations of pyrite and chalcopyrite were observed locally in these acidic phases of the meta-gabbro and in the schists nearby.



M.J.F. 2-4-50

PLATE XI

Imperfect columnar jointing in meta-gabbro, 2 miles south of Retty Lake, Willbob Lake map-area.

Under the microscope, the meta-gabbros vary in texture from ophitic to granulitic. The constituent minerals are amphibole (pale greenish to brownish actinolite, tremolite, or blue-green hornblende), altered or secondary plagioclase, and lesser amounts of chlorite, clinozoisite, sphene, epidote, ilmenite–magnetite, biotite, quartz, and apatite. The ophitic texture of the original rock may be preserved by large actinolite grains up to 7 mm across, presumably pseudomorphic after pyroxene, which enclose swarms of small dusty unidentifiable plagioclase laths. More commonly the texture is subophitic, consisting of stubby to elongate, shredded to fibrous blades of actinolite, commonly twinned on 100, and partly surrounding euhedral plagioclase. The latter varies from dusty, semi-opaque, non-recrystallized laths to fairly clear crystals of albite, and in some slides andesine. Much of the secondary plagioclase is also interstitial. The amphibole content is estimated to be as high as 65 per cent, but it may be extensively altered to chlorite. The meta-gabbro is characterized by accessory sphene, which may run as high as 10 per cent in extreme cases. It occurs as small grains, clusters, and, occasionally, large skeletal growths up to 7 mm across. Apatite and quartz are common minor components. One specimen from Lac Eracourcie carries considerable carbonate, possibly of post-metamorphic origin.

In those meta-gabbro sills in the Murdoch Formation and to a lesser extent elsewhere, some of the amphibole consists of blue-green hornblende; quartz is an important constituent, forming as much as 25 per cent of the rock, partly in micrographic intergrowths, according to Kavanagh (1954) who studied the intrusion near Walsh Lake. Kavanagh found the blue-green hornblende content to be proportional to that of secondary Fe–Ti oxide, appearing only where the latter exceeded 3 per cent. The formation of blue-green hornblende he attributed to the oxidation, during metamorphism, of iron of primary ilmenite and its entry into amphibole. The writer likewise found blue-green hornblende restricted to specimens high in sphene.

In the spotted leucometa-gabbro northeast of Thompson Lake, the light colour is evidently due to an abundance of pale secondary amphibole.

No evidence of primary olivine was observed in the meta-gabbro sections examined.

Structural Relations, Age, and Origin

The conformity of the meta-gabbro sills with invaded strata is readily apparent, particularly in the ground west and southwest of Thompson Lake, where intervening sedimentary layers, in some cases less than 200 feet thick, persist for many miles. Observable contacts are scarce, but a few chilled margins were seen at the upper and lower boundaries. The margins of the sill in the Murdoch Formation of Willbob Lake map-area parallel the adjacent schistosity; locally, these intrusions were seen to include blocks of Murdoch chlorite schist. This constitutes the only direct evidence of any transection of the neighbouring formations by these intrusions. The sheet and columnar joints are useful indicators of the attitudes of the intrusions and the invaded strata.

The meta-gabbro sills appear to be close affiliates of the associated extrusive rocks, and essentially contemporaneous with them. The age relationship with the ultrabasic sills (described in the following section), which also intrude the Thompson Lake and Willbob Formations, remains in some doubt. No sharp contact between the two was observed anywhere in the map-areas. As indicated below, a minor amount of basic gabbroic material may have originated by differentiation in place within or at the top of ultrabasic sills, as shown by apparently gradational contacts. If one accepts the essentially separate intrusion of meta-gabbro and peridotite, it appears feasible that the meta-gabbro represents the temporal and magmatic equivalent of the extrusive basaltic rocks, and that the ultrabasic intrusions were emplaced shortly thereafter, perhaps upon further subsidence of the geosyncline.

Normal Gabbro

Distribution and Occurrence

Normal gabbros, i.e., relatively unaltered intrusions of typical gabbroic composition and texture (Baragar, 1960), are distributed over an area about 25 miles long and 9 miles wide, almost entirely within Willbob Lake map-area. Bands apparently composed entirely of such gabbroic rocks extend up to a mile or more in width. These probably represent more than one intrusion, for although actual contacts could not be found, fine-grained basaltic material, probably representing chilled border zones, occurs at various intervals within some of them. In addition, the generally scattered nature of the exposures permits the presence of unexposed weathered contact zones or even interlayered sediments, which may be reflected by some of the numerous minor topographic depressions on the broad ridges. However, individual sills are thought to be as much as 1,000 feet thick and to persist laterally for indeterminate distances, probably several miles or more.

Lithology

The gabbro is characteristically medium to coarse grained, tough, massive, and brown weathering. Freshly-broken surfaces are grey or black, but more commonly are mottled, grey or white on black or greenish grey. Texturally, the rock may be porphyritic, ophitic, or equigranular, and it is unfoliated. Plagioclase, pyroxene, amphibole, ilmenite, and magnetite are recognizable in hand specimens. The mineral proportions vary considerably, so that leucocratic and melanocratic varieties occur. Some of the latter are distinctly magnetic, and others carry disseminated sulphides. Porphyritic and sub-porphyritic varieties are common, and result from the tendency of the plagioclase in these rocks to form irregularly distributed, greenish to cream coloured clots up to half an inch or more in diameter. Coarse to subpegmatitic material, characterized by long, curving ferromagnesian minerals, appears to form local patches grading into the surrounding gabbro. Gabbro pegmatite, other than 'leopard rock', which is described separately, was not observed.

The gabbroic rocks are cut by numerous short narrow veins of quartz and epidote or quartz alone.

From his study of the Wakuach Gabbro belt in Ahr Lake map-area to the northwest, Baragar (1960, pp. 1600, 1606) concluded that many sills show an orderly arrangement resulting from differentiation in situ, whereby, ideally, a lowermost, ophitic, olivine-bearing zone, whose base is porphyritic, is successively overlain by an equigranular zone and by an upper, coarse-grained to pegmatitic zone.

Probably because of the scale of mapping and the irregular distribution or lack of outcrops, the only types of normal gabbro that could be mapped separately in Willbob Lake and Thompson Lake map-areas were two generally defined areas of porphyritic gabbro near Aeromat Lake and the northwest end of Connolly Lake, respectively. No regular arrangement of the gabbroic types could be demonstrated.

In Willbob Lake map-area, three relatively small conformable bands of porphyritic feldspathic peridotite occur near Lac Servais, and angular fragments of the same rock, probably representing bedrock, were seen at the south end of Snowshoe Lake. One band is flanked on both sides by 'leopard rock', but the others are evidently overlain by gabbro, and may represent more basic, basal material belonging to the differentiation sequence described by Baragar; it is for this reason that they are included in this section. At the single locality where the margin of one of these bands could be observed, the contact against gabbro is quite sharp, and, although neither rock is chilled, the possibility exists that these are separate intrusions. Megascopically, the rock has an irregular content of white to cream plagioclase clots up to an inch across, similar to those in the porphyritic gabbros, and set in a black, coarse-grained, mafic matrix that weathers to a rich brown. The surface is corrugated by easily weathered seams of serpentine and magnetite.

The following general description is based on about twenty thin sections of various gabbro types, mostly from random localities in Willbob Lake map-area. A fuller account, including chemical and mineralogical details, which is based on investigations a few miles to the northwest (Baragar, 1960) has previously been published.

The gabbros are essentially made up of clinopyroxene and plagioclase, with lesser amounts of orthopyroxene. Minor constituents are chlorite, serpentine, brown and blue-green hornblende, quartz, ilmenite, magnetite, leucoxene, iron sulphides, and sphene; in basic varieties, olivine also is important. Texturally, the gabbros may be porphyritic to equigranular, and ophitic to non-ophitic. In two mafic specimens, an alignment of plagioclase presumably representing flow structure was observed.

The plagioclase content of the rocks ranges from about 25 per cent in mafic varieties to two-thirds of the rock in feldspathic varieties. Commonly it is fresh and shows excellent albite twinning, but it may show considerable alteration to clinozoisite, sericite, chlorite, and a dusty aggregate difficult to identify. Alteration is particularly prevalent in the aggregates or clots of plagioclase that characterize the porphyritic gabbros. The plagioclase is labradorite (An_{55}–An_{70}).

The most common pyroxene is neutral to greenish grey augite; in some slides it is considerably altered to chlorite or serpentine, and, less commonly, to brown hornblende, blue-green hornblende, or tremolite. The amphiboles in turn also alter to chlorite. Twinning of augite on the 100 plane is common. Baragar (1960, pp. 1612–1615) reported an unusual variation in the optic angle and birefringence of the augite from crystal to crystal and also from one part of a crystal to another, possibly the result of alteration. Some slides contain pyroxene characterized by very fine striations, that may be unaltered pigeonite. Orthopyroxene occurs in large crystals half a centimetre or more long, typically altered to chlorite–serpentine and iron oxide. In some cases it is intergrown with augite. Fresh augite inclusions appear in some altered orthopyroxene and vice versa. Orthopyroxene is exsolved from augite and vice versa; this process, according to Baragar, is confined to mafic gabbros (1960, p. 1612). However, olivine gabbro from Willbob Lake map-area lacked exsolution features other than striated clinopyroxene.

Olivine is common in ophitic gabbros and may constitute 20 per cent or more of the rock. In some slides, it is notably fresh; elsewhere it is partly to completely altered to serpentine and minor tremolite. The mineral occurs either poikilitically within augite or externally as subhedral grains up to 2 mm across, surrounded mainly by plagioclase.

Iron oxide, notably ilmenite, is the most common accessory mineral, accompanied by leucoxene or sphene. Alternating lamellae of leucoxene and magnetite form some grains. Skeletal ilmenite growths attain a length of 3 mm. Iron sulphide in the form of pyrite and pyrrhotite, occasionally with chalcopyrite, are common but sparse accessories. The total metallic mineral content may run as high as 10 per cent. One mafic gabbro specimen contains about 10 per cent magnetite–ilmenite. Quartz appears in less mafic types and forms interstitial micropegmatite in the coarse-grained type. Holmes (1950) recognized quartz gabbro as a separate type in a local study near Lac Faute, Willbob Lake map-area.

Equigranular, anorthositic gabbro, of local extent adjacent to the Denault Formation at Attikamagen Lake, is distinctive in that it consists of highly altered plagioclase and carbonate, and lacks ferromagnesian constituents. Some of the carbonate replaces plagioclase pseudomorphically, but the carbonate also apparently crystallized independently in a mosaic pattern with plagioclase. The abundance of this carbonate presumably is the result of assimilation from the Denault Formation.

Under the microscope, the feldspathic peridotite is seen to consist of large, extensively saussuritized labradorite individuals or aggregates surrounded by a matrix made up of mostly euhedral to subhedral olivine grains from .15 to 2 mm in long dimension, poikilitically enclosed in augite, with a few very small laths of plagioclase. The matrix also includes some brown amphibole and magnetite. Although partly altered to tremolite and serpentine, much of the augite and olivine is fresh. A few of the smaller olivine kernels are embedded in plagioclase, which has anhedral outlines against the mafic minerals.

Structural Relations and Age

As indicated, the intrusions of normal gabbro apparently take the general form of sills. Except for a single small-scale occurrence transecting sediments, contacts are concordant. From the map, it is however evident that in general the numerous sills have transected sedimentary septae of the Menihek Formation and assimilated parts thereof. It should be noted, however, that additional thin septae exist, but could not be indicated because of the scale of the map, and that some of the septae mapped probably continue considerably farther than shown, but could not be traced because of their ease of erosion. Large-scale assimilation or replacement of the invaded rocks is considered unlikely also, because of the lack of inclusions, hybrid rocks, or relict sedimentary structures and the uniformity of the various gabbroic types over the area.

The relationship of the normal gabbro with other intrusive rocks of the map-areas is discussed in later sections.

Glomeroporphyritic Gabbro ('Leopard Rock')

Distribution and Occurrence

As indicated, this rock is spatially and genetically closely related to the 'normal' gabbro and is restricted to the same belt. Numerous leopard rock layers are prominent in Willbob Lake map-area in the zone between Howse Lake and Lac Philippe, but the rock is perhaps best exposed near the south end of Snowshoe Lake, where fires have removed most of the vegetation. Leopard rock layers are typically persistent, and near Lac Philippe and Lac Blais there are examples exceeding 12 miles in length. Most of these sills lens out abruptly, but some appear to interfinger terminally with gabbro or sediments. If they are parallel with the invaded sediments, leopard rock intrusions may attain approximate thicknesses of as much as 1,300 feet, but most would be less than 500 feet thick. Leopard rock is distinctly subordinate to normal gabbro, the ratio being estimated at 4:1 or greater.

Lithology

Leopard rock is an exclusively coarse-grained gabbro of glomeroporphyritic texture resulting from the occurrence of numerous creamy white to greenish aggregates of plagioclase, generally an inch or so across but ranging up to 6 inches, in a dark matrix. The spotted appearance led to the use of the field name 'leopard rock'. In places, as for example near Snowshoe Lake where the feldspar aggregates are very numerous and nearly all of them large, a striking white weathered surface results (Plate XII). The matrix of the rock is commonly composed of smaller clots and individual grains of plagioclase and large ferromagnesian constituents up to 2 cm

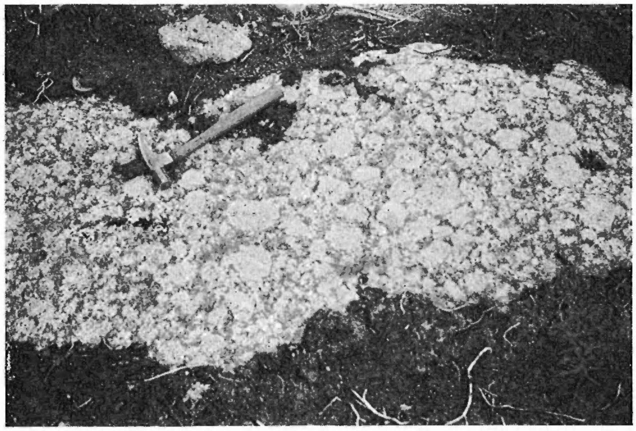


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PLATE XII

Outcrop of anorthositic, glomeroporphyritic gabbro ('leopard rock'), Snowshoe Lake, Willbob Lake map-area.

across. In numerous specimens, however, practically all the feldspar has accumulated into large clusters which are separated by ferromagnesian-filled interstices. The latter may be subordinate as some specimens contain 70 per cent or more plagioclase. Ferromagnesian crystals, individually or in groups, occur in the central part of some feldspar clots.

South of Snowshoe Lake and elsewhere, leopard rock grades into distinctive, patchy, silicic areas and ill-defined veinlets consisting of coarse feldspar, epidote, long bladed amphibole, and quartz. Some veinlets consist of quartz and epidote alone.

In places, leopard rock contains appreciable amounts of disseminated sulphide minerals, chiefly pyrrhotite, possibly of late magmatic origin.

Under the microscope, leopard rock is seen to consist almost entirely of plagioclase, pyroxene, amphibole, and their alteration products. Minor amounts of biotite, quartz, sphene, and ilmenite are also present. Biotite, sphene, and iron ore cluster together. The plagioclase aggregates consist of broad, interlocking, moderately saussuritized crystals up to 5 mm long. A number contain micrographic intergrowths. The aggregates are relatively fresh at the margins. Most pyroxene is highly altered to green and brown amphibole and to tremolite; some altered grains retain a bleb-type exsolution texture. Plagioclase composition falls in the basic andesine range (An_{45}).

Structural Relations and Age

Although bodies of leopard rock are fairly numerous, in only a few localities can these intrusions be traced closer to the adjacent rocks than a few feet, and contacts actually exposed are very rare. However, as with the normal gabbro sills the general conformity of these intrusions is readily apparent. The chief point of interest is their relationship with the normal gabbros.

Following work in the Ahr Lake map-area to the northwest, Baragar (1960, p. 1598) concluded that leopard rock was intruded first, to be centrally invaded by normal gabbro slightly later, to form composite sills. The same interpretation was made earlier by Kavanagh (1954), who examined a restricted area near mineral showings just southwest of Walsh Lake, Willbob Lake map-area. At least some of the leopard rock mapped by the latter, however, is evidently porphyritic gabbro which Baragar and the writer consider as separate material belonging to the normal gabbro series, largely differentiated in place.

The interpretation by Baragar postulates a process whereby certain pairs of the large bands of leopard rock shown on the map are taken as the original flanks of the first intrusion, invaded and separated, before cooling, by the gabbro now intervening. The scale of the proposed composite intrusion, in comparison with the classical European occurrences, where the total thickness rarely exceeds one hundred feet (Harker, 1904; Tomkeieff and Marshall, 1935; Oftedahl, 1957), would be very large indeed, as the flanking walls of leopard rock in the Ahr Lake examples are as much as several hundred feet or more thick and the central gabbro component attains a like thickness. However, in Willbob Lake map-area, sedimentary septae and remnants within the intervening gabbro masses apparently eliminate the possibility of composite intrusion, as proposed, for all but one pair of the fifteen or more leopard rock bodies mapped. These two, lying immediately northeast of Lac Servais and Lac Blais, are arranged *en échelon*, are of unequal length and width, and lack the well-defined symmetrical arrangement of the smaller, classical, three-part composite intrusions. Assuming the present dip of these sheets to be 45 degrees, it is suggestive from the map that a leopard rock wall at least 300 feet thick must have been destroyed by the central gabbro if composite intrusion in fact took place there.

The detailed field evidence from outcrops in the map-areas, though not abundant, strongly indicates an intimate relationship between normal gabbro and leopard rock, but there is little to confirm the suggested composite intrusion process. At one locality near the northwest tip of Snowshoe Lake, alternating outcrops of the two rocks were encountered, and in one of them, small irregular dyke-like masses of leopard rock that did not appear to be xenoliths were seen within normal gabbro. Neither rock showed a chilled contact. On the southeast shore of Howse Lake, is an outcrop consisting of several alternating bands of leopard rock and gabbro, again without chilled borders, separated by some 200 feet of overburden from a larger outcrop of the former. In a nearby exposure, leopard rock grades over 25 feet into coarse-grained gabbro, and a similar relationship was observed east of Snowshoe Lake. These occurrences indicate either in situ differentiation or broad chilled contact zones of leopard rock sills. The second alternative is the more likely; a post-gabbro age for the leopard rock intrusions is then indicated, as these zones are separated from nearby masses of normal gabbro by only narrow strips of drift. It is possible, of course, that the latter conceals very thin sedimentary or volcanic septae.

The only positive evidence was seen about a mile east of Limestone Bay of Attikamagen Lake, where a number of leopard rock–gabbro contacts are exposed in a restricted outcrop area. In three instances, neither rock was chilled along the well-defined boundary; in the fourth, leopard rock was moderately chilled against gabbro. No gabbro cores were observed within any of the individual leopard rock bands themselves, and no xenoliths or absorption effects were seen in either rock. The apparent inclusion of a lens of feldspathic peridotite within leopard rock northeast of Lac Servais suggests a younger age for the leopard rock there.

In summary, the field evidence demonstrates a close relationship between the two rocks but offers little support for the suggestion that leopard rock sills were divided by later intrusion of normal gabbro. Some type of composite intrusion may have occurred, but the detailed evidence suggests in part possible differentiation in place, and in part post-gabbro intrusion of leopard rock.

Relations of Meta-gabbro with other Gabbroic Rocks

Direct evidence bearing on the relationship of the normal gabbro and leopard rock sills with the contrasting meta-gabbros to the northeast is lacking, as the two terranes are sharply separated by the Walsh Lake fault. Baragar (1960) considered the demarcation as primarily metamorphic, ascribing the mineralogical differences to an abrupt increase in metamorphism across the fault. However, other contrasts between meta-gabbro and normal gabbro suggest that more than a difference in metamorphic grade may be involved.

1. Association: The intrusive association northeast of the fault is meta-gabbro–peridotite; to the southwest it is normal gabbro–leopard rock. In each pair the association is an intimate one, and composite intrusion has been suggested to explain it. The difference in association suggests a difference in age and possibly in source.

2. Differentiation and Cooling Phenomena: Whereas a clear-cut sequence resulting from differentiation in place has been described for the normal gabbro, ranging from olivine gabbro (possibly even feldspathic peridotite) to gabbroic pegmatite (Baragar, 1960), this is apparently lacking in the meta-gabbros, where, because of better exposure and clearer delineation of individual sills, it should be evident, particularly since metamorphism has been mild. The writer found the meta-gabbro intrusions to be finer grained on the whole, and to exhibit better developed primary joints.

3. Composition: The meta-gabbro appears to differ in minor element content, Cr and Sr being on the whole appreciably higher, and P, Mn, and V

appreciably lower (Baragar, 1960, pp. 1624–1625). Olivine was either rare or absent.

If the meta-gabbros are considered to be essentially volcanic and contemporaneous with the Willbob lavas, the normal gabbro–leopard rock suite may have been emplaced at a different time, from a magma source of somewhat different composition, and at greater depth, permitting slower cooling and better differentiation.

Retty Peridotite

Distribution, Occurrence, and Name

The Retty Peridotite (Frarey and Duffell, 1964) forms a group of concordant ultrabasic bodies restricted to the Thompson Lake and Willbob Formations of the Doublet Group. Following a narrow stratigraphic zone straddling the contact of the formations, they extend, regionally, from about 6 miles southeast of Willbob Lake map-area northwestward to about latitude 56 degrees, an approximate distance of 100 miles. Although it evidently passes northwestward into a geologically unmapped strip of territory, the belt of ultrabasic intrusions does not continue beyond (Gross, 1960), and probably terminates not far outside the known limit, possibly around 56° 30′. Thus the segment of the central and southern Labrador Trough containing ultrabasic intrusions is rather limited relative to the trough as a whole. Some 160 miles to the northwest, ultrabasic intrusions reappear along the eastern flank of the northern part of the Trough, between Koksoak River and Hopes Advance Bay (Gross, 1960).

Throughout most of the two map-areas, there are up to three sills in a given section, although near Willbob Lake there appear to be five. They are normally less than a thousand feet thick, but are remarkably persistent. The most prominent sill, lying just below the contact of the two formations, is believed to be continuous for a strike length of more than 50 miles across these two map-areas, and its further continuation northwestward for at least another 30 miles is indicated by more recent mapping (Baragar, 1963). It is most prominent in Thompson Lake map-area, where it is well exposed along Gomez, Thompson, and Retty Lakes. Intruded above the contact is a second large sill, extending southeastward for about 35 miles from near Thompson Lake, crossing the northeast corner of Willbob Lake map-area into the adjoining Griffis Lake map-area to the vicinity of Lac Girard, where it has been the subject of a detailed study (Fahrig, 1953, 1962). Among other, thinner sills is one following the contact through most of Thompson Lake map-area. With local exceptions, the sills maintain a fairly uniform thickness for miles, but thin or terminate abruptly. The thickness of some of the thinner intrusions has been exaggerated on the accompanying maps.

Because of their striking character and appearance and their fairly restricted distribution stratigraphically, the sills of the Retty Peridotite constitute a distinct igneous unit.

Lithology

The Retty Peridotite varies lithologically because of the effects of alteration, but appears to have been composed dominantly of peridotite. Locally, as for example just southwest of the main body of Doublet Lake and in the sill north of the northwest end of Retty Lake, a few gabbroic interlayers or lenses up to a few feet thick appear within the ultrabasic bodies (Pl. XIII). The marginal parts of the large sills appear to have been more pyroxenitic in composition (Fahrig, 1962, p. 23), and this is probably also true of smaller intrusions which are similar to those margins in composition.

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PLATE XIII

Gabbroic layer in serpentinized peridotite near Doublet Lake, Willbob Lake map-area. Note closely-spaced (flow?) layering in the serpentinite; white patches, lichen.

Less serpentinized peridotite is jet black, weathers a deep rich brown, and is medium to coarse grained. Aside from local foliation, ubiquitous jointing, and numerous irregular cracks filled with serpentine and magnetite, the rock is massive and structureless. More extensively serpentinized peridotite is dark grey or greenish grey, weathering to rust, fawn, or buff. Because of the alteration, the texture commonly appears to be fine grained, but microscopically the primary texture can usually be discerned. These more altered rocks are likewise massive, although serpentine–magnetite veinlets are more abundant. Jointing is less well defined. A third, more distinct lithological type of ultrabasic rock consists essentially of tremolite and chlorite. This type forms a characteristically coarse-grained dark grey rock commonly mottled by light grey crystals or aggregates of amphibole, weathering to a distinctive, sharply rough, reddish brown surface. In common with the other types, this rock is very tough and difficult to break. It too is structureless except for jointing and local foliation, and serpentine veinlets here and there. This variety is marginal to the larger sills, almost invariably forming a thin basal layer probably not more than 100 feet thick and also occurring along the top. These marginal zones are regular and well defined, and at several places are discernible on aerial photographs. They normally appear to be of uniform composition, but at one locality at least, about a mile northeast of the northwestern extremity of Retty Lake, tremolitic zones contain thin interlayers of serpentinized peridotite similar to that of the interior zones. In addition to the border zones of large sills, separate thin ultrabasic intrusions are composed of this tremolitic material.

Some sections across larger sills show, between the tremolitic borders, a further zoning of the other two types mentioned, whereby serpentine-rich peridotite lies along both flanks of a central, less altered zone that is lower in serpentine. In general, however, this arrangement proved not to be mappable at this scale; lack of outcrops across the broad tops of the ultrabasic ridges may be in part responsible, but one or the other of the interior zones commonly appeared to be missing.

Petrography

The original nature of the Retty Peridotite is seen to be obscured in most thin sections by varying degrees of alteration. However, relatively fresh peridotite consists essentially of clinopyroxene and altered olivine, with secondary chlorite, serpentine, magnetite, and minor tremolite. The clinopyroxene is faintly pleochroic, grey to pinkish grey, and forms interlocking crystals up to half an inch across. In the large sill continuing into Griffis Lake map-area, its composition has been determined as diopsidic augite (Fahrig, 1962). Rhombic pyroxene has been reported by Kavanagh (1954), who studied these intrusions between Kalko Lake in Thompson Lake map-area and Doublet Lake in Willbob Lake map area; he also identified small amounts of chromite. Magnetite, pyrrhotite, pentlandite, and chalcopyrite, thought to be of primary origin, have been identified in the two large sills mentioned (Findlay, 1958). The olivine is enclosed poikilitically within the pyroxene, either as single grains or in clusters of grains in contact. In places, closely crowded olivine pseudomorphs constitute 70 per cent or more of the rock. The mineral forms euhedral to subhedral crystals, commonly of stubby habit, less commonly tabular, and equant rounded grains, 0.1 to 3 mm long, showing no deformation and exhibiting sharp extinction. A wide range of grain sizes may occur together. Its composition near Lac Girard in Griffis Lake map-area was determined to be chrysolite with 13.5 to 15 per cent fayalite (Fahrig, 1962), and, near Hyland Lake, Thompson Lake map-area, with 14 per cent fayalite (Kavanagh, 1954).

The alteration of olivine and pyroxene produced various mixtures of primary and secondary minerals. The dominant alteration products are chlorite, serpentine, tremolite–actinolite, and magnetite. In general, pyroxene has been more resistant to alteration and persists to some degree in all parts of the sills, though evidently decreasing outward. Olivine, on the other hand, remains only in some interior, less altered areas. One anomalous specimen, however, contains much unaltered olivine in a highly altered matrix. The outer zones are mineralogically and texturally the simplest, being composed essentially of coarse tremolite–actinolite and chlorite. In some marginal specimens, pseudomorphs after olivine appear to be preserved. In the interior areas, the rock ranges from moderately altered peridotite with abundant olivine to complex mixtures of serpentine, chlorite, tremolite, and magnetite, with or without subordinate amounts of primary pyroxene and pseudomorphs after olivine.

Serpentinization has affected all parts of the sills, and as indicated is most evident in highly altered interior zones. In fresher specimens containing olivine remnants, the latter are surrounded by borders of chrysotile or by greenish yellow serpentine (xylotile), in turn rimmed and veined by chrysotile (Pl. XIV). Where no olivine remains, the pseudomorphs are of chrysotile and antigorite, with or without tremolite. Xylotile, therefore, appears to be an early, transitional product, although Fahrig (1962) considered it the latest secondary mineral. Chrysotile and antigorite also replace the pyroxene extensively in some specimens, in two stages, pre-tremolite and post-tremolite. Nickeliferous serpentine, garnierite, occurs in the least altered peridotite replacing pyroxene. Kavanagh (1954) considered garnierite and xylotile the earliest serpentines.

Colourless, amorphous, semi-isotropic chlorite ('serpophite') commonly replaces pyroxene of the interior zones (Pl. XV). Similar, pale green isotropic chlorite, together with penninite, replaces tremolite, whereas in other thin sections chlorite of normal birefringence appears to precede tremolite.

Tremolite–actinolite is most abundant in the border zones, but also occurs in substantial amounts in the interior, where it is evidently related to the degree of serpentinization as sections showing remnant olivine contain little secondary amphibole. Olivine and serpentine pseudomorphs after olivine, whether in fresh or partly serpentinized pyroxene, show a greater susceptibility than the matrix to

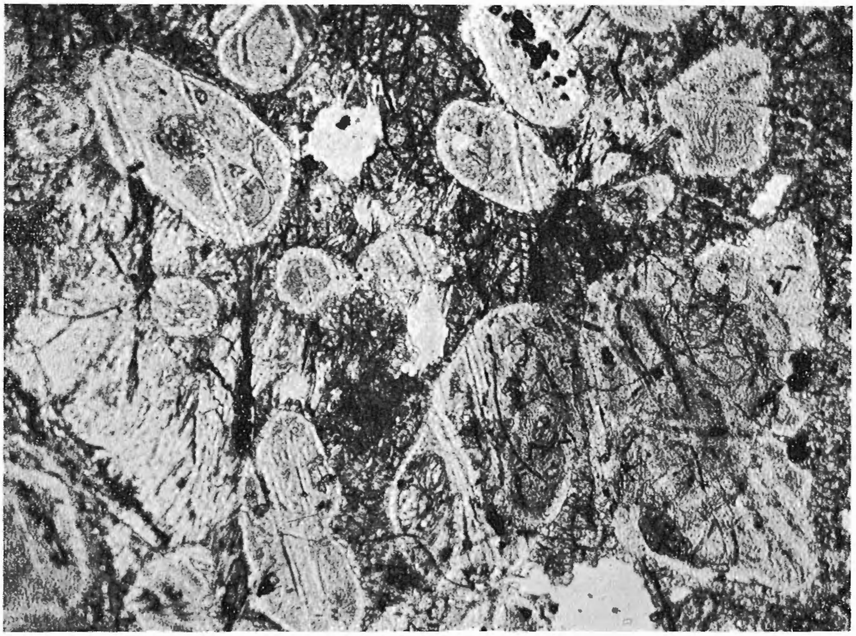

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PLATE XIV. Photomicrograph of moderately altered peridotite of the inner zone of sill near Willbob Lake. Large single pyroxene grain with magnetite-filled cracks and partly altered to antigorite chrysotile, contains subhedral olivine (see core remnants) altered to xylotile (dark areas) and chrysotile (white veins and rims). One nicol x 50 (Specimen F-113-50).

replacement by tremolite, which forms prominent white rims and bladed clusters in the cores. A notable feature is the crystallographic control exerted by the surrounding pyroxene over the tremolitization of all contained pseudomorphs, as exhibited by the optical continuity of the tremolite from one to the other (Fahrig, 1962, pp. 14–16). A somewhat similar effect is shown in some border specimens, where cleavage of the remnant pyroxene continues into small ovoid areas of optically

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PLATE XV. Photomicrograph of completely altered peridotite, Retty Lake, Willbob Lake map-area, showing serpentine pseudomorphs after olivine, rimmed and veined by magnetite, and semi-isotropic chlorite (white with dark specks) and magnetite (black patches) replacing pyroxene. One nicol x 80 (Specimen F-142-50).

continuous tremolite, with or without serpentine or chlorite. These areas are lacking in magnetite, and rather than being pseudomorphs appear to be unstable parts of the original pyroxene. The highly altered border rocks are characterized by large ragged tremolite–actinolite individuals a centimetre or more long, evidently pseudomorphic after pyroxene, and in some instances forming 80 per cent or more of the rock. In other thin sections, in contrast, the pyroxene is seen to be extensively obliterated by a mat of small, unoriented tremolite laths. Actinolite in the ultrabasic sills is subordinate to tremolitic amphibole. Brown amphibole is an additional alteration product of the clinopyroxene, appearing sparingly in all parts of the sills, mostly where pyroxene remains. It alters to tremolite, and evidently is a transitional product in the development of that mineral.

While the bulk of the evidence indicates that tremolitization in general followed serpentinization, alteration subsequent to tremolitization is shown by the microscopic observation of antigorite, penninite, some chrysotile, and some isotropic chlorite succeeding tremolite. Much of the vein serpentine is probably of late origin related to regional deformation.

Small talc schist zones are present in the ultrabasic sill near McNeill Lake, Willbob Lake map-area, and, to the east, in the adjoining Griffis Lake map-area, the sill near Lac Girard contains large replacement areas of carbonate–talc (Fahrig, 1962). This is a later type of alteration occurring along faults and shear zones; conspicuous carbonatization characterizes several such zones, cutting various rocks, in these map-areas.

Origin of Tremolitic Border Zones and Sills

As all the ultrabasic rocks are considered to have had, originally, the composition of peridotite, the tremolitic zones and sills, with their concentrations of Al, Ca, Ti, and Fe relative to serpentinized peridotite, are of considerable interest and have been the subject of previous comment (Kavanagh, 1954; Fahrig, 1953, 1962). Fahrig suggested that the contrast in Al, Ca, and Ti resulted from a mechanical differentiation process during the intrusion of partly crystallized ultrabasic material, whereby olivine crystals, because of flow phenomena, became more closely packed in the central areas of large sills and the fluid, more pyroxenitic part, relatively more plentiful along the margins. The increase in iron he attributed to increased serpentinization outward. Kavanagh, on the other hand, considered the increase in pyroxene content resulting from such differentiation to be insufficient to account for the sharp chemical contrast, particularly in the case of aluminum which increases tenfold (Fahrig, 1962), and he suggested the large-scale transfer of material from the wall-rocks in exchange for magnesium by hydrothermal action along the contacts, producing border zones in large sills and completely altering thin ones.

However, the ubiquity and continuity of the tremolite–chlorite zones, with their massive alteration in bulk along all ultrabasic sills, and the lack of concomitant alteration effects in any adjacent sedimentary or igneous rocks make it appear likely that the tremolitization was an endogenic process rather than a later hydrothermal event. Furthermore, known hydrothermal-type alteration effects in the ultrabasic bodies produced talc–carbonate zones, as mentioned above, rather than tremolite–chlorite concentrations.

The border zones may have been more strongly differentiated than was previously believed. While some thin sections are seen to contain pseudomorphs after olivine, in almost an equal number none appears. Fahrig (1962, p. 23) suggested the presence of plagioclase in the border zones, though no trace was seen in thin section. However, it is of interest in this connection to note the reported occurrence of plagioclase in the border zones of similar, possibly related, ultrabasic intrusions in the Cape Smith Proterozoic belt north of the Labrador Trough (Findlay, 1958). Findlay also found epidote in border zone samples from the sill east of Hyland Lake, Thompson Lake map-area. Further detailed field and laboratory study of the tremolitic rocks might be of value.

Structure and Relations with Adjacent Rocks

As noted previously, the ultrabasic rocks are characteristically massive. Commonly, the fresher, dark brown weathering, interior variety exhibits well-defined regular joints consisting of a prominent, closely-spaced set parallel with the attitude of the sill, complemented by one or in places two sets at right angles. The former set has been interpreted as flow layering (Fahrig, 1962, p. 23). Commonly, the three sets produce a distinctive rectangular surface pattern, and locally where weathering is advanced along them, a rubble of small fragments results. Normally, however, these openings decrease to mere hair-like cracks a few millimetres below the surface. In places along the border zones, and, rarely, in the interior of sills, a rude columnar jointing was also recognized.

Numerous, randomly-oriented, irregular cracks, most common in more serpentinized areas, occur in the ultrabasic bodies. These cracks are typically filled by serpentine or, more rarely, by tremolite, and commonly accompanied by magnetite. The serpentine in these veinlets is normally hard and brittle, but in some places soft asbestiform fibre has formed. The more prominent occurrences are mentioned in Chapter IV. The fairly common observation of slickensides along such fractures indicates that numerous minor internal movements affected the sills after serpentinization, during the general period of regional deformation.

The ultrabasic sills are moderately sheared in places, normally in the vicinity of known strike faults or sharp folds. This shearing has produced discontinuous fractures an inch or so apart, which are inconspicuous except on weathered surfaces. Aside from the locality near McNeill Lake, no carbonate–talc or other alteration effects were observed in these deformed zones. Some, however, are sulphide-bearing. The sills are also transected by numerous prominent cross-fractures, along some of which slight displacement has taken place. The main asbestos occurrences appear to be related to such cross-fractures.

In general, sills of the Retty Peridotite are notably conformable with adjacent formations, and no discordance was seen at the observed contacts. Rarely, however, the sills bifurcate and reunite, including large lenses of invaded strata of mappable extent, as for example just southeast of Gomez Lake, Thompson Lake map-area. Although the observed lower contacts of sills were sharp and regular, in a few places evidence appears to point to inclusion and, possibly, assimilation or replacement of the adjacent rock at this boundary. Near the northwest corner of Doublet Lake, Willbob Lake map-area, and also near the north edge of that map-area about a mile east of Retty Lake, areas containing pillow-like structures occur within the ultrabasic body near the base, suggesting the incorporation of blocks of the underlying volcanic rock. Similar forms have also been reported northeast of Hansen Lake, Thompson Lake map-area (Labrador Mining and Exploration Company, private reports). Time did not permit detailed investigation of these findings. Possibly of related significance is an apparent gradation upward from basic volcanic to ultrabasic rock in Griffis Lake map-area (Fahrig, 1962).

Commonly, the ultrabasic sills are overlain by a layer of meta-gabbro, as is evident from the maps (*in pocket*). This layer may equal or exceed the adjacent ultrabasic intrusion in width, or be too narrow to show on the map. In some sections it appeared to be entirely missing for considerable distances along strike. Conversely, in a few instances the meta-gabbro layer persists for several miles beyond the underlying ultrabasic sill (Kavanagh, 1954). At the few places examined, where the boundary zone between ultrabasic and gabbroic rock is well exposed, no chilled contact exists, and the contact is best defined as an abrupt change of colour from brown to greenish grey. A thin section showed the gabbroic material to consist mostly of altered pyroxene, replaced by tremolite and chlorite, with no indication of olivine or feldspar. It contains titanite, a characteristic mineral of the meta-gabbro and meta-basalt of the district. Within a few feet, the pyroxenitic material grades upward into common meta-gabbro.

Less commonly, the ultrabasic sills are also underlain by meta-gabbro, but as a rule they rest on sediments or volcanic rocks. This is evident in Thompson Lake map-area, where the main ultrabasic sill probably overlies sediments throughout.

The association of meta-gabbro above ultrabasic layers, together with the lack of chilled contacts, suggested that this meta-gabbro was differentiated in situ from the ultrabasic material (Frarey, 1954; Kavanagh, 1954). This explanation seemed particularly applicable to the thin, wholly tremolitic ultrabasic intrusions and their overlying matching meta-gabbro, as for example the two thin pairs invading the Willbob Formation west of the northwest arm of Retty Lake. In the large sills, such differentiation could not be extended downward to include the interior serpentinized peridotite because of the underlying, basal, tremolite zone. However, the profusion of separate meta-gabbro sills over the map-areas, for the most part identical to those adjacent to the Retty Peridotite sills, and the wide variation in thickness (even absence in places) of those above ultrabasic bodies and the continuation of meta-gabbro sheets for great distances beyond the latter apparently militate against common intrusion of the two rocks and differentiation in situ.

As mentioned earlier, flow differentiation has been suggested elsewhere to explain the upper and lower marginal tremolitic zones, flanking one of the larger ultrabasic intrusions, which commonly show this bilaterally symmetrical pattern. The general lack of a similarly symmetrical meta-gabbro–ultrabasic distribution pattern in these map-areas makes unlikely any extension of the flow differentiation hypothesis to include associated meta-gabbro sheets.

A third alternative (Kavanagh, 1954; Baragar, 1958; and Fahrig, 1962) is separate intrusion of peridotite and meta-gabbro. The field relations and distribution of the two types can be accounted for as being the result of emplacement of ultrabasic sills along the base of earlier, still uncooled, gabbroic sheets.

Classification

The folded eugeosynclinal environment of the Retty Peridotite sills leads readily to their classification as 'alpine-type' (Kavanagh, 1954; Fahrig, 1962). Differences said to distinguish this group from stratiform bodies (Thayer, 1960) are partly structural and result from the tectonic history of the region. In the case of the Retty Peridotite sills, emplacement was pre-orogenic, and subsequent deformation was insufficient to disrupt their contact relations or produce high-intensity effects. This restricted tectonic history is reflected in the Labrador Trough as a whole by the lack of angular unconformities, discordant intrusions, late-orogenic acidic intrusions, and post-orogenic dykes. The lack of internal layering, interbanding, or intergradation in these sills and the absence of appreciable contact metamorphic effects strengthen the 'alpine' classification, according to the criteria mentioned above.

C. H. Smith (1962) discussed Canadian ultrabasic intrusions generally, and emphasized apparently fundamental differences between Precambrian intrusions, including those of the Labrador Trough, and younger ultrabasic bodies. He pointed out that the older intrusions exhibit distinct chemical differences from the "true" alpine-type intrusions of younger mountain belts, as shown by the presence in the former of notably more iron-rich olivines and the relative abundance of genetically-related sulphide deposits. On the basis of scanty data, the Retty Peridotite sills appear to conform to this concept, as, in the tabulation by Smith (p. 163), their olivines are shown to be relatively iron-rich; likewise, sulphide mineralization, while not abundant in the ultrabasic and meta-gabbro sills, is fairly common, and in a few places sulphide minerals appear to be primary constituents of these rocks.

Metamorphism

Regional Metamorphism

Metamorphism within the map-areas has been slight to moderate. The most prominent metamorphic boundary coincides with the Elsie Lake fault, separating pelitic and semi-pelitic schists of the Laporte Group, representing the almandine–amphibolite facies, from volcanic rocks of the Doublet Group and associated intrusions, largely of the greenschist facies (Fyfe *et al.*, 1958). Farther southwest, the rocks of the Knob Lake and Doublet Groups and their intrusions show metamorphic effects varying, somewhat irregularly, from almost negligible to well-developed greenschist levels.

In nearby Ahr Lake map-area, a distinct pattern of metamorphism in these same strata was described (Baragar, 1960), in which the extension of the Walsh Lake fault is said to be the major metamorphic boundary, dividing sub-greenschist rocks on the southwest from a well-defined greenschist zone on the northeast. Other authors, in contrast, have classified the entire block southwest of the Laporte Group as unmetamorphosed, at the same time indicating the presence of incipient metamorphism and some greenschist representatives (Gastil *et al.*, 1960). Evidence from these map-areas indicates that greenschist rocks are present almost to their southwestern limit, but that they are sporadically and weakly developed, particularly southwest of the Walsh Lake fault.

The designation of the Walsh Lake fault as a metamorphic as well as a structural boundary is, in these map-areas, best supported by the contrast between the gabbroic intrusions on either side. Those to the southwest, while commonly showing alteration to chlorite, clinozoisite, sericite, and actinolitic amphibole, are dominantly composed of primary minerals and exhibit original textures; to the northeast, the sills are of highly-altered meta-gabbro, in which the pyroxene has evidently been entirely replaced, largely by actinolite, and the plagioclase, while retaining original outlines, is typically altered to saussuritic aggregates and, less commonly, to fresh secondary plagioclase (albite or andesine). Clinozoisite, epidote, chlorite, sphene, quartz, biotite, and calcite are other constituents. The meta-gabbros thus approach the albite–epidote–actinolite–chlorite–sphene assemblages of the greenschist facies (Fyfe *et al.*, 1958, p. 222), while partly retaining their primary textures. The same is generally true of the volcanic rocks between the two major faults, with notable exceptions. Completely recrystallized, foliated greenschists of volcanic origin characterize the Murdoch Formation adjacent to the Walsh Lake fault. These schistose pyroclastic rocks represent the most advanced metamorphism in the Doublet Group, presumably because of their incompetence and susceptibility to shearing, and they accentuate the fault as a metamorphic boundary. These schists conform to the quartz–albite–epidote–biotite subfacies of the greenschist facies. Farther northeast, the bulk of the volcanic rocks of the Doublet Group, consisting mostly of pillow lavas, while generally altered, in large part, to greenstones in a manner corresponding to that in which the meta-gabbros were changed, commonly shows primary textures and a limited development of clear secondary plagioclase, and in some samples retains remnant pyroxene. In contrast with the fine-grained, grey-green meta-basalts is the much less abundant, dark, coarser, unaltered basalt in the Willbob Formation. For example, in the lower part of the formation, a thin stratigraphic layer of almost completely fresh massive basalt flanked by meta-basalt occurs along the northeast limb of the major syncline just southwest of Retty Lake, Willbob Lake map-area. It is also present on the opposite limb, and at about the same stratigraphic position in other parts of the map-area. Other layers are probably also present. It is not clear why this basalt should consistently escape the alteration ascribed to regional metamorphism in the associated rocks.

As regards metamorphic changes in the sedimentary rocks of the Knob Lake and Doublet Groups, the Walsh Lake fault in Willbob Lake map-area marks a northeastward increase in the amounts of secondary minerals and in the degree of textural modification, rather than a clear-cut change in metamorphic grade. In the Menihek Formation southwest of the fault, with the possible exception of some argillitic beds of submicroscopic texture, chlorite appears to be almost ubiquitous, and white mica and biotite occur sparingly, the latter having been noted near Lac Philippe and Frederickson Lake. In nearly all specimens, primary textures are well preserved. In the Thompson Lake sediments to the northeast, both chlorite and white mica are almost invariably component minerals, and biotite becomes appreciably more abundant. These minerals, together with quartz and some albite, to varying degrees replace the argillaceous beds, and appear in the matrices of the arenites, where as a rule they attack the margins of the coarser detrital grains. The degree of recrystallization is slight to moderate, and primary textures as a rule are largely preserved.

In summary, the strata of the Knob Lake and Doublet Groups in these map-areas occupy a broad zone of low-grade metamorphism, within which the Walsh Lake fault may be considered to separate subzones of higher intensity on the northeast and lower on the southwest. The chief contrast across the fault is provided by the gabbroic intrusions. The greenschist facies is best exemplified by the Murdoch schists adjacent to the fault.

Along the northeastern edge of the Doublet Group in a zone a mile or so wide, the flows of the Willbob Formation are deformed by a number of shear zones, parallel with the fault boundary, that render them moderately schistose and chloritic at many places, without however increasing the metamorphic grade significantly. A marked increase in metamorphism across the Elsie Lake fault is visible in the metasediments of the Laporte Group with their strong foliation, cataclastic effects, and complete reconstitution to quartz–plagioclase–biotite–chlorite schists. A mile and a half northeast of the boundary, the plagioclase is oligoclase (An_{20}), placing the rocks in the almandine–amphibolite facies of Fyfe *et al.* (1958, p. 218). About 2 miles farther northeast, small pink garnets appear.

Age of Metamorphism

Because of the results of the isotopic age determinants by the Geological Survey, the deformation and metamorphism of the Labrador geosyncline have been assigned to the Hudsonian orogenic period, about 1,700 million years ago (Stockwell, 1963). This designation follows mainly from several dates (between 1,635 and 1,935 m.y.) derived from rocks adjacent to the eastern margin of the known Kaniapiskau strata. It is in general agreement with interpretations by other investigators, based on a series of age determinations carried out independently on samples from the northern sector of the Trough, which place the major period of metamorphism at 1,600 m.y. (Beall and Sauve, 1960).

Dates obtained from material from the Kaniapiskau belt itself, or its intrusions, in the central part of the geosyncline, have so far been notably lacking. A sample from the top of the Murdoch Formation on the southwest shore of Kalko Lake, Thompson Lake map-area, submitted by the writer, gave a figure of 1,375 m.y. (Stockwell, 1963b). This agrees with the only other date determined from this part of the Trough, namely 1,420 m.y. obtained from the Menihek Formation near Schefferville (Quirke *et al.*, 1960). The northern series of dates referred to above included two from Kaniapiskau strata in the 1,400 m.y. range, which were interpreted as representative of a post-Hudsonian disturbance, the youngest of three disturbances thought to have affected that part of the geosyncline, and possibly the Cape Smith Belt to the north as well (Beall and Sauve, 1960). The Kalko Lake and Schefferville dates lend some support to the possibility that this post-Hudsonian disturbance affected a much larger area (Gastil *et al.*, 1960).

Contact Metamorphism

Contact metamorphic effects in these map-areas have been very slight. The only result observed along the contacts of the basic and ultrabasic sills was a slightly 'baked' appearance extending for not more than a few inches. No porphyroblasts appear megascopically, but Kavanagh (1954) reported microscopic tremolite–actinolite and epidote in hornfels adjacent to meta-gabbro, and Baragar (1960) reported small flakes of chlorite and biotite, and possibly altered cordierite crystals, in similar zones. In places, contact metamorphism appears to be entirely lacking along sill borders.

Chapter III

STRUCTURAL GEOLOGY

Except for the Laporte Group, the structure of the rocks of the map-areas clearly conforms to the general pattern of northwest-trending folds and faults prevailing in the Labrador Trough. Within the map-areas, three main structural divisions may be recognized, separated by prominent faults. The first or southwestern division extends from Attikamagen Lake northeastward to the Walsh Lake fault and consists of narrow bands of Knob Lake strata isolated from one another by multiple intrusions of gabbroic sills. The central division coincides with the Doublet Group, and is characterized by large, southeasterly-plunging folds cut by secondary faults and shear zones. The northeastern division comprises the Laporte foliated rocks northeast of the Elsie Lake fault in Thompson Lake map-area. In this division, no folds and few faults can be recognized. Structural information on the stratified rocks was obtained from bedding, crossbeds, pillow structure, jointing, and cleavage; in the Laporte rocks only foliation, lineation, and relict bedding were available for study.

Folds

Southwestern Division

In this block much of the field evidence from the strata between gabbro sills indicates that they form a homocline facing northeast. The homoclinal arrangement is well displayed near Attikamagen Lake where a regular succession northeastward from the Attikamagen to the Menihek Formation appears. Nearly all measured attitudes indicate that strata in this division strike almost regularly at N40°W and have a moderate to steep dip northeast, although opposing dips occur locally. Most of the scattered crossbeds seen in the Menihek beds indicate that the succession also faces northeast; however, the existence, at least locally, of close folding and overturning is shown by opposing dips and top determinations in a restricted area southeast of Howse Lake. In addition, larger scale folding is evident, mainly from the study of aerial photographs, along the northeast edge of this block, from Walsh Lake southeast to Connolly Lake. In this zone, a fairly distinct structure about a mile across is preserved east of Lac Philippe, and a number of gently curving structural trends are transected by the Walsh Lake fault.

Small-scale folds in Attikamagen slate and chert near Attikamagen Lake plunge at 35°SW. Crumpling of Menihek beds west of Lac Faute plunges at 25°SE. These observations may be indicative of the plunge of larger structures in this block. If such is the case, the larger structure near Lac Philippe is synclinal, and the plunge of folding conforms to that in the adjacent block to the northeast.

The curved outlines of a few lakes in the drift-covered southwest corner of Willbob Lake map-area may also reflect large, gentle folds. However, the limited structural data and profusion of intrusions prevent the delineation of any other major folds, if present, in this division.

Central Division

In the Doublet Group that constitutes this division, folds are generally well defined, and are topographically emphasized by prominent ridges and intervening curving lakes and streams, easily seen on air photographs (Pl. I). The axial regions of the main anticlinal folds are, to a great extent, underlain by easily-eroded sediments of the Thompson Lake Formation, and are the site of large lakes such as Thompson, Retty, and Willbob Lakes. In general, the more prominent folds are large open structures 5 or 6 miles across, whose axes strike N40° to 50°W, and plunge southeastward at 20° to 45°. A doubly-plunging anticlinal zone lies between Retty and Gomez Lakes. These large plunging folds are preferentially developed in the zone embracing the Thompson Lake Formation and the lower part of the Willbob Formation. The Murdoch Formation was in part similarly folded, but generally the development of a distinct fold pattern within it was prevented by the lack of well-defined stratification, the absence of sills intruding it, and its inherent incompetence. In addition, the delineation of any folds that developed in the formation is prohibited by the lack of marker beds and the paucity of outcrops. Deformation at these stratigraphic levels is accentuated by the development of large buckles and drag-like secondary structures (Pls. I and XVI) involving strata of the two upper formations, particularly the Thompson Lake sediments and their associated sills, as shown southeastward from Kalko Lake, Thompson Lake map-area, to Willbob Lake. Within these structures the sediments are severely crumpled and sheared. In the upper part of the Doublet Group, above the level of the main ultrabasic intrusions, folding tends to be less pronounced, and the upper flows of the Willbob Formation in Thompson Lake map-area assume a northeast-facing homoclinal aspect, with the exception of a synclinal structure near the eastern edge of the map-area, close to the Elsie Lake fault. Most folds in this division appear to be essentially upright, but the syncline just mentioned is overturned to the southwest.

Northeastern Division

No folds are discernible in the Laporte rocks, where marker beds are lacking, primary structures are scarce, and exposure is limited. In a few places near the north edge of the area mapped, relict bedding can be seen to strike northwest and dip northeast, as does much of the observed foliation. However, away from the fault boundary with the Willbob Formation, particularly in the southern part of

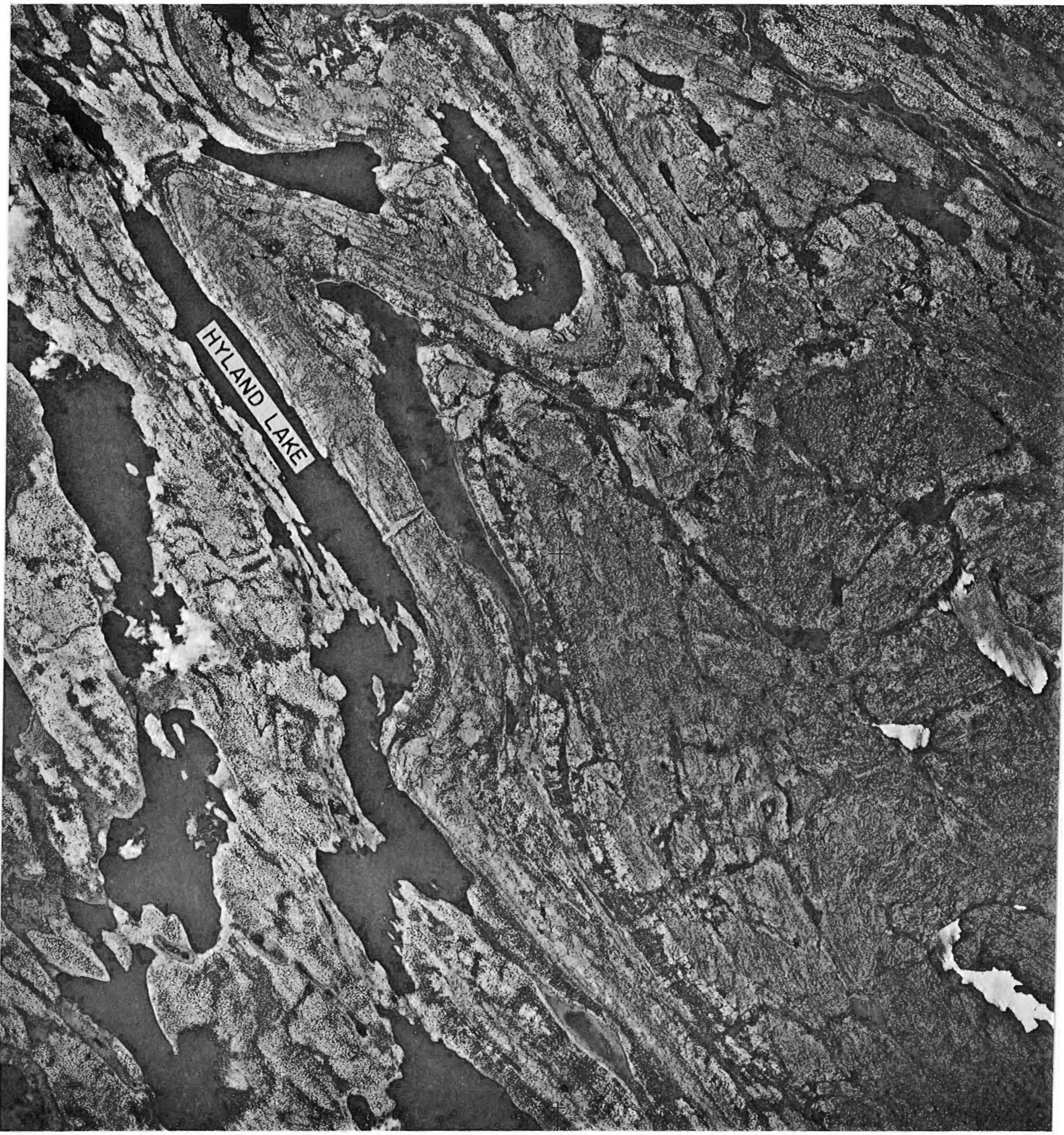

PLATE XVI. Aerial photograph showing prominent buckles on flank of major fold, Hyland Lake, Thompson Lake map-area. (RCAF A11512-110) the area examined, the foliation commonly trends more easterly and dips north. Some outcrops central to the area mapped show both foliations. The attitudes of bedding and foliation in these rocks contrast markedly with those of the adjacent Willbob Formation, where the schistosity and the flows themselves strike uniformly northwest and dip more steeply northeast, at angles of 45 degrees or more. The lineations shown consist of crenulations on foliation planes.

Faults

Southwestern Division

No important faults affecting the Knob Lake strata between Attikamagen Lake and the Walsh Lake fault have been recognized. West of Lac Faute, Willbob Lake map-area, several strike and transverse faults of small displacement have cut the Menihek slates and intervening sills and other small transverse breaks occur. Shearing parallel with bedding is commonly evident in the argillaceous beds between sills, and is possibly related to fault movements.

Walsh Lake Fault

This is the most conspicuous structural feature in the map-areas. As previously indicated, it follows a prominent lineament that can be traced in a straight line for about 90 miles, trending an approximate N30°W. About 40 miles southeast of Willbob Lake map-area, in Michikamau Lake map-area (Wynne-Edwards, 1960), the fault evidently merges with the fault bounding the known Kaniapiskau rocks on the east and generally taken to be the eastern boundary of the Labrador Trough. Within the map-areas, the Walsh Lake fault is accentuated physiographically by a prominent front with steep slopes up to 500 feet high on the southwest side, and by straight water courses following its valley. On the northeast side, the easily eroded rocks of the Murdoch Formation form gentler hills and extensive tracts with low relief. The valley bottom is everywhere covered with drift or water so that the fault cannot be directly observed. However, strata of the Menihek Formation and some of the associated sills between Walsh and Connolly Lakes curve into and are truncated by it. Southeast of the map-areas, the truncation of fold structures in the Knob Lake Group by this fault is more pronounced (Donaldson, 1960). The Walsh Lake fault is marked by intermittent concentrations of carbonate and hematite in the nearby rocks.

Cleavage in the schistose rocks adjacent on the northeast for the most part parallels the trace of the fault and dips northeastward at 35° to 75°. From this and the rectilinear course, the fault is presumed to dip steeply to the northeast. The nature of the relative movement, however, is not readily determined in these map-areas. While some upward movement of the northeast side probably occurred, as indicated by the absence of the truncated Knob Lake strata, the major component of the movement may have been horizontal. The occurrence, on Dobbin Lake and near Walsh Lake, of pinnate cleavage in the Murdoch Formation pointing northwest into the fault may signify northwestward movement of the northeast block.

Kavanagh (1954) deduced such left-hand lateral displacement from consideration of the attitude of cleavage and axes of minor folds on either side of the fault near Walsh Lake. On the other hand, prominent drag-like buckles on limbs of major folds near Donald Lake (Pl. I), Retty Lake, and Lac Eracourcie, in Willbob Lake map-area, and Hyland Lake (Pl. XVI) and Kalko Lake, in Thompson Lake map-area, strongly suggest a south or southeastward-directed force component during regional deformation, which would produce right-hand displacement on the Walsh Lake fault, provided it is co-genetic with the folding. In addition, evidence has been cited from southeast of the map-areas to indicate right-hand transcurrent movement (Donaldson, 1960; Labrador Mining and Exploration Company, private reports). The available evidence thus appears to be too inconclusive for generalizations to be made regarding the relative displacement along this structure as a whole. In general, the Walsh Lake fault resembles features classed as wrench-faults (De Sitter, 1956).

Central Division

This zone contains most of the recognized faults of the map-areas. The most persistent and numerous are strike faults trending about N40°W, and manifested chiefly by shearing, chloritization, and fracturing along linear depressions. Bleaching, carbonatization and sulphide mineralization are other effects observed along these structures. The displacement along the strike faults does not appear to have been great, as there is no major dislocation of transected fold structures. Along the northeast edge of the Doublet Group in Thompson Lake map-area, the concentration of strike faults adjacent to and parallel with the Elsie Lake fault has resulted in the conversion of much of the Willbob Formation to chloritic schistose rocks.

Numerous small faults trending east, northeast, or north have displaced the formations of this zone a slight to moderate amount, notably east and southeast of Thompson Lake. Included on the map with these, as probable faults, are a number of lineaments along which movement is not definitely known to have taken place.

Northeastern Division

A few northwest-trending faults marked by strong, persistent lineaments occur in the Laporte Group. Shorter lineaments trending northeast to north are also believed to represent faults. The relative displacement and, sometimes, the length of these faults could not be learned because of the lack of outcrops and marker beds.

Chapter IV

ECONOMIC GEOLOGY

The map-areas formerly lay within two large concessions held by Hollinger North Shore Exploration Company and Labrador Mining and Exploration Company. The part of the region lying in Quebec was held by the former company and that in Labrador by the latter, which performed the actual exploration work in both concessions. Prospecting of the eastern part of the concessions began in 1942, primarily for base metals. In 1943, detailed investigation of mineral showings in and near the map-areas was carried out, and in 1944, the better prospects were tested by shallow drilling. In 1949, detailed surveys near Frederickson Lake, Lac Faute, Connolly Lake, and Walsh Lake were carried out, and in 1953, a strip a few miles wide extending from Walsh Lake northeast to Kalko Lake was re-examined. Subsequent work, mainly by geophysical methods, was done at selected localities. In 1955, 1956, and 1957, the Canadian Johns Manville Company prospected the ultrabasic rocks and examined asbestos showings in both map-areas.

Base Metals

Mineralization in Sediments

Exploration for base metals was prompted by the widespread distribution of sulphide minerals in a variety of rock types along the east side of the Labrador Trough. In these map-areas, mineralization is chiefly in the dark argillaceous sediments, although sulphides also are found in other strata and in basic and ultrabasic sills. The more promising showings consist of mineralized dark shale or slate, in some instances with the marginal parts of adjacent sills. In approximate order of abundance the sulphide minerals are: pyrite, pyrrhotite, chalcopyrite, sphalerite, and galena. Arsenopyrite has been reported (Labrador Mining and Exploration Company, private reports), but was not seen by the writer. The dominant mineralization in the dark shales consists of barren pyrite–pyrrhotite. These minerals are typically fine-grained replacements, selectively following particular laminae or thin beds (Pl. XVII). Fifty per cent or more of such layers may be replaced, but there is marked contrast in sulphide content between adjacent laminae of otherwise similar appearance. The iron sulphides also form coarser crystals or crystal aggregates replacing the shale, or coating fractures therein. The replacement of dark shales is prevalent, and although normally these sediments are poorly exposed, the intermittent occurrence of gossans and small mineralized outcrops or frost-heaved frag-

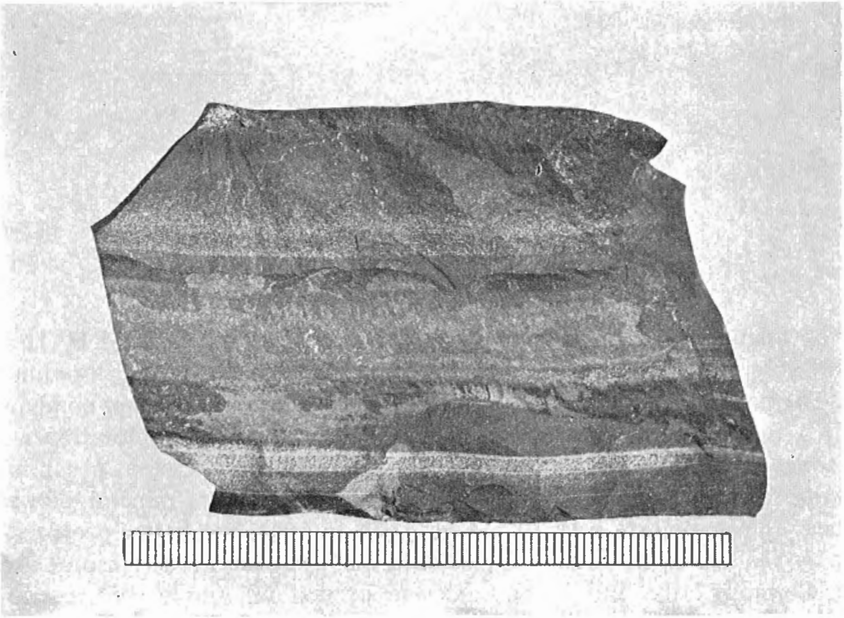

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PLATE XVII. Hand specimen of Menihek shale near Frederickson Lake, Willbob Lake map-area, showing selective sulphide replacement. Note thin laminae entirely replaced (lower), barren layers, and incomplete replacement decreasing upward (top) (millimetre scale).

ments along strike suggest the lateral persistence, for miles, of sulphides in some sedimentary bands, as for example the one above the main ultrabasic sill at Thompson Lake.

The copper, lead, and zinc sulphides are also fine-grained disseminations. Although consistently present in the better showings, they appear to be spatially restricted compared to the iron sulphides. As some assays showed the presence of nickel, a small amount of nickeliferous pyrrhotite apparently accompanies the chalcopyrite, sphalerite, and galena in places. Low silver values were also obtained at some showings. Relatively well-mineralized sedimentary zones up to 1,500 feet long were intersected during the course of diamond drilling (Labrador Mining and Exploration Company, private reports).

Mineralization in Igneous Rocks

Sulphide mineralization in the basic and ultrabasic sills appears to be related mainly to shearing, and was observed mostly along the margins. However, the sills on the whole are not widely mineralized, and most shear zones are barren. Here and there, sulphides of apparently primary origin are disseminated in massive gabbroic and ultrabasic rocks. Normally pyrrhotite is the chief sulphide in gabbroic sills, with lesser amounts of pyrite and minor chalcopyrite. At the drilled deposits, the mineralization also includes chalcopyrite, sphalerite, galena, nickeliferous pyrrhotite, and pyrite. In contrast with the writer's observations, mineralization, in ultrabasic sills in general, has been said to be more abundant in serpentinized peridotite of the interior type, rather than in the high tremolite–actinolite border type (Findlay, 1958). The sulphides encountered commonly in basalt, and rarely in arenaceous sediments, are also typically related to shear zones or cross-fractures, and are, as a rule, iron sulphides. The basalt of such zones commonly has a bleached appearance.

Sulphide-Bearing Late Veins

Some of the numerous small quartz veins scattered over the map-areas carry minor amounts of sulphides, but are not of economic interest. Rare calcite veins with minor quantities of chalcopyrite and magnetite were also observed.

Gossans

The development of prominent gossans is characteristic of the sulphide zones, and these are a useful guide to some of the mineral deposits, as they are readily visible from aircraft and nearby hilltops. As most sulphide zones lie on slopes, the iron of these gossans has been moved varying distances downhill by surface and underground water, to form a veneer, commonly containing abundant organic matter. Such transported gossans range from a few feet to more than a thousand feet in length, but their size is not necessarily proportional to that of the source deposit. Their exact position and areal extent appear to be controlled essentially by local topographic factors. A few slate fragments with sulphides were observed in indigenous gossans. The location of gossans in the map-areas is shown on the maps (*in pocket*).

Stages of Mineralization and Origin

Observed field evidence corroborated by information in company reports indicate two or more stages of mineralization. In the first, iron sulphides were formed in the shales. This preceded at least some deformation, since at several localities, iron sulphide replacements in sediments are sheared. Copper, zinc, lead, and more iron sulphides followed, occupying shear zones and in some places filling fractures. Commonly, a small amount of quartz gangue accompanied these sulphide minerals, which were deposited in both sedimentary and igneous rocks. A third, if insignificant, phase of mineralization, presumably occurring after the relief of regional compressive forces, is represented by the minor sulphide content in fissure-filling quartz veins.

Because of the widespread and persistent nature of the selective iron sulphide layers of the shaly sediments southwest of the Walsh Lake fault, Kavanagh (1954) and others regarded these as syngenetic. The later mineralization has generally been ascribed to a hydrothermal origin, related to the gabbroic magma source. It seems significant that, regionally, the area of persistent iron sulphide shale replacement, with its included copper, zinc, and lead deposits, is coextensive with the Wakuach gabbro belt, and that outside it, to the southwest of the map-areas, are broad areas of unmineralized Menihek shales, with only local occurrences of pyrite. In the main iron ore zone, black slates of the Ruth and Sokoman Formations seem also to be virtually barren of sulphides (Harrison, 1952). A fundamental relationship is thus suggested between all the sulphide mineralization of the map-areas and the basic and ultrabasic igneous rocks.

Although interesting estimates of copper, zinc, and nickel were obtained from some of the showings, these metals were too spotty or tonnages outlined were too small to warrant extensive development, and there has been no base metal production from the map-areas.

Asbestos

Narrow chrysotile-bearing veinlets occur sporadically in the ultrabasic sills of the map-areas. In the occurrences prospected in Thompson Lake map-area, these appear to be concentrated in fracture zones related to prominent cross-faults. The results were insufficient to merit further work.

Description of Deposits

Frederickson Lake

Diamond drilling was carried on at three separate localities northwest of the western extremity of Frederickson Lake. The deposits occur along the strike of the Menihek sediments and the adjoining gabbro sill, which trend N35°W and dip 60 to 90°E.

The southernmost showing lies about half a mile from the lake and consists of a vein-like replacement body in gabbro, averaging 13 feet wide, dipping 45°NE, and apparently persisting northwestward for 660 feet. Drilling disclosed deposits with average values of about 7 per cent zinc, 1.3 per cent copper, and 0.5 per cent lead. Gold and silver of low value are also present (Gilbert and Bergeron, 1957). A thinner, unmapped sedimentary band about 250 feet to the northeast is mineralized as well.

The second showing lies about 2,000 feet northwest of the first. There a small outcrop of gabbro contains pyrrhotite and chalcopyrite, and a dip-needle survey indicated an anomaly extending about 300 feet to the south. A grab sample from the outcrop ran 2 per cent nickel, but core samples from the drilling were low in nickel and copper.

The third showing is about half a mile to the northwest. There, a few outcrops of shaly and cherty sediments scattered along strike carry disseminated sulphides, including galena at the north end, according to company reports. There again drilling results were not encouraging.

Walsh Lake

This showing lies about half a mile south-southwest of the southeast end of Walsh Lake, near the top of the east-facing hillside rising southwest of the Walsh Lake lineament. At this locality there are several narrow bands of mineralized

Menihek shales and, in addition, a band of sulphide-rich gabbro. The rocks are poorly exposed, but the occurrence is marked by a conspicuous yellow-orange gossan, 400 or 500 feet long, on the hillside. The sediments near the showing contain a thin volcanic intercalation. The strata have been warped, sheared, and drag-folded. Only pyrite and pyrrhotite were seen at the surface.

Diamond drilling was carried out on anomalies outlined by dip-needle surveys. The mineralized shale proved to be relatively barren of metals of economic interest. The gabbro zone yielded encouraging values in copper and nickel but proved to be narrow.

Doublet Lake

This occurrence is about 3,000 feet southeast of the southwest arm of Doublet Lake. There a band of sediments near the top of the Thompson Lake Formation and flanked by basic sills lies on a large anticlinal warp or dragfold. It strikes N5°E and dips eastward at a moderate angle. In the upper part of the band, slate and greywacke have been sparingly replaced over a zone at least 1,500 feet long and as much as 200 feet wide. Sparse sulphides also appear in the adjacent border of the basic sill. A few laminae seen in the drill core were abundantly replaced by iron sulphide and minor chalcopyrite. Small gossans appear over the same sedimentary band about 2,000 feet north of the showing. The drilling resulted in low assays in copper, zinc, and nickel.

Indian Lake

About 3,500 feet south of the west end of Indian Lake, near the southeast corner of Willbob Lake map-area, a small sulphide showing is present in poorly-exposed, sheared sediments lying near the crest of another large anticlinal dragfold in the Doublet Group. Several bands of rusty schist were observed nearby, and it appears that a broad shear zone trends east along the fold axis. The sediments are bordered by basic sills and flows. As shown by drilling, they contain moderate to small amounts of pyrite, pyrrhotite, and chalcopyrite.

Lac Faute

A fairly well-exposed showing occurs about 2,200 feet southwest of the central part of Lac Faute, near the south boundary of Willbob Lake map-area. A band of slaty shale and argillite of the Menihek Formation lies between gabbro sills and trends N40°W, dipping steeply northeast. Some chert layers occur in the argillite. At one place, the gabbro contact is well exposed, showing a chilled zone a few inches wide above the conformable boundary. With the possible exception of undulations in the bedding, the shales are undeformed and unmetamorphosed by the intrusion. The mineralization, consisting of disseminated pyrrhotite, pyrite, and possibly some chalcopyrite in the shale was traced along strike for about a quarter of a mile, but is too lean to be of economic importance. Small vuggy veinlets of chert and quartz carrying the same sulphides cut the sediments.

Retty Lake

A number of sulphide concentrations in ultrabasic rocks flanking the south bay of Retty Lake were tested by drilling in 1957 (Findlay, 1958). The showings contain pentlandite, sphalerite, chalcopyrite, pyrrhotite, and magnetite, but are not of economic significance.

Other Deposits

On the preceding pages are described those areas known to carry minerals of economic interest and on which appreciable work, including drilling, was done. Scattered over the map-areas are numerous other showings, of which the more interesting are mentioned here.

1. About $1\frac{1}{2}$ miles north of the northwest end of Willbob Lake, a number of sulphide deposits appear along strike near the top of a prominent northwest- to west-facing slope. Most of the hillside is underlain by sediments of the Thompson Lake Formation, invaded by basic and ultrabasic sills, and overlain by flows of the Willbob Formation. There, as in the general area east of Donald Lake, the sediments and sills form well-defined, southeasterly-plunging anticlines and synclines, whereas at or near the boundary with the resistant igneous formation above, there is an abrupt change to more gentle flexuring. The sulphides lie along the boundary zone where extensive shearing and slippage has taken place between the two units. Locally, the rocks near the deposit are intensely altered to carbonate. Barren quartz stringers are numerous in places along the zone.

Small areas replaced by pyrite, pyrrhotite, and possibly chalcopyrite are exposed in slate, chloritic schist, gabbro, and ultrabasic rock. Sulphides can be traced, mostly by intermittent gossans, around the structure for at least a mile, and are marked by some of the largest gossans observed in these map-areas. However, the showings were stripped and presumably sampled, with unsatisfactory results.

2. Another zone of deformation and mineralization lies between the southeast end of Willbob Lake and the large ultrabasic sill about three-quarters of a mile to the east. Several small valleys lie in this zone, separating bands of peridotite, meta-gabbro, and flows, and some of these draws are underlain by slate. Considerable shearing has taken place in this zone and many outcrops are schistose.

Disseminated pyrite and pyrrhotite occur along these depressions in slate, chlorite schist, and bleached volcanic rocks. Although sulphides of economic interest were not identified, much of the ground is low and swampy. The most persistent mineralization may occur between the two upper ultrabasic sills.

3. About a mile from the northeast shore of Lac Eracourcie, Willbob Lake map-area, slate beds near the top of the Thompson Lake Formation have been replaced by fine-grained pyrite and pyrrhotite, along a zone about 1 mile long. The mineralization is only manifested by intermittent small gossans and sulphide-bearing chips of slate. This band appears to be a continuation of the drilled zone near Doublet Lake to the north.

4. Near the north edge of Willbob Lake map-area, in the first drainage valley southwest of the west arm of Retty Lake, upper Thompson Lake sediments are replaced by pyrite and pyrrhotite. Abundant iron sulphides were seen on the west shore of the narrows in the small lake just south of the map boundary. Sparser disseminations occur along the valley to the northwest, extending into Thompson Lake map-area, where small gossans appear. This horizon, in fact, shows mineralization of this type at intervals all around the major syncline southwest of Retty Lake.

5. One mile east of the south end of Thompson Lake, several small gossans indicate the presence of sulphides in the corresponding upper Thompson Lake strata. Locally, the adjacent flows and sills are also mineralized. The persistent recurrence of sulphides at this horizon is shown again a few miles to the northwest, where they can be traced around the major structures east of Gomez Lake. Nowhere, however, were showings of economic importance seen.

6. Coarse blebs of chalcopyrite and pyrite were seen here and there, in minor amounts, in the schistose fragmental rocks of the Murdoch Formation. Elsewhere in the formation, sulphide mineralization appears to be related to the contacts of meta-gabbro–meta-diorite sills, as for example near the northeast shore of Walsh Lake, Willbob Lake map-area, where Kavanagh (1954) noted sulphides disseminated in the volcanic rocks and conglomerate, and in quartz and calcite veins cutting the former, near the margins of small dioritic offshoots from the main intrusion there. Sulphides, in some cases in quartz veins, were also described as occupying fractures in the intrusive rock, and this mineralization at Walsh Lake was considered post-deformational. A closer relationship with the intrusions of the Murdoch Formation may be indicated in Thompson Lake map-area where pyrite and chalcopyrite are disseminated in dioritic meta-gabbro about half-way between Dobbin Lake and the south end of Duncan Lake, and on the island in Keating Lake near the inlet from Kalko Lake.

Just east of the east bay of Keating Lake, a calcite vein, described by Kavanagh (1954) as 150 feet wide, carries as much as 5 per cent disseminated magnetite and lesser amounts of pyrite, but is not of economic importance. A vein or veins up to 5 feet wide, carrying sulphides including chalcopyrite and galena, occurs on islands in about the middle of Kalko Lake, in carbonatized meta-gabbro.

Future Possibilities

As indicated, base metal occurrences are generally widespread along the east side of the Labrador Trough. They are well known and have received considerable attention at intervals since their discovery. The latest revival of interest was in the years 1960–1963, mainly northwest of the map-areas. Results of the work done on the showings described above indicate that a substantial increase in metal prices is required to encourage more advanced development in the report area. As the district appears to have been prospected thoroughly by various methods, significant additional discoveries are unlikely, except possibly through techniques not utilized heretofore.

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