CANADA
DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA
MEMOIR 283

COURAGEOUS-MATTHEWS LAKES AREA, DISTRICT OF MACKENZIE, NORTHWEST TERRITORIES

BY

J. C. G. Moore

EDMOND CLOUTIER, C.M.G., O.A., D.S.P.,
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1956.

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PLATE I

R. E. F. 5-3-48

Characteristic flat surface, Matthews Lake. Mafic lavas in left foreground, felsic lavas in centre foreground, sedimentary rocks in background.

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PREFACE

Gold was discovered in 1939 near Courageous Lake in the Barren Lands 150 miles northeast of Yellowknife. From 1946 to 1951 certain gold prospects were explored by limited surface trenching, diamond drilling, and underground development. In 1944 officers of the Geological Survey of Canada commenced reconnaissance geological investigations in the district and in 1950 and 1951 the detailed field studies described in this memoir were undertaken to assist prospectors and those directing exploration of the deposits.

The part of the prospecting belt described in detail is underlain by volcanic and sedimentary rocks occupying an area from 4 to 6 miles wide and more than 40 miles long. These formations are similar in many details to those at the Yellowknife camp and other gold camps within the Canadian Shield. In each camp, however, certain details vary significantly, but such features are recognized only after detailed field and laboratory studies. The report discusses in detail the particular geological problems of this area, giving the average mineral composition of the rocks in ten tables and illustrating their regional and local structure in four figures. The gold deposits and their development are described in detail.

The report is accompanied by two geologically coloured maps on a scale of 1 inch to 2,000 feet and the illustrations include four plates and six figures.

GEORGE HANSON,
Director, Geological Survey of Canada

OTTAWA, April 5, 1955

Courageous-Matthews Lakes Area, Northwest Territories

CHAPTER I

INTRODUCTION

GENERAL STATEMENT

The Courageous-Matthews Lakes area is in the southwest corner of the Lac de Gras map-sheet, District of Mackenzie, and lies between latitudes 63°56′ and 64°19′ and longitudes 111°00′ and 111°30′. The east arm of Courageous Lake divides the area almost in half and this lake is 150 miles northeast from Yellowknife on Great Slave Lake. The area described includes more than three-quarters of a volcanic belt 40 miles long and 1 mile to 4 miles wide. The part of this belt mapped in detail during the summers of 1948 and 1949 is about 26 miles long and 5 to 6 miles wide and covers an area of about 150 square miles. Geological mapping was done on aerial photographs enlarged from 1 inch equals 2,640 feet to 1 inch equals 800 feet. Preliminary maps, on a scale of 1 inch to 1,500 feet, Folinsbee and Moore (1950)* and Moore (1951) show the outcrops.

The area is easily accessible by aircraft from Yellowknife. The large lakes break up from June 10 to July 10 and may freeze as early as mid-September. A proposed winter tractor road from Thompson Landing on Great Slave Lake to Matthews Lake would be about 90 miles long. Travel by canoe in the area is restricted mainly to the lakes because most streams connecting lakes are not navigable. Lack of trees facilitates travel overland by foot.

Gold was discovered in the Courageous Lake area in 1939 by Territories Exploration Limited under the direction of W. L. Brown. The claims containing the Salmita Consolidated Gold Mines Limited and Bulldog Yellowknife Gold Mines Limited deposits were staked in 1945. The mapping program was undertaken to provide a detailed map of the area as an aid in its prospecting and in the development of known deposits.

ACKNOWLEDGMENTS

Previous geological mapping in the area was done by J. F. Henderson (1944) and R. E. Folinsbee (1949) and the results of this were published on a scale 1 inch to 4 miles. During the field season of 1948, detailed mapping was mainly confined to the Matthews Lake area and was under the direction of R. E. Folinsbee; during the field season of 1949, mapping was under the direction of the writer. In 1948 student assistants, in addition to the writer, were S. W. Holmes and C. Youngren, and in 1949 B. R. Pelletier, R. A. W. Simpson, and L. P. Purcell. All assistants undertook independent mapping. Courteous assistance was given by officers of the Bulldog Yellowknife Gold Mines Limited and Salmita Gold Mines Limited. Newnorth Gold Mines Limited kindly gave permission to use their cabin on Courageous Lake in 1949. The writer wishes to thank Professor M. P. Billings and Professor H. E. McKinstry of Harvard University for general criticism and helpful suggestions in the preparation of the manuscript.

* Dates in parentheses refer to those in Selected Bibliography at the end of this chapter.

PHYSICAL FEATURES

The Courageous-Matthews Lakes area displays the low relief characteristic of much of the Canadian Shield (*see* Plate I). Elevations in the area range from 1,415 to 1,600 feet and the topography at most localities expresses the character of the bedrock. The highest ridges and the most marked changes of relief, up to 150 feet, are in areas underlain by mafic volcanic rocks, and these rocks form the most conspicuously continuous topographic feature of the area. Rounded hills with changes of relief ranging from 50 to 100 feet characterize areas underlain by granitic rocks. Here and there, granitic cliffs and linear drift-filled depressions produce a rugged topography. Granitic plutons project above surrounding sedimentary rocks that occupy the lowest areas and also are characterized by the least relief of the area. Such areas are relatively featureless, except when modified by glacial deposits. The sedimentary rocks are commonly frost-thrust, but in a few places the felsic volcanic rocks, as well, are frost-thrust. Frost-thrusting (*see* Plate II) has been described recently by Yardley (1951) and Tremblay (1952).

The only timber in the area consists of stands of black spruce scattered over an area of about ½ square mile at the north end of Courageous Lake. Some of the trees there reach a height of 30 feet and a diameter of 10 inches, but most are about 8 inches in diameter at the base. Much of the timber is large at the butt and of twisted grain, but from it a log cabin 15 feet long and 13 feet wide was built at the northern end of Courageous Lake by Newnorth Gold Mines Limited.

SELECTED BIBLIOGRAPHY

Armstrong, H. S.
(1950) : The Geology of Echo Township; Ann. Rept., Ont. Dept. Mines, vol. 59, pt. 5.

Barlow, A. E.
(1895) : On Some Dykes containing Huronite; Ottawa Naturalist, vol. IX, No. 2, pp. 25-47.

Brown, I. C.
(1949) : Structure of the Yellowknife Gold Belt, Northwest Territories; unpublished Ph.D. thesis, Harvard University, May 1949.

Cooke, H. C., James, W. F., and Mawdsley, J. B.
(1931) : Geology and Ore Deposits of the Rouyn-Harricanaw Region, Quebec; Geol. Surv., Canada, Mem. 166.

Daly, R. A.
(1933) : Igneous Rocks and the Depths of the Earth; McGraw-Hill, New York.

Derry, D. R.
(1939) : Some Examples of Detailed Structure in Early Precambrian Rocks of Canada; Quart. Jour. Geol. Soc. London, vol. 95, p. 126.

Emmons, R. C. *et al.*
(1953) : Selected Petrogenetic Relationships of Plagioclase; Geol. Soc. Amer., Mem. 52.

Evans, J. E. L.
(1944) : Porphyry of the Porcupine District, Ontario; Bull. Geol. Soc. Amer., vol. 55, pp. 1115-1142.

Fairbairn, H. W.
(1936) : Elongation in Deformed Rocks; Jour. Geol., vol. 44, No. 6, pp. 670-680.

Flaherty, G. F.
(1936) : Mechanics of Structure at Tashota Goldfields Mine, Tashota, Ontario; Can. Inst. Min. Met., Bull. 295, pp. 723-738.

Folinsbee, R. E.
(1949) : Lac de Gras, District of Mackenzie, Northwest Territories; Geol. Surv., Canada, Map 977A.
(1950) : Walmsley Lake, Northwest Territories; Geol. Surv., Canada, Paper 50-4.

Folinsbee, R. E., and Moore, J. C.
(1950) : Matthews Lake, Northwest Territories; Geol. Surv., Canada, Paper 50-2.

Fortier, Y. O.
(1946) : Yellowknife-Beaulieu Region, Northwest Territories; Geol. Surv., Canada, Paper 46-23.
(1947) : Ross Lake, Northwest Territories; Geol. Surv., Canada, Paper 47-16.

Gunning, H. C.
(1941) : Bousquet-Joannes Area, Quebec; Geol. Surv., Canada, Mem. 231, p. 21.

Gunning, H. C., and Ambrose, J. W.
(1940) : Malartic Area, Quebec; Geol. Surv., Canada, Mem. 222, pp. 50-54.

Henderson, J. F.
(1936) : Geology and Mineral Deposits of Ville-Marie and Guillet (Mud) Lake Map-areas, Quebec; Geol. Surv., Canada, Mem. 201.
(1941) : Gordon Lake South, Northwest Territories; Geol. Surv., Canada, Map 645A.
(1943) : Structure and Metamorphism of Early Precambrian Rocks Between Gordon and Great Slave Lakes, Northwest Territories; Am. Jour. Sci., vol. 241, pp. 430-446.
(1944) : MacKay Lake, District of Mackenzie, Northwest Territories; Geol. Surv., Canada, Map 738A.

Horwood, H. C.
(1940) : Geology and Mineral Deposits of Red Lake Area; Ont. Dept. Mines, vol. 49, pt. 2.

Jolliffe, A. W.
(1942a) : Structures in the Canadian Shield; Trans. Am. Geophysical Union, pt. 11, pp. 699-707.
(1942b) : Yellowknife Bay, District of Mackenzie, Northwest Territories; Geol. Surv., Canada, Map 709A.

Larsen, E. S., Irving, J., Gonyer, F. A., and Larsen, E. S. 3rd
(1937) : Petrologic Results of a Study of the Minerals from Tertiary Volcanic Rocks of the San Juan Region, Colorado; Amer. Mineral., vol. 22, No. 8, pp. 889-905.

Lord, C. S.
(1942) : Snare River and Ingray Lake Map-areas, Northwest Territories; Geol. Surv., Canada, Mem. 235.
(1951) : Mineral Industry of District of Mackenzie, Northwest Territories; Geol. Surv., Canada, Mem. 261.

Lord, C. S., and Barnes, F. Q.
(1954) : Aylmer Lake, Northwest Territories; Geol. Surv., Canada, Map 1031A.

Matheson, A. F.
(1945) : Private report, Newnorth Gold Mines Limited.

Misch, P.
(1949) : Metasomatic Granitization of Batholithic Dimensions, Pt. 2, Static Granitization in Sheku Area, Northwest Yunnan (China); Am. Jour. Sci., vol. 247, No. 6, pp. 372-406.

Moore, J. C. G.
(1951) : Courageous Lake, Northwest Territories; Geol. Surv., Canada, Paper 51-14.

Moore, J. C. G., Miller, M. L., and Barnes, F. Q.
(1951) : Carp Lakes Area, Northwest Territories; Geol. Surv., Canada, Paper 51-8.

Moorhouse, W. W.
(1942) : The Northeastern Portion of the Timagami Lake Area; Ann. Rept., Ont. Dept. Mines, vol. 51, pt. VI, pp. 1-42.

Satterly, J.
(1941a) : Pillow Lavas from the Dryden-Wabigoon Area, Kenora District, Ontario; Univ. Toronto Studies, Geol. Ser. No. 46, pp. 119-136.
(1941b) : Geology of the Dryden-Wabigoon Area; Ann. Rept., Ont. Dept. Mines, vol. 50, pt. 2.

Singer, H. H.
(1951) : Salmita Consolidated Mines, Limited, Progress Report.
(1952) : Salmita Consolidated Mines, Limited, Progress Report.

Swanson, C. O.
(1941) : Flow Cleavage in Folded Beds; Bull. Geol. Soc. Amer., vol. 52, pp. 1245-1264.

Todd, E. W.
(1926) : Anima-Nipissing Lake Area; Ann. Rept., Ont. Dept. Mines, vol. 35, pt. 3, p. 85.

Tremblay, L. P.
(1952) : Giauque Lake Map-area, Northwest Territories; Geol. Surv., Canada, Mem. 266.

Turner, F. J.
(1948) : Mineralogical and Structural Evolution of Metamorphic Rocks; Geol. Soc. Amer., Mem. 30.

White, W. S.
(1949) : Cleavage in East-central Vermont; Trans. Am. Geophysical Union, vol. 30, No. 4, Aug., pp. 587-594.

White, W. S., and Billings, M. P.
(1951) : Geology of the Woodsville Quadrangle, Vermont-New Hampshire; Bull. Geol. Soc. Amer., vol. 62, pp. 647-696.

Yardley, D. H.
(1951) : Frost-thrusting in the Northwest Territories; Jour. Geol., vol. 59, pp. 65-69.

CHAPTER II

GENERAL GEOLOGY

GENERAL SUMMARY

All consolidated rocks in the Courageous-Matthews Lakes area are of Precambrian age and probably Archæan, with the exception of some dykes of diabase. The oldest rocks are steeply dipping lava flows of the Yellowknife group*, which are continuous the full length of the area surveyed. The total thickness ranges from a maximum of 16,500 feet to a minimum of 4,000 feet. The variation in thickness is probably in part primary, but the removal of the lavas by effects of the introduction of granite is believed by the writer to be an important factor in determining the exposed thickness.

For purposes of mapping, the volcanic rocks were divided primarily into mafic lavas, which weather light green, light grey, dark green, and black, and felsic lavas, which weather light grey, pink, and buff. Further subdivisions are shown on the maps accompanying the memoir. The basal members of this volcanic group are predominantly a mixed assemblage of mafic lavas, massive and fragmental, but in places they contain interbedded slates, phyllites, and mica schists. These rocks are commonly overlain by pillowed flows, amygdaloidal flows, and porphyritic flows. Although the felsic lavas form the upper member of the assemblage, they are interbedded also with the lower mafic members in a few places.

Sedimentary rocks of the Yellowknife group conformably overlie the volcanic rocks, comprise greywacke, slate, quartzite, arkose, and their metamorphosed equivalents, and are at least 5,000 feet thick. Here and there, at the base, are a few grey weathering felsic flows and tuffs.

Strata of the Yellowknife group have been folded closely and invaded by granodioritic and dioritic rocks. Large areas in the volcanic rocks are metamorphosed to mafic and felsic schists and the sedimentary rocks around some of the plutons are metamorphosed to nodular schist. Contacts of schist with intrusive rocks are sharp where observed. About 20 per cent of the contact is marked by areas of mixed granodioritic and mafic rocks, and about 15 per cent of the contact is marked by granitic gneisses.

The Yellowknife group strata are intruded by sills of meta-gabbro and irregular masses of felsic porphyries. Dykes of diabase and gabbro are the youngest consolidated rocks in the area and are probably Proterozoic in age.

The approximate percentage by area of the rock types, according to their origin, are: sedimentary rocks 50, volcanic rocks 30, and granodioritic rocks 20.

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* The name Yellowknife group as described by Jolliffe (1942b) includes volcanic and sedimentary formations about Yellowknife Bay that are older than the widespread granitic intrusive rocks. Henderson (1944) extended this group name to MacKay Lake, and in this report the same formations also are placed in the Yellowknife group, although these formations have not been traced continuously to Yellowknife Bay. They are placed in this group solely because of lithological similarity to rocks of the original locality and because of similar relationship to granitic intrusions.

TABLE OF FORMATIONS

Era		Lithology	Estimate of thickness feet
Cenozoic	Pleistocene	Sand, gravel, and clay	
	Great unconformity		
Proterozoic		Diabase and gabbro	
	Intrusive contact		
Archæan or Proterozoic		Quartz-feldspar porphyry, quartz porphyry, feldspar porphyry, and meta-gabbro	
	Intrusive contact		
		Biotite granodiorite and related rocks	
	Intrusive contact		
		Quartz diorite and related rocks	
	Intrusive contact		
Archæan	Yellowknife group	Greywacke, slate, quartzite, arkose; quartz-feldspar mica schist, phyllite, and nodular schist	5,000
		Meta-gabbro and porphyritic meta-gabbro	0 to 4,000
		Felsic lavas (meta-rhyolite and meta-dacite); agglomerate, breccia, buff and minor mafic lava; feldspar porphyry, quartz porphyry, and quartz-feldspar porphyry	0 to 8,000
		Mafic lavas (meta-andesite and meta-basalt); amphibolite, agglomerate, breccia, and tuff; conglomerate; minor felsic lavas	2,000 to 12,000

YELLOWKNIFE GROUP

MAFIC LAVAS (META-ANDESITE AND META-BASALT)

Terminology

In mapping intermediate to basic rocks in the Canadian Shield, it has been customary to use the term andesite for grey to light green varieties and the term basalt for dark green to black varieties. In most places where these terms have been used the inference is that they represent the metamorphic derivatives of these rocks and that a more exact terminology would class them as meta-andesite and meta-basalt. However, in only a few instances have chemical analyses been made, and it has long been questioned "whether the present composition is sufficiently like the original composition to be of much value for purposes of comparison" (Cooke, James, and Mawdsley, 1931, p. 29).

Satterly (1941a) provides a compilation of chemical analyses that include four of the lighter coloured varieties. Two of these analyses approach a basaltic or quartz-basaltic composition, and a third, based in part on microscopic examination, is believed to represent a silicified basalt. On the other hand, from chemical analysis of the grey-green variety, Horwood (1940) reports an andesitic composition.

In Courageous-Matthews Lakes area the use of the terms "basalt" and "andesite" has been avoided although, in mapping, a colour distinction has been made as shown in the map-legend. Satterly (1941a) "is of the opinion that many green lavas so often mapped as andesites are actually basalts and that they are green because of the development of chlorite or hornblende as products of metamorphism". The present writer agrees with this in part. Microscopic examination of twenty thin sections of the light green to grey variety reveals that the lighter colour can be caused by an increase in the amount of one of the following minerals: feldspar, chlorite, epidote, or carbonate. In fact, in a few of these sections the light green varieties appear to have approximately the same composition as some of the dark green to black varieties and the results from the study of these examples suggest that the separation of the light- from the dark-coloured varieties is artificial. The term mafic is used because, in the averaging of the measured modes, mafic minerals amount to more than 50 per cent of these rocks.

In addition to colour distinction, the following types of lava were recognized: pillowed, amygdaloidal, porphyritic, ropy and fragmental, schistose, and carbonatized. The term schistose lava was used to distinguish those lavas in which foliation was well developed over large areas. Schists in which chlorite could be distinguished megascopically are restricted in distribution, so far as observed, to a small area within 2,000 feet of the granodiorite contact, in the Courageous Lake area, near latitude 64°09′30″ and longitude 111°21′30″. Carbonatized lava refers to those rocks containing a rusty weathering carbonate that occurs in some schist and in small amounts in certain massive flows.

General Statement and Lithology

The mafic lavas, which range in thickness from 2,000 to 12,000 feet, extend the full length of the area, bounded by the granitic rocks on the west and conformably overlain by the sedimentary rocks or felsic lavas on the east. These mafic lavas are massive to schistose, fine to medium grained, and are essentially hornblende schists, amphibolites, or epidote amphibolites. They weather light grey to light green and dark green. Fresh surfaces are green to black. The grain size is commonly less than 2 mm. and rarely larger than 3 mm.

An examination of eighty thin sections revealed fine- to medium-grained, recrystallized aggregates of the average mineral composition given in Table I*.

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* The percentage of minerals by volume given in this report was estimated using an area-percentage card that showed the following percentages: 2, 5, 10, 20, 35, and 50. Rosiwall analyses were done on 10 per cent of the thin sections of each map-unit and the results of these checked within 3 per cent on percentages above 20 and within 2 per cent on those below 20.

TABLE I

Average Mode of Mafic Lavas

	Range	Average
	%	%
Plagioclase (An_5-An_{45})	0–50	35
Quartz	0–10	tr.
Hornblende	0–95	45
Biotite	0–35	4
Chlorite	0–60	8
Epidote	0–35	7
White mica	0–15	tr.
Carbonate	0–20	1
Titanite	0– 5	tr.
Apatite, pyrite, tourmaline, magnetite, garnet	——	tr.

In places epidote replaces feldspar partly or completely, or forms veinlets transecting the rock. At least two types of chlorite are present: one shows the typical anomalous blue interference colour and has positive elongation (probably negative penninite), whereas the other has an interference colour ranging from grey to buff to bronze and has negative elongation. The plagioclase ranges in composition between An_5 and An_{45}, but most of it is so altered to epidote or saussurite that it cannot be determined. Hornblende has an extinction angle of $Z \wedge C$ 15-20 degrees, Z=blue-green, X=light green, Y=yellowish green. The garnet found in the ropy lavas has a low index (1.723) and low specific gravity (3.56); it is possibly pyrope or grossularite.

The chemical composition of two samples of the mafic lavas is given in Table II, and for comparison the average of 43 analyses of plateau basalt by Daly (1933, p. 17) is included. The similarities in composition to the plateau basalt suggest that the mafic lavas were originally near a basaltic composition and Table II shows the changes in composition that can produce a chlorite schist and an amphibolite from a basalt.

TABLE II

Chemical Analyses of Lava Flow Rocks and, for Comparison, Average of Plateau Basalt

	1	2	3
	%	%	%
SiO_2	48.63	46.26	48.80
Al_2O_3	12.56	14.36	13.98
Fe_2O_3	1.22	3.21	3.59
FeO	10.91	11.62	9.78
CaO	7.46	10.28	9.38
MgO	5.04	6.91	6.70
Na_2O	2.29	1.83	2.59
K_2O	0.02	0.13	0.69
H_2O+	4.19	2.89	1.80
H_2O-	0.16	0.09	
TiO_2	1.64	1.23	2.19
P_2O_5	0.19	0.12	0.33
MnO	0.21	0.27	0.17
CO_2	5.60	0.97	
Total	100.12	100.17	100.00

1. Chlorite schist, Courageous Lake area, latitude 64°09'10" and longitude 111°20'55". Composition as determined in thin section: 50 per cent chlorite, 40 per cent quartz and feldspar, 10 per cent carbonate, and a trace of magnetite. Analyst, John A. Maxwell, Geol. Surv., Canada.
2. Basic volcanic rock, amphibolite, Matthews Lake area, latitude 64°08'47" and longitude 111°21' 22". Composition as determined in thin section: 75 per cent hornblende, 20 per cent highly altered (saussuritized?) plagioclase, 3 per cent epidote, 2 per cent quartz, and trace of magnetite. Analyst, John A. Maxwell, Geol. Surv., Canada.
3. Plateau basalt, average of 43 analyses (Daly, 1933, p. 17).

Pillowed Lavas. Pillowed lavas, which underlie about 35 per cent of the area of the volcanic rocks, are erratic in their distribution throughout the belt. The pillows vary in size and shape but the average is 3 feet long by 1½ feet wide. Because they are poorly preserved, only a few determinations of the tops of the flows from their contained pillows were possible.

Amygdaloidal Lavas. An amygdaloidal zone that extends 2 miles northwesterly from the northeast bay of Courageous Lake has a maximum exposed width of 800 feet. Some of the pillowed lavas also are amygdaloidal. The amygdules are filled with quartz or calcite or epidote and they are rarely more than 4 mm. long.

Porphyritic Lavas. Although there are a few comparatively isolated bodies, the main porphyritic zone attains a width of 800 feet at about ¾ mile north of the east arm of Courageous Lake. This zone is confined to the flows forming the upper part of the volcanic assemblage so that the easternmost contact of the zone is always within 1,500 feet of the top of the mafic lavas. This zone of discrete porphyritic flows begins near latitude 64°02', longitude 111°13', and from there has been traced northward more than 18 miles. The porphyritic lavas (*see* Plate IIIA), pillowed in places, usually form lenticular bands concordant with the regional schistosity. The flows grade along and across their strike into non-porphyritic types. These porphyritic lavas consist of phenocrysts of feldspar in a groundmass of hornblende and plagioclase. The phenocrysts range in size from 1 mm. to 1½ inches; the most common size is ¼ inch. They are rounded, frayed, and rarely retain their crystal faces. The feldspar of the phenocrysts is commonly altered to some member of the epidote group or saussurite or in places to sericite.

Although porphyritic mafic volcanic rocks have been found here and there throughout the Canadian Shield, they are commonly of limited extent. They were recorded first by Barlow (1895) and since then such rocks have been variously designated basalt porphyry, spotted lava, leopard rock, and bird porphyry. These rocks are described as grading into the surrounding non-porphyritic lava by gradual decrease in the number of phenocrysts, and in the Courageous-Matthews Lakes area porphyritic mafic lava grades into pillowed lavas, some of which have phenocrysts of feldspar. The rounded outline and frayed edges of phenocrysts suggest that these crystals have undergone resorption. Although some porphyritic lava has been found near the base of the volcanic succession, its concentration near the upper part of the assemblage of flows in the Courageous-Matthews Lakes area suggests the phenocrysts began to grow in the magma chamber before some of the earlier flows were extruded. Another occurrence of feldspar phenocrysts in pillow lavas of the Yellowknife group is described by Brown (1949, p. 19) as follows:

"Just south of the dacite flows south of Niven Lake, there is a narrow flow that contains large phenocrysts. These phenocrysts may be single crystals or groups of crystals ranging up to 2 inches in diameter. They occur anywhere in the pillows or in the massive coarse-grained base of the flow. The phenocrysts are identical with the altered feldspar phenocrysts found in the early basic dykes."

The presence of feldspar crystals in pillow lavas is unusual, and it might be suggested that some of the crystals are metacrysts because metacrysts of hornblende up to $\frac{1}{8}$ inch across occur in some pillows about Matthews Lake, but hornblende metacrysts were not recognized in those pillows containing feldspar phenocrysts. If the feldspar phenocrysts are metacrysts their localization, with a few exceptions, to flows near the upper part of the volcanic assemblage is unusual, for metacrysts of hornblende are widespread. Such a localization of feldspar metacrysts implies a restricted zone where metamorphic conditions were especially favourable for their development, and no apparent reason is known why the porphyritic zone is more favourable for the growth of feldspar metacrysts than any other zone in the volcanic rocks. Nor is there anything to indicate that this zone was more sheared or fractured than non-porphyritic zones. Inasmuch as non-porphyritic and porphyritic pillowed lavas are intercalated, probably at a certain stage in the eruption some of the magma became porphyritic and this part was extruded as pillowed porphyritic lava in the succession of non-porphyritic flows.

Ropy and Fragmental Lavas. A zone of ropy and fragmental lava (*see* Plate III B) occurs in the upper 500 feet of the volcanic rocks, and these types are best exposed in the southern part of the area between MacKay and Matthews Lakes. A band of fragmental lava, perhaps 30 feet wide, at latitude 64°04′30″ and longitude 111°18′, lies within the main belt of lava flows. Other zones are present at latitude 64°12′ and at the northern extremity of the area of lava flows. The ropy structure is best seen on an irregularly weathered surface where it resembles a number of entangled ropes. In places lava characterized by the ropy structure is 500 feet thick and this grades downward into massive lava. Within the ropy variety at some locations are beds of tuff and breccia that range in thickness from 5 to 100 feet.

Metamorphism

With the exception of a few bodies of chlorite schist, the mafic lavas are represented by hornblende schist, amphibolite, and epidote-amphibolite containing the minerals hornblende-plagioclase-epidote-chlorite-calcite in almost all combinations. No evidence was noted that the hornblende is a direct alteration product of a pyroxene, and as much of the hornblende is poikilitic it probably represents the product of progressive metamorphism from the greenschist facies.

The mafic volcanic rocks near Courageous Lake average about 12 per cent chlorite and 11 per cent epidote, whereas those near Matthews Lake contain only about 3 per cent chlorite and 3 per cent epidote. A zone of shearing about $3\frac{1}{2}$ miles long is known in the mafic lavas at Courageous Lake and the more intense shearing the rocks have undergone here, as compared with those elsewhere in the area, may explain the greater quantity of chlorite present. The quantity of chlorite, carbonate, and epidote in the volcanic rocks is not related to the distance they occur from exposed bodies of granite although biotite always is present in the lava near granite. As chlorite schist is not widespread in this area that present may represent small areas of the greenschist facies unmetamorphosed to amphibolite. Some chlorite, however, appears to form by replacing hornblende or biotite, and epidote as well as carbonate occurs with this chlorite. Epidote replacing hornblende and pseudomorphic after plagioclase probably is the product of retrogressive metamorphism. The same solutions that affected permeable zones within the mafic lavas to produce the epidote may also have formed chlorite from amphibolite, therefore, almost all of this chlorite is interpreted as a product of retrogressive metamorphism. Chlorite near gold-bearing deposits is always the anomalous blue type and probably formed as an effect of the deposition of the deposits.

MAFIC AGGLOMERATE AND BRECCIA

This map-unit is widespread in the southern part of the area where two bodies at about latitude 64° and latitude 64°04′ attain widths of 1,000 feet and exposed lengths of 7,000 feet. Elsewhere in the southern part of the area, and in the northern part, the bodies are not this large and occur as lenses.

The fragmental rocks of these bodies are highly sheared and include narrow and short bands of mafic and felsic volcanic flows. The fragments make up about 30 per cent of the rock, and are set in a light green to dark green matrix composed principally of hornblende and chlorite with some plagioclase. The fragments range from angular to well rounded and are commonly elongated, seldom exceeding 4 inches in the longest dimension exposed. They consist of varying proportions of quartz, plagioclase, hornblende, chlorite, sericite, and carbonate and are probably andesitic in composition. These fragmental rocks are interpreted as highly sheared pyroclastic agglomerate and tuff that probably were secondarily brecciated. Meta-gabbro always occurs nearby and there is a rough correspondence between the amounts of the two rocks present at a given locality. This association in the field suggests similarities in origin and that the meta-gabbro magma may have entered by the same craters that supplied the pyroclastic material. The pyroclastic rocks, however, may have controlled the localization of the meta-gabbro at these localities by forming lines of structural weakness.

FELSIC LAVAS (META-RHYOLITE AND META-DACITE)

The main belt of felsic volcanic rocks is 14 miles long, and this formation overlies and is bounded on the west by mafic volcanic rocks. On the east the belt is bounded by younger meta-sedimentary rocks, except locally at Matthews Lake where outcrops of mafic volcanic rocks occur between the felsic rocks and the meta-sedimentary rocks. The maximum thickness is about 6,000 feet at Matthews Lake and this gradually becomes less northward; there is also an abrupt decrease in thickness at the south end of Matthews Lake, possibly due to faulting, and from there the thickness gradually decreases southward. Thin and short bodies of felsic lava also occur within the mafic lavas, mainly about Courageous Lake. Bands of agglomerate and tuff up to 200 feet wide lie within and at the base of the sedimentary formations in the Matthews Lake area, mainly between latitudes 64°03′ and 64°08′.

The felsic lavas weather grey, cream, pink, and buff, and commonly have an irregular or pitted surface. The following types were distinguished in mapping: (1) massive; (2) agglomerate and breccia; (3) tuff and agglomerate interbedded with sedimentary rocks; and (4) carbonatized (*see* Plate IVA).

Massive refers to the non-fragmental type, although locally it is slightly sheared or banded. This type is predominantly porphyritic and rarely amygdaloidal. Only a few phenocrysts of quartz and feldspar exceed 3 mm. in length and almost all are between 1 mm. and 2 mm. The fragments in the agglomerate and breccia are lenses of squeezed and flattened felsic lava from 1 inch to 6 inches in diameter and of mineral content close to that of the matrix. On some weathered surfaces these fragments protrude above the matrix. The tuff is a banded to massive rock in which bedding can be seen in only a few places. Some tuff contains fragments of felsic lava rarely more than 4 mm. long. The carbonatized type is everywhere schistose and commonly is a light grey, rusty weathering, carbonate-sericite schist. Bedding can be distinguished in a few places, but schistosity, which is parallel with the bedding and the regional trend of the belt, is common.

In thin sections of all types, phenocrysts of biotite, quartz, and feldspar can be seen. Only a few biotite phenocrysts attain the size of those of quartz or feldspar. Phenocrysts may be randomly oriented, they may parallel the foliation, or they may be aggregated in clots. Biotite is commonly poikilitic with irregular edges and with pleochroic haloes around enclosed grains of zircon. In some thin sections the biotite is altered to chlorite although in others the biotite is completely resorbed and replaced by fine-grained magnetite. Such resorption of biotite in volcanic rocks has been described by Larsen *et al* (1937, p. 900) in the San Juan Mountains of Colorado. Only a few feldspar phenocrysts are euhedral and many of them are altered to saussurite or sericite. Twinning is present in some phenocrysts; in these the anorthite content ranges from An_5 to An_{15}. No potash feldspar was identified. The quartz phenocrysts are commonly rounded and embayed by the groundmass. A few examples of pressure fringes around a quartz phenocryst were observed. The materials of the matrix have been recrystallized and the sericite commonly is aligned to give a distinct foliation. Where the plagioclase in the matrix could be determined, indices are less than those of quartz, and both greater and less than Canada balsam, and the feldspar is probably albite to oligoclase. It is rarely possible to distinguish quartz from feldspar in the fine-grained matrix, and in the following list of percentage composition (Table III), based on twenty-six thin sections, these two minerals have been combined.

TABLE III

Average Mode of Felsic Lavas

	Range	Average
	%	%
Quartz and feldspar	25–85	55
Sericite and muscovite	0–45	20
Carbonate	0–50	15
Chlorite	0–50	2
Epidote	0–30	2
Biotite	0–45	5
Hornblende	0–15	1
Ilmenite	0– 5	tr.
Garnet	0– 5	tr.

Almost all of the felsic volcanic rocks were erupted at the close of the period of mafic vulcanism although some flows overlapped slightly the following period of sedimentation. The fragmental types amount to perhaps 50 per cent by area of the volcanic rocks and probably represent flow breccia rather than pyroclastic breccia as the fragments are similar to the matrix in mineral content, texture (porphyritic), and structure (flow lamination).

Quartz-plagioclase (An_5 to An_{15})–mica-carbonate schists are widespread in the felsic lavas. Chlorite, biotite, and hornblende at no point are plentiful but carbonate is widespread and near the gold-bearing quartz veins is abundant, and there probably results from hydrothermal alteration. The felsic lavas hence reflect essentially the same grade of metamorphism as the adjacent mafic lavas.

META-GABBRO

Distribution and Lithology

Although meta-gabbro is found throughout the area of volcanic rocks, the largest bodies of it are sills that occur beside or close to granite. The widest known body is 4,000 feet across and is exposed along MacKay Lake, whereas the longest known body is 20,000 feet in length and crosses the northeast bay of Courageous Lake. At three places in the area dykes of meta-gabbro cut granodiorite. The most northerly of these, near latitude 64°14′30″ and longitude 111°24′, has a chilled margin 2 feet wide. This dyke appears to be the feeder to a sill more than 3 miles long. At another place along the granodiorite-volcanic contact, at a point near latitude 64°12′ and longitude 111°21′, narrow bodies of meta-gabbro occur along and on each side of the contact. Here bodies, on the average about 75 feet wide, swell in places to 500 feet wide. The contact of the meta-gabbro with the granodiorite is not well exposed but in places the meta-gabbro has a chilled zone 1 foot wide and at other places the meta-gabbro is sheared at the contact. At the third place, near latitude 64°04′ and longitude 111°19′, a dyke of meta-gabbro seems to be a feeder to a sill of meta-gabbro about 9,000 feet long.

The meta-gabbro is a massive rock that weathers chocolate brown, light green, and dark green, whereas the fresh surface is greyish green to dark green. Coarse hornblende crystals, with cleavage surfaces as much as $\frac{3}{8}$ inch in size, characterize this rock. An unusual body exposed about 1,500 feet northwest of the Matthews Lake fault has rounded phenocrysts of feldspar up to 10 inches in size and these comprise as much as 70 per cent of the rock (*see* Plate IVB).

Hornblende and plagioclase are the essential constituents, but traces of pyroxene were found in a few thin sections. Some of the plagioclase is labradorite and the rock, therefore, is a meta-gabbro. Ophitic texture was observed in a few thin sections. The feldspar, particularly that of the phenocrysts, is commonly altered completely to sericite or epidote or clinozoisite. In some sections hornblende is altered partly to chlorite and epidote, whereas biotite, in places, is altered to chlorite. Epidote, in addition to forming irregular masses, is present as euhedral crystals. The average mineral composition of seventeen thin sections is given in Table IV.

TABLE IV

Average Mode of Meta-gabbro

	Range	Average
	%	%
Hornblende	40–85	70
Plagioclase (An_{30}-An_{50})	0–35	16
Epidote	0–25	7
Chlorite	0–35	3
Biotite	0–30	2
Quartz	0–15	2
Sphene, sericite, apatite, magnetite, zircon, pyrite		tr.

The distinction between meta-gabbro and coarse-grained flows is somewhat arbitrary, and this is based on size, shape, and attitude of the body and texture of the rock. Small, irregular-shaped masses and transecting bodies are mapped as meta-gabbro. Those bodies that are elongated parallel with the structure but are mainly of coarse-grained rock were also mapped as meta-gabbro.

Origin

Those bodies of meta-gabbro commonly elongated parallel with the structure are believed, by the writer, to represent sills, although some recrystallized coarse-grained flows may also take this form. Local recrystallization of mafic lavas does occur, as about Matthews Lake where some pillows contain grains of hornblende up to $\frac{1}{8}$ inch long. In the Snare River area, Lord (1942, p. 11) describes lavas with dioritic texture as follows:

"Elsewhere the lavas are massive or have traces of pillow structure, and are dark greenish grey rocks of dioritic texture made up of equal parts of black amphibole and greenish white, plagioclase feldspar; the individual grains range up to $\frac{1}{4}$ inch. In places this massive, dioritic variety grades within 50 feet into the dense variety with well-formed pillows."

At a few localities contacts are exposed, and there it is impossible to distinguish positively intrusive rocks from extrusive rocks. No evidence of deformation or thermal metamorphism was detected around the sills, but this is not surprising because the contacts are commonly with massive mafic flows. The sills are predominantly concordant and local discordancies are, for the most part, inferred at points where contacts were not observed.

Two sills have what appear to be feeder dykes. One of these sills at latitude 64°15′ and longitude 111°22′30″ is more than 3 miles long and more than 700 feet wide in a few places. The other sill, near latitude 64°04′ and longitude 111°19′, has a width of at least 1,500 feet. This sill contains a band of slate that extends more than 4,000 feet along the strike and is 100 feet wide at one place. The contact of meta-gabbro and slate is not always sharp and although the outline of the band parallels the regional structure, the band is distributed somewhat erratically in meta-gabbro and, in places, fragments of slate are surrounded by meta-gabbro. Thus, intrusion there is indicated as the method of emplacement. A similar feature in the Yellowknife area is described by Brown (1949) where an undisturbed band of tuff lying entirely within a sill was traced for nearly 2 miles. Brown suggests the sill-rock was formed by replacement.

Meta-gabbro dykes were not found in contact with late diabase dykes. In Ross Lake area about 80 miles southwest from Courageous Lake, Brown (1949) describes hundreds of post-granodiorite dykes of similar composition and probably of the same age as the meta-gabbro dykes in the Courageous-Matthews Lakes area. Brown places the meta-gabbro dykes in the Proterozoic and some of the meta-gabbro described with the Yellowknife group about Courageous and Matthews Lakes also probably is post-Yellowknife group in age.

SEDIMENTARY ROCKS

Distribution

Sedimentary rocks underlie about 50 per cent of the area mapped and include slate, greywacke, quartzite, arkose, conglomerate, phyllite, mica schist, and nodular schist, and gradations between each type. The assemblage of sedimentary rocks is at least 5,000 feet thick, and extends the entire length of the area mapped. Sedimentary rocks overlie the volcanic rocks, except at a few places as about Matthews Lake where the sedimentary rocks are interbedded with the lavas. A band of conglomerate and slate 5,000 feet long and averaging 400 feet wide lies within the volcanic rocks north of Courageous Lake. A band of slate from 50 to 100 feet wide lies within meta-gabbro west of Matthews Lake.

Conglomerate

Conglomerate lies within volcanic members of the Yellowknife group and this rock forms part of a sedimentary band, averaging 400 feet wide, that is exposed here and there for 1 mile along the strike, at the northern end of the area studied. The body of conglomerate and interbedded slate and greywacke is 150 feet wide in places. The pebbles range in size up to 1 foot long and they are elongated in places and in others they are well rounded. The pebbles consist mainly of light grey to green rock composed of quartz, feldspar, hornblende, chlorite, and epidote. The matrix is commonly a darker green than the pebbles and this contains chlorite, actinolite, plagioclase, biotite, epidote, quartz, and leucoxene. Some pebbles are of amygdaloidal lava and this and the mineral content of the matrix indicate that the conglomerate represents water-sorted volcanic materials.

Greywacke, Quartzite, Arkose, and Slate

This group of sedimentary rocks forms a succession of grey to black, well-bedded types that commonly weather dark grey, greenish grey, or buff, and individual beds range in thickness from a few inches to a few feet but some beds attain a thickness of 15 feet. The weathered surfaces of greywacke, quartzite and arkose are sandy in appearance, and on these some subangular and rounded grains of quartz are visible. Fresh surfaces show grains of quartz in a light grey to dark grey, fine-grained matrix. Although cross-bedding is rare, graded bedding is common and many beds have slaty tops.

The greywackes are composed mainly of quartz, feldspar, biotite, white mica, and chlorite with accessories such as epidote, magnetite, hematite, graphite, ilmenite, leucoxene, zircon, rutile, and tourmaline. Lenticular grains of quartz, as much as 1 mm. along the major axis, commonly parallel the foliation. A few light-weathering beds are feldspathic and these are impure arkose; others are impure quartzite because they contain only quartz and mica. It was not practicable to map separately the arkose and quartzite, but the largest known area of quartzite is along the northernmost bay of the east arm of Courageous Lake.

The slate is thinly bedded, fine grained, grey to black with a pronounced cleavage, which in many places crosses the bedding. Slate forms single beds as well as part of beds that grade into greywacke. Minute biotite scales in small conspicuous knots develop on the cleavage surfaces of some slate. Some beds are a few inches thick but most are thinner, and grain size of the rock ranges from 0.01 mm. and less to 0.3 mm. The main constituents of the slate are quartz and feldspar. Sericite and biotite form fine-grained aggregates in places elongated parallel with the cleavage. The quartz and feldspar are not readily distinguished from one another under the microscope. Much, if not all, of the feldspar has a refractive index below Canada balsam and some of the grains have albite twinning. This would indicate that the feldspar is albite with possibly some orthoclase. The micaceous material of the slates includes sericite, biotite, and chlorite in flakes or shreds from 0.007 to 0.01 mm. long and these are arranged parallel. Such material makes up to about 55 per cent of the rock by volume. Chlorite is less abundant than sericite in almost all sections. The amount of opaque minerals present varies greatly but this rarely exceeds 5 per cent of the rock; the minerals include magnetite, ilmenite, hematite, pyrite, carbonaceous matter (probably graphite), and limonite.

Phyllite and Mica Schist

Phyllite and mica schist occupy a zone intermediate in position between greywacke, graphite, arkose, and slate and the nodular schists. The slaty cleavage remains but the cleavage planes have acquired an intense silky sheen due to the formation of abundant white mica. Tiny flakes of brown biotite visible to the naked eye are peppered through the groundmasses. Thin sections show porphyroblasts of brown biotite in various stages of growth containing tiny, oriented, drop-like inclusions of quartz that produce a poikilitic texture in each porphyroblast. Pleochroic haloes surround zircon inclusions. These porphyroblasts are irregular aggregates that rarely show signs of parallelism. Flame-like fingers of biotite and sericite project from the periphery of porphyroblasts and these parallel roughly the foliation. The oriented lenticular quartz of the less metamorphosed members probably has been crushed and reduced in size by differential movement.

Nodular Schist

This map-unit is limited in distribution to two zones: one at the northeastern corner of the area and the other at the southernmost part of the area. For purposes of description the two areas will be referred to as the northern zone and the southern zone respectively. The northern zone is part of a larger zone adjoining a projection of the Courageous Lake batholith. The batholith does not extend into the area mapped, but its contact, according to reconnaissance mapping (Folinsbee, 1949) is about 4 miles from the contact of the nodular schist with the phyllite. The southern zone surrounds at intervals a granitic pluton, less than 1 square mile in area, and lies between the MacKay Lake stock, and the volcanic rocks. The zone is not continuous around the MacKay Lake stock.

The nodular schist weathers light buff to brown whereas fresh surfaces are grey with a massive, fine to medium grained, granular texture. Commonly the nodules form protuberances on the weathered surface but some weather away and these leave depressions. Nodules may weather lighter or darker in colour than the matrix, they are commonly oval, and they differ in size; the most common size is about ½ by 1 inch.

There is a transition from greywacke and slate, through phyllite, into nodular quartz-feldspar-mica schist. The contact was drawn at the point where nodules appear. In order to study the changes in mineral composition in passing from slate and greywacke to nodular schists, in the northern zone, a series of thirty specimens was collected at intervals along the strike of the beds and also along a line nearly at right angles to the contact between the phyllite and nodular schist and at a point about 4 miles from the nearest exposed granitic rocks. Wherever possible, two specimens were taken at each place; one from a coarse-grained bed and one from a fine-grained slaty bed. The results of this study are given in Table V.

TABLE V

Modes of Greywacke, Phyllite, and Nodular Schist at Points about 4 Miles from nearest Outcrop of Granite

	Greywacke and phyllite				Nodular schist			
Number of specimens	8		12		5		5	
	Fine-grained		Coarse-grained		Fine-grained		Coarse-grained	
	Range	Average	Range	Average	Range	Average	Range	Average
Chlorite	% tr-10	% 5	% 0–25	% 10	% tr-5	% tr.	% tr-5	% tr.
Muscovite and sericite	tr-50	30	0–60	15	15–70	35	0–10	5
Biotite	10–30	15	10–40	15	15–40	20	15–30	25
Quartz and feldspar		50		60		40		65
Cordierite						5		5
Andalusite						tr.		tr.

Nodules were found about 200 feet farther away from the granitic intrusive rocks in the fine-grained sedimentary rocks than in the coarser grained sedimentary rocks. The nodules consist commonly of cordierite and rarely of andalusite. One thin section contains a nodule consisting of chlorite, muscovite, and quartz. This was from the zone in which, approaching the pluton, the first sign of nodules was detected, and it indicates a possible source of the cordierite, if the minerals in the nodules are not retrogressive after cordierite. All cordierite noted is poikiloblastic with inclusions of quartz, feldspar, and mica commonly exceeding 55 per cent of the area of the cordierite. Diagnostic yellow pleochroic haloes around zircon crystals are common.

The mineral composition varies within both fine-grained and coarse-grained sedimentary rocks, hence the average given for the few thin sections of nodular schists may not be significant. In addition to the variation in mineral proportions of the micaceous minerals, these are coarse grained in the nodular schist. Instead of irregular fine-grained sericite, distinct crystals of muscovite are present. Although the long axis of the micaceous minerals is predominantly parallel with the foliation, this is in some places randomly oriented and in other places perpendicular to the foliation.

Chlorite has the following optical properties: $N_X = 1.595$, $N_Z = 1.590$, optic sign positive, pleochroism X= pale green, parallel with the elongation, Z=pale yellow-green to colourless. The optical properties thus indicate clinochlore. It persists throughout the metamorphic sequence and is found in the following relationships: as euhedral crystals transecting the biotite; as a fringe around the biotite with an irregular apparently gradational contact (although this may be due to the orientation of the thin section); and as a fringe around the cordierite nodules. Rutile needles and zircon are found in some of the chlorite. Some chlorite shows evidence of formation during or since the rotation of the biotite porphyroblasts. For these reasons much of the chlorite is considered to be retrogressive after biotite and cordierite.

Biotite has the following optical properties: $N_X = 1.570$–1.580, $N_Z = 1.595$–1.625; pleochroism X=yellow, Z=reddish brown. The indices of refraction for biotite were determined in nodular schists but no regular variation with increasing degree of metamorphism was found. Biotite, however, increases in amount and becomes coarser with progressive metamorphism. Inclusions of zircon with haloes and rutile needles are common. In places the biotite in higher metamorphic grades has been altered to fine-grained magnetite and leucoxene and this product resembles the "resorbed" biotite of volcanic rocks. Such material forms sharp and irregular gradational contact with muscovite.

As a result of five determinations, indices for muscovite were found to be $N_Y = 1.610$, $N_X = 1.580$, which corresponds to ferrophengite (a high iron muscovite). Sericite fringing andalusite crystals probably represents an effect of retrogressive metamorphism.

Metamorphism

All sedimentary rocks of the area belong to the greenschist facies of metamorphism with the exception of the nodular schist. The greenschist zone is interpreted as being due to the effects of regional metamorphism, the nodular schist zone as being due to contact metamorphism, and the chlorite and muscovite in nodular schist as being due to retrogressive metamorphism. Table V indicates the range of variation in mineral composition between beds of the greenschist zone and those of the nodular schist zone. Some of the abundant alumina of the fine-grained, clayey, sedimentary rocks probably went to form muscovite. The 10 per cent average increase in biotite in the nodular schist zone where cordierite is present may have resulted either from the addition of potash from a granitic magma or from the breaking down of muscovite and sericite because these minerals decrease in volume by from 10 to 30 per cent.

Nodular schist occurs in sedimentary rocks along the contact with granitic bodies although all such contacts are not bordered by nodular schist. The Courageous Lake stock, for instance, has no exposed nodular schist.

Small plutons in this region, however, are surrounded by nodular schist and those with irregularly trending contacts are in part or completely surrounded by nodular schist. Bodies of biotite granite and granodiorite in the Courageous-Matthews Lakes area have nodular schist distributed only erratically around them.

The importance of water in metamorphism is emphasized by many and Turner (1948, p. 51) states: "it is generally believed that metamorphic adjustment of a mineral assemblage to imposed temperature-pressure conditions is very largely brought about by reaction taking place through the medium of aqueous pore solutions (or at high temperatures their gaseous equivalents), the water of which is supplied by the rock itself, and partly is derived from magmatic sources;—the latter especially in contact metamorphism". In the Courageous-Matthews Lakes area and the region generally, nodular schist is widespread in sedimentary rocks around all bodies of muscovite granite and pegmatite; Folinsbee (1949) states "the belt of thermally metamorphosed sedimentary rocks is particularly wide around the muscovite granite". This constant association and extensive development of nodular schist around bodies of muscovite granite and pegmatite are attributed to the effects of water and this probably was more plentiful in magmas forming bodies of muscovite granite than those forming granodiorite. The access of the water in the magmas to the surrounding sedimentary rocks would be controlled by the permeability of the wall-rocks but the attitude of the contact of the invading magma and the sedimentary rocks is regarded as an important factor. If permeability were the only factor, an unusual distribution of especially permeable zones would be required to account for the present irregular distribution of nodular schist. The small plutons as well as some of the larger ones or batholiths are surrounded by nodular schist, hence temperature does not appear to be an important controlling factor in their development and distribution. Confining pressure could have little influence in the distribution of nodular schist because the lithostatic pressure around the different plutons should be almost the same.

Water vapour from the magma naturally would tend to migrate upward more readily into a sloping sedimentary roof than into a flat roof and a vertical contact would offer relatively little impediment to the migration upward of water vapour within the magma. Thus the water vapour would migrate to the upper part of the intrusive and concentrate in the cupolas. On the basis of these assumptions the presence of nodular schist in noteworthy amounts implies a sloping contact of the granitic and sedimentary rocks and the absence of nodular schist implies a vertical or steeply dipping contact or the bottom contact of a pluton. Lack of sufficient water is the main reason postulated to explain the absence of nodular schist around some plutons occupying an area of 80 square miles or more and distributed only erratically around others. Although magma forming granodiorite probably did not contain as much water as magma forming muscovite granite, and the sedimentary rocks may have varied from bed to bed in water and mineral content, the main reasons for lack of sufficient water in the surrounding sedimentary rocks probably are the slope of the roof and the margins of the magma body impeding the escape of water from the magma chamber.

In some nodular schist chlorite fringes biotite and cordierite, and some forms metacrysts without an apparent host mineral. Muscovite also fringes crystals of andalusite and occurs within cordierite. Chlorite and muscovite occurring in all these positions are interpreted as a product of retrogressive metamorphism.

Andalusite characterizes some nodular schist west of the MacKay Lake stock and this mineral also is present in some quartz veins within nodular schist near its contact with volcanic rocks. In the quartz veins the andalusite is in euhedral crystals, some 1 inch in cross-section. These large crystals are within or near fragments of sedimentary rock in the quartz and almost all the constituents of the andalusite probably originated from the sedimentary rocks, and the crystals grew especially large in the highly fluid siliceous solutions from which the vein was deposited.

POST-YELLOWKNIFE GROUP

QUARTZ DIORITE AND RELATED ROCKS

Distribution

The largest area underlain by quartz diorite and related rocks is along the contact of the granodiorite with the volcanic rocks. This pluton, which is at least 3,000 feet wide, extends from a point about 2 miles west from the north end of Matthews Lake north to and across the east bay of Courageous Lake. The continuity of the body is interrupted by inclusions of recrystallized volcanic rocks and small intrusions of granodiorite. A small diorite pluton lies along the granodiorite-volcanic contact near the northeast bay of Courageous Lake. Five small plutons, of which the largest covers an area of 1 square mile, occur within the sedimentary rocks between latitudes 64°03′ and 64°05′, longitudes 111°08′ and 111°10′, and along the granodiorite-sedimentary contact at latitude 64°07′ and longitude 110°10′.

Lithology

The dioritic rocks are massive and fine to coarse grained. They weather light green to dark green and black. Fresh surfaces are green to black. The dioritic rocks consist of plagioclase (oligoclase to andesine) and two or more of the following minerals: quartz, biotite, and hornblende. Examination of thin sections disclosed in a few bodies a rock of a texture and composition similar to that of the meta-gabbro. The average mode based on eleven thin sections is given in Table VI.

TABLE VI

Modes of Dioritic Rocks

	Range	Average
	%	%
Plagioclase	20–80 (An_{32}-An_{47})	52
Microcline	0–5	tr.
Hornblende	0–65	35
Biotite	0–15	7
Quartz	0–15	5
Chlorite	0–15	1
Titanite	0–5	tr.
Apatite	0–3	tr.
Epidote	0–3	tr.
Magnetite	0–3	tr.

The degree of alteration of plagioclase to a fine-grained aggregate of saussurite and sericite varies. Determinations on the relatively unaltered grains gave a composition ranging between An_{32} and An_{47}. The plagioclase displays polysynthetic and complex twinning as well as oscillatory and progressive zoning. Microcline is seldom present and rarely altered. Hornblende is light green to colourless, commonly fresh but in some sections it is altered to biotite. The hornblende from the plutons surrounded by sedimentary rocks, however, is brown to colourless and probably has a different composition from that in diorite cutting volcanic rocks. Biotite is rarely fresh and shows various degrees of alteration. In some specimens it is partly altered to opaques and has a "shaggy" appearance, in others it contains scattered opaques, and in still others only opaques preserve the form of the biotite. Chlorite has the anomalous blue birefringence. Although some of it has formed from biotite, almost all chlorite exhibits no sign of the host mineral.

Some representatives of this group were distinguished from recrystallized volcanic rocks on the basis of texture, percentage of feldspar, and the presence of quartz. Those rocks with a granular texture and those with more than 50 per cent feldspar were mapped as diorite. Those rocks in which quartz was not visible and the texture was distinctly neither granular nor schistose were mapped as diorite provided they had more than 50 per cent feldspar.

Origin

In the field dioritic rocks, recrystallized volcanic rocks and meta-gabbro have the same general appearance and it is possible that some of the diorites are metamorphosed equivalents of these rocks. The restricted distribution of almost all diorite along or near the contact between the granitic and volcanic rocks would support this hypothesis. On the other hand, they are restricted to only 30 per cent of the length of the contact zone and this hypothesis does not explain why the metamorphism was not more extensive.

The plagioclase of the diorite is complexly twinned with oscillatory zoning and this is regarded by Emmons (1953, p. 50) as indicative of magmatic origin. If the dioritic rocks are reconstituted volcanic rocks, a dioritic magma probably was produced that migrated to form the bodies of diorite in their present position.

In addition to the diorite bodies along the contact of granitic and volcanic rocks a few small plutons of diorite are surrounded by sedimentary rocks. These sedimentary rocks are metamorphosed to hornfels indicating that this diorite is intrusive. Other bodies of diorite occur along the granitic-sedimentary contact, east of the north end of Matthews Lake. Because no volcanic rocks are exposed here this diorite probably was not produced by metamorphism of pre-existing volcanic rocks in situ but more probably is intrusive. This supports the conclusion that the main body of diorite, apparently of the same age, is also intrusive. A few granitic dykes cut the dioritic rocks and at such localities the diorite is older than the granodiorite.

GRANODIORITE AND RELATED ROCKS

The granitic* rocks of the area comprise chiefly a part of the Courageous Lake batholith and parts of the MacKay Lake and Courageous Lake stocks.

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* Although very few true granites were found, the term is used in its general sense to include rocks ranging from granite to possibly diorite in composition.

Only the eastern part of the Courageous Lake batholith lies within the map-area. It lies west of the belt of volcanic rocks and extends the full length of the area. A zone of nodular schists in the northeast corner of the area probably reflects an extension of the batholith in this direction. A part of the MacKay Lake stock occupies the southeast corner of the area and is exposed over an area of 15 square miles. A part of the Courageous Lake stock extends across the east arm of Courageous Lake and covers an area of 30 square miles.

The granitic rocks are massive, equigranular, mainly grey to pink, and medium grained. Granite-gneiss is exposed in the southern part of the area near the granitic-volcanic contact, and at a few places around the Courageous Lake stock. Although there are a few aplites, no pegmatites were observed. The average mineral composition based on an examination of thirty thin sections is given in Table VII.

TABLE VII

Average Mode of Granitic Rocks

	Range	Average
	%	%
Quartz	5–40	18
Microcline	0–40	9
Plagioclase	15–70 (An_{18}-An_{40})	54
Biotite	0–20	10
Hornblende	0–20	5
Muscovite	0–20	2
Chlorite	0–15	1
Epidote	0–10	1
Saussurite, apatite, magnetite, carbonate, allanite		tr.

Almost all microcline and plagioclase are altered to a fine-grained aggregate of saussurite and sericite, but some grains of these minerals are completely fresh. Fresh plagioclase ranges between An_{18} and An_{40}. Polysynthetic twinning of the plagioclase is not uncommon; complex twinning is rare; progressive zoning is more common than oscillatory zoning. Biotite is green to brown in thin section and is commonly partly altered to a dirty, "shaggy" aggregate of minute opaques accompanied in places by chlorite. This probably reflects an effect of retrogressive metamorphism. Biotite is fresh in a few specimens but all of it is altered to chlorite or a mass of opaques in a few others. Hornblende is blue-green to yellow-green in thin section and commonly fresh although here and there some hornblende is altered to biotite or chlorite. All chlorite, with one exception, has anomalous blue birefringence and Z parallels the elongation (a).

FELSIC PORPHYRIES (IN PART YELLOWKNIFE GROUP)

Distribution and Lithology

Felsic porphyries are found throughout the steeply dipping volcanic sequence, but bodies of rocks of this group are concentrated principally in the Matthews Lake area in a belt about 7 miles long, in a direction parallel with the strike of the lava flows. The greatest concentration of felsic porphyry adjoins and is within 8,000 feet west of the thickest part of the felsic flows at Matthews Lake. A few bodies of felsic porphyry also occur in a group on an island in the southern part of Courageous Lake and these porphyries are 2,000 feet west of a small area of felsic flow rocks that occur near the base of the volcanic sequence.

The felsic porphyries weather cream and light grey with slightly darker fresh surfaces. The rocks are massive to slightly schistose and they consist of phenocrysts of quartz and feldspar (albite to oligoclase) in a fine-grained groundmass of quartz, feldspar, biotite, and sericite. The phenocrysts range from 1 mm. to 4 mm. long, and their average length is about 2 mm.

Table VIII gives the mineral compositions of these porphyries and the mode is based on a study of twenty thin sections.

TABLE VIII

Average Mode of Felsic Porphyry and, for Comparison, Mode of Felsic Lava

	Porphyries		Felsic lavas
	Range	Average	Average
	%	%	%
Quartz and feldspar	30–70	67	55
Sericite	0–30	15	20
Biotite	0–20	15	5
Carbonate	tr.	tr.	15
Chlorite	0–5	1	2
Epidote	0–10	2	2
Hornblende	0–10	tr.	1
Tourmaline	tr.	tr.	
Apatite	tr.	tr.	
Magnetite	tr.	tr.	tr.
Zircon	tr.	tr.	
Garnet			tr.

Comparison of Massive Intrusive Felsic Porphyries with Massive Felsic Lavas

It is rarely possible in the field to distinguish the felsic porphyries from the massive and porphyritic type of felsic lava. The difficulty of distinguishing massive felsic flow rocks from intrusive felsic porphyries in other areas of the Canadian Shield has been mentioned by Satterly (1941b), Gunning (1941), Moorhouse (1942), and Armstrong (1950). At only one place were massive porphyry and massive felsic lava observed close together and there the porphyry formed an area of about 4 by 4 feet, and within a radius of 40 feet of this mass a number of irregular bodies and lenses of milky quartz, from 1 foot to 2 feet wide, occur in the felsic lava. The massive porphyry at this place is fine grained and not as markedly porphyritic as the banded and moderately sheared flow rock.

Where felsic porphyry occurs within mafic lavas, the bodies are mapped as intrusive because of their irregular outline and crosscutting relationships as for example near latitude 64°02′ and longitude 111°13′. Along the west shore of Matthews Lake, however, at the contact of mafic and felsic volcanic rocks the boundary between intrusive and extrusive porphyry was placed at the easternmost exposure of mafic volcanic rocks. Thus the distinction at this latter locality is entirely arbitrary. The mineral composition of the porphyries is approximately the same as that of the felsic lavas (*see* Table VIII) but differences in the various minerals are as follows: carbonate is common in the lavas and rare in the porphyry; there is more sericite in the lavas; microcline, not found in the lavas, was identified in some thin sections of the porphyry near granodiorite. Alteration of the minerals in the two rocks is similar; the quartz phenocrysts are commonly rounded or embayed, and the feldspar phenocrysts are commonly altered to saussurite or sericite. The biotite in the intrusive porphyry is commonly altered to chlorite or has a "shredded" appearance that represents a stage in the alteration to chlorite. The complete alteration of biotite to opaques is common in the lavas but this alteration is rare in the porphyries.

Method of Emplacement

Many porphyries in the mafic lavas have a massive structure, extreme irregularity of outline, and crosscutting relationships, although a few are definitely flow rocks. Contact relations of almost all bodies of felsic porphyry with the surrounding mafic lavas are obscure. Only rarely were a felsic porphyry and non-porphyritic mafic lava found in the same outcrop and even then the nature of the contact could not be determined principally because of the growth of lichen on the surface. At one place the contact relation appeared gradational where, over a distance of 3 feet not continuously exposed, massive felsic porphyry changed through a light grey felsic-looking volcanic rock to a green mafic volcanic rock. At the only other place where the contact was observed, the porphyry was fine grained at the sharp contact with the surrounding medium-grained mafic volcanic rocks. Two thin sections of mafic volcanic rocks from this locality consist of 20 to 40 per cent of chlorite, 10 to 20 per cent of biotite, and a trace of muscovite. Biotite is unknown in the mafic volcanic rocks except near bodies of granite or felsic porphyry. At a few places aggregates of hornblende occur in the porphyry.

The gradational nature of the contact at the one known locality suggests replacement, and from this some might conclude that the porphyry bodies were emplaced by metasomatic action. Similar porphyries have been described in sedimentary rocks from China, by Misch (1949) and by Evans (1944) in the Precambrian sedimentary and volcanic rocks of the Porcupine district, Ontario. Both writers interpret the porphyry bodies as metasomatic replacements.

This writer, however, interprets the porphyries of the Matthews Lake area as intrusive bodies with replacement only a minor factor in their origin and such as would be expected with an intrusive porphyry. Evidence for this interpretation is largely negative and the main features are summarized as:

(1) No evidence of pre-existing structures within the rocks of the bodies of porphyry is visible. Foliation is rare and where present probably is the result of later deformation.

(2) The quartz phenocrysts of the porphyry have the same "resorbed" shape as the quartz phenocrysts in the nearby felsic volcanic rocks. It seems reasonable to assume that this resorption of phenocrysts in both rocks is due to the effects accompanying igneous activity rather than to growth during metasomatic processes.

(3) Only one quartz phenocryst and no feldspar phenocryst present evidence of pushing aside the adjacent minerals so characteristic of metacrysts. The pushing aside of minerals adjoining the one known quartz phenocryst may have been the result of rotation of this phenocryst.

(4) The inclusions in the feldspar are saussurite and sericite, and these minerals are normal products of alteration.

(5) No feldspar metacrysts were noted in the mafic volcanic rocks surrounding the felsic porphyries.

(6) Almost all the features cited by Evans (1944) as evidence for the formation of porphyry by replacement are absent in the Matthews Lake porphyries that were studied in detail.

Age Relations

The porphyry bodies are probably of more than one age. Bodies of felsic porphyry that cut granodiorite are younger than this rock. These porphyry bodies probably are the same age as porphyries cutting the sedimentary rocks of the Yellowknife group. Lord (1942) in Snare River map-area, about 100 miles southwest, describes similar porphyries as post-Yellowknife group in age. The concentration of porphyry bodies in mafic lava near the thickest part of felsic lava flows strongly suggests that such porphyries are feeders to felsic flows and are the same age as these flows. Thus, both post-Yellowknife group porphyries and Yellowknife group porphyries are probably present.

As a possible aid in distinguishing intrusive felsic porphyry within the mafic lavas from massive porphyritic felsic lava minor elements were determined in each by means of semi-quantitative spectrographic analyses, and these were compared with minor elements in granite (Table IX). The results are inconclusive in establishing genetic relations although the average composition of the minor elements of the porphyry approaches more nearly that of the granite than that of the lavas. The average of the range in so few samples, however, is of doubtful significance.

DIABASE AND GABBRO

Distribution

Dykes of reddish brown weathering diabase and gabbro, probably of Proterozoic age, are distributed throughout the area. Similar dykes occur throughout the Canadian Shield and are particularly common in the Northwest Territories part of the Shield where, based on general strike, the following four groups have been recognized: (1) north-northwesterly to northwesterly: (2) northerly; (3) north-northeasterly to northeasterly; and (4) east-northeasterly to easterly. Within a single area, however, the range of the strike of any one group of dykes is commonly more restricted than that indicated in the grouping. Dykes of the first group are the most prevalent in the Northwest Territories and dykes of the last group are the least common.

In the Courageous-Matthews Lakes area, by far the greatest number of dykes are in the first group and strike northwesterly. One reason for

TABLE IX

Range and Average per cent of Minor Elements in Granite, Porphyry, and Lavas as Determined by Semi-quantitative Spectrographic Analyses

	Granite (6 samples)		Porphyry (3 samples)		Lavas (3 samples)	
	Range	Average	Range	Average	Range	Average
	%	%	%	%	%	%
Na	2.0–4.0	3.2	1.0–8.0	3.7	1.0–5.0	2.7
Ba	0.31–1.24	0.78	0.31–1.5	0.81	0.31–0.62	0.41
Be	0.00–0.0017	0.0003	0.00–0.0016	0.001	0.0000	0.00
As	0.64–0.80	0.72	0.64–0.80	0.75	0.56–0.66	0.63
B	0.00–0.088	0.017	0.000–0.011	0.007	0.000–0.011	0.004
Mn	0.01–0.03	0.025	0.03–0.04	0.03	0.01–0.04	0.03
Mg	0.4–1.6	1.0	0.9–1.6	1.4	0.4–1.5	0.97
Cr	0.016	0.016	0.016	0.016	0.016	0.016
Ni	0.0175–0.038	0.032	0.035	0.035	0.035	0.035
Fe	0.80–0.90	0.87	0.90–1.50	1.1	0.30–0.90	0.7
Cu	0.0025–0.015	0.0047	0.005–0.010	0.0074	0.0025–0.015	0.0018
V	0.0000–0.0056	0.0075	0.0056–0.011	0.008	0.0000–0.0056	0.012
Ti	0.10–0.20	0.15	0.10–0.30	0.22	0.10–0.6	0.4

Analyst, W. F. White, Mines Branch, Department of Mines and Technical Surveys, Ottawa.

this prevailing strike is that this direction parallels the regional trend more closely than that of any of the other groups. Where the structural trends of the pre-dyke rocks change, the dykes, in places, pass from group (1) to group (2). However, the strike of group (1) dykes is an established direction followed by faults in other parts of the territories, and this trend is so prominent in the area mapped that in one place dykes transect the beds at an angle as low as 20 degrees without becoming parallel with the beds. Dykes of group (3) are rare in the area and are limited in distribution to areas underlain by granitic and the massive volcanic rocks. The widest dyke known in the area is 300 feet and is included in group (4). The longest dyke probably is more than 14 miles. The long dykes are as common in one type of rock as another, but among those that parallel the regional strike, the widest are in the sedimentary rocks.

Lithology

The rock of the dykes weathers reddish brown or dark green and has greenish grey to black fresh surfaces. The dykes are characterized by sharp contacts and chilled borders that are up to 8 inches wide. The adjacent country rock is commonly altered; granitic rocks, in places, are reddened as far as 20 feet from the contact; volcanic and sedimentary rocks weather buff and have been baked as far as 80 feet from the contact. In places, phenocrysts of feldspar 1 mm. long are found in the dyke rock near the contact but towards the centre of the widest dykes the average grain size of all minerals is, in places, up to 4 mm. The texture of the dyke rock is commonly ophitic. Uralitic hornblende and chlorite replace the pyroxene. The feldspar ranges from parts almost fresh to other parts completely altered to sericite and epidote. Magnetite forms both euhedral crystals and fine-grained aggregates. Quartz, where present, is commonly in the form of vermicular intergrowths with feldspar. Table X gives the average mineral composition based on measurements of seven thin sections.

TABLE X

Average Mode of Diabase and Gabbro

	Range	Average
	%	%
Pyroxene	40–60	50
Feldspar	15–50 (An_{55}-An_{75})	37
Sericite	0–15	4
Hornblende	0–15	3
Epidote	0–10	2
Magnetite-ilmenite	0–7	4
Olivine	0–5	tr.
Apatite, biotite, chlorite, quartz, and saussurite		tr.

Relative Age

Little is known about the age of these dykes relative to one another. About $2\frac{1}{2}$ miles west-northwesterly from the north end of Matthews Lake, a northerly dyke (group 2) is cut by a northwesterly dyke (group 1). In the Walmsley Lake area, about 50 miles southeasterly from Matthews Lake, Folinsbee (1950) describes a northeasterly (group 3) dyke cut by northwesterly (group 1) and easterly (group 4) dykes. In the area studied, group (1) dykes are younger than those of group (2) and at Walmsley Lake dykes of group (4) are younger than those of groups (1) and (3).

PLEISTOCENE

Large parts of the Courageous-Matthews Lakes area are covered by glacial drift consisting of sand, gravel, clay, and boulder till. Glacial forms include drumlins, kames, eskers, and irregular morainic hills. The drumlins range from a few hundred feet to 3,000 feet long, but are seldom more than 25 feet high. Esker ridges of sand and gravel are conspicuous on aerial photographs and at places these are 75 feet high and 500 feet wide.

Glacial striæ and drumlins trend between north 75 degrees west and south 85 degrees west. Glacial grooving is best preserved on granitic rocks, and the lee and stoss forms observed in a few places in these rocks indicate a westward direction of movement of the glacier. Esker ridges parallel, in general, the westerly trend of the movement of the glacier but locally they deviate from this as much as 90 degrees.

CHAPTER III

STRUCTURAL GEOLOGY

GENERAL STATEMENT

Figure 1 shows the general structural pattern of the area north and northwest from MacKay Lake through Matthews Lake and beyond Courageous Lake. On this map the lines representing bedding indicate only the general strike and do not refer to the same bed or zone. The position of fold axes is based on data establishing the tops of beds from graded bedding. The axes of major and minor folds could not be differentiated at many places and more details of the closely spaced fold axes are shown on geological Maps 1024A and 1025A in the pocket of this report.

The beds, schistosity, and cleavage in the sedimentary and volcanic rocks have a general northerly to northwesterly strike except near the contacts with plutons or at the noses of folds. The beds dip vertically at most points and form a series of steeply plunging isoclinal folds. The axial planes of these folds parallel the general strike of the contact of the sedimentary rocks with volcanic and granodioritic rocks. Cleavage dips steeply and parallels bedding locally, but at most places crosses the horizontal projection of the fold axis at an acute angle. The volcanic rocks at most points dip steeply to the east and probably represent a part of a homocline. Shear zones in the volcanic and sedimentary rocks may reflect strike faults and two cross faults were recognized, one of which is near the south end of Matthews Lake.

The sequence of known events in the formation of the structures of the area is summarized as follows: first, isoclinal folding; second, plutonic intrusion accompanied by (a) shearing couples that produced the regional cleavage pattern and (b) the formation of the synclinal cross-fold, the Matthews Lake chevron, and possibly the Courageous Lake chevron; and third, post-diabase faulting.

FOLDS

HOMOCLINE AND ISOCLINAL FOLDS

The lava flows dip easterly at angles of from 65 to 90 degrees except at a few places where the dip is steeply to the west. Tops of flows were not recognized about Courageous Lake but to the south about Matthews Lake a study of pillows at a few localities indicates that the tops of the flows face east. Although the mapping was not in enough detail to indicate repetition of flows by close folding, and top determinations are localized, the available evidence suggests an easterly facing succession of flows that form a part of a homocline.

The sedimentary strata lie in a series of isoclinal folds with the beds on their limbs dipping as low as 65 degrees, but in most places the beds dip at between 85 and 90 degrees. The plunge of these folds is between 75 and 90 degrees at the few places where the plunge was indicated from a study of the nose of the fold or a projection of converging beds.

Tops of beds are indicated at many places by graded bedding and 730 determinations were made, as recorded in Table XI. In this table the area of sedimentary rocks is divided from north to south into eleven blocks of about 4 square miles each. The results of this study show that an average of 57 per cent of the determinations are of beds facing easterly (55 per cent without weighing according to size of area and number of readings). In the Matthews Lake area the predominating percentage of the beds studied face easterly. In blocks 4 and 5 south of Courageous Lake, easterly dipping beds decrease from 69 to 48 per cent and this decrease continues gradually northward. This marked change in the position of tops facing westerly may reflect merely that in this particular area the beds of a large part of the west limb of an anticline are under a lake about $\frac{3}{4}$ mile long, thereby limiting the number of possible determinations of westerly facing beds. Other variations in the percentages may be due to the same or other conditions.

TABLE XI

Top Determinations of Beds

	Block No.	No. of determinations	Per cent easterly facing beds
Courageous Lake....	1	105	45
	2	70	53
	3	144	55
	4	130	48
	5	57	62
Matthews Lake.....	6	19	69
	7	34	68
	8	54	57
	9	81	60
	10	27	56
	11	9	45
		730	Weighted average per cent 57

Figure 2 is a diagrammatic presentation of the difference in structure between folded areas where, in 2A 50 per cent and in 2B 60 per cent, of the beds face easterly. This figure illustrates that if more than 50 per cent of the beds face easterly, and there are no structural complexities, the depth of a given bed from an assumed plane increases to the east.

The known distances between the axes of adjacent folds are from 200 to 5,000 feet but most fold axes are from 1,500 to 2,000 feet apart. Tremblay (1952) in the Giauque Lake area determined the fold axes in the sedimentary rocks of the Yellowknife group as about 1 mile apart. Fortier (1947) in Ross Lake map-area shows the beds of the Yellowknife group sedimentary rocks facing fairly uniformly in the same direction for 2 miles across their strike, to indicate a minimum thickness of about 10,000 feet of strata. At Gordon Lake, north of Ross Lake, Henderson (1941) indicates that the fold axes are between $\frac{1}{8}$ and $\frac{1}{4}$ mile apart. In Courageous-Matthews Lakes area exposures showing the direction the tops of beds face are plentiful along one section, and these data combined with that of the indicated intensity of folding for the area suggests a thickness of at least 5,000 feet of sedimentary rocks.

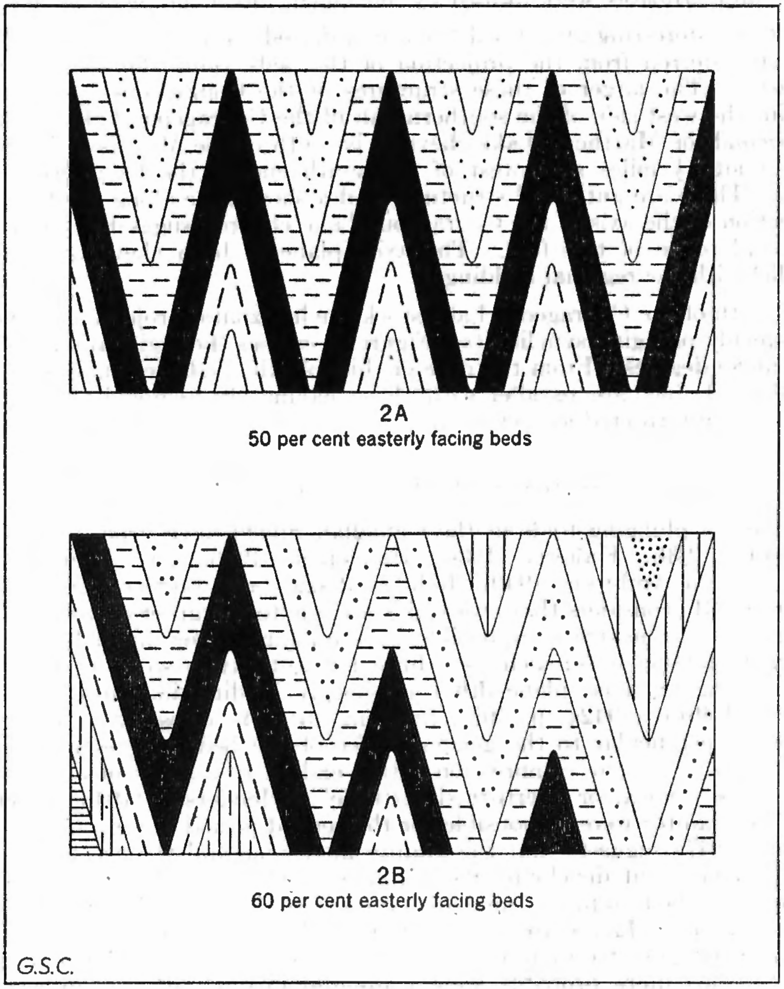


Figure 2. Diagrammatic statistical cross-sections of folds.

STEEPLY PLUNGING MINOR FOLDS, CHEVRONS, AND SYNCLINAL CROSS-FOLD

The beds were traced around the noses of two folds near latitude 64°05′ and longitude 111°12′. These folds are about 500 feet apart and they are steeply plunging dextral drag-folds as described by White and Billings (1951, p. 668). Near latitude 64°12′ and longitude 111°20′ sheared tuff within lava flows displays steeply plunging folds about 4 mm. wide and accompanied by slip cleavage (White, 1949, p. 588). At about 3,000 feet north from the northeast bay of Courageous Lake a band of sedimentary rocks about 400 feet thick is folded sinistrally, and this fold plunges steeply. North of the Matthews Lake fault a minor syncline plunges southerly about 70 degrees. The steeply plunging minor folds beside and just north of the Matthews Lake fault probably were formed by movement along the plane of this fault.

Two interesting structural features referred to as chevrons (*see* Figure 1) were inferred from the projection of the beds along the strike between outcrops. The larger of these structures or the Courageous Lake chevron adjoins the west side of the southern half of the Courageous Lake stock, and the second, or Matthews Lake chevron, is south of the Matthews Lake fault and about $1\frac{1}{2}$ miles southwest of the south end of the Courageous Lake stock. These are anticlinal structures and a shear zone along the horizontal projection of the axis of the Courageous Lake chevron suggests a fault along the axial plane of this fold. The axial plane of both chevrons is almost parallel with the regional bedding.

North of the Courageous Lake stock the horizontal projection of the axis of a steeply plunging syncline (*see* Figure 1) crosses the regional strike of the beds at 80 degrees. From the nose of this fold the beds gradually change in strike until they are parallel with those having the regional strike. This syncline is interpreted as a cross-fold.

ORIGIN OF STEEPLY PLUNGING FOLDS

Steeply plunging folds in the Canadian Shield have been described by Fairbairn (1936), Flaherty (1936), Henderson (1936, 1943), Derry (1939), Gunning and Ambrose (1940), Jolliffe (1942a), and Fortier (1947). Derry (1939, p. 131) considers that cross-folds are due to an earlier period of folding or that ". . . . the stress responsible for the main folding might be deflected by an unyielding mass such as a buried granite knob so as to form local folds having an axial plane differing sharply in directions from the main folds". Jolliffe (1942a, p. 707), referring to folds whose axial planes are almost perpendicular to the general strike of the beds, suggests such folds are formed ". . . . by compression acting end-on to a series of beds already tilted to a vertical or overturned attitude". Henderson (1943) concluded that the granites were responsible for the second period of deformation, and Fortier (1947) suggests that the granite intrusions and the cross-folds were roughly coincident developments. Numerous shear zones parallel with the strike of the beds support the explanation that the drag-folds in the Courageous-Matthews Lakes area resulted from the effects of nearly horizontal stresses acting on steeply dipping strata. These stresses may have been pre-intrusive but more probably were contemporaneous with the intrusion of the granite or were post-granite.

The chevrons may represent folds in which the essentially parallel beds of the isoclinal folds either continue around the apex of the fold (*see* Figure 3A) or do not continue around the apex but have been pushed together into a position of convergency (*see* Figure 3B). On the basis that the structure of the Courageous Lake chevron is type 3B the general position and character of the contact of the Courageous Lake stock and the sedimentary rocks to the west suggest a genetic connection of the structure with the intrusion. At the northwest corner of this stock the beds are truncated and bent by the intrusion within a small area (*see* Figure 1) and this is interpreted as the combined

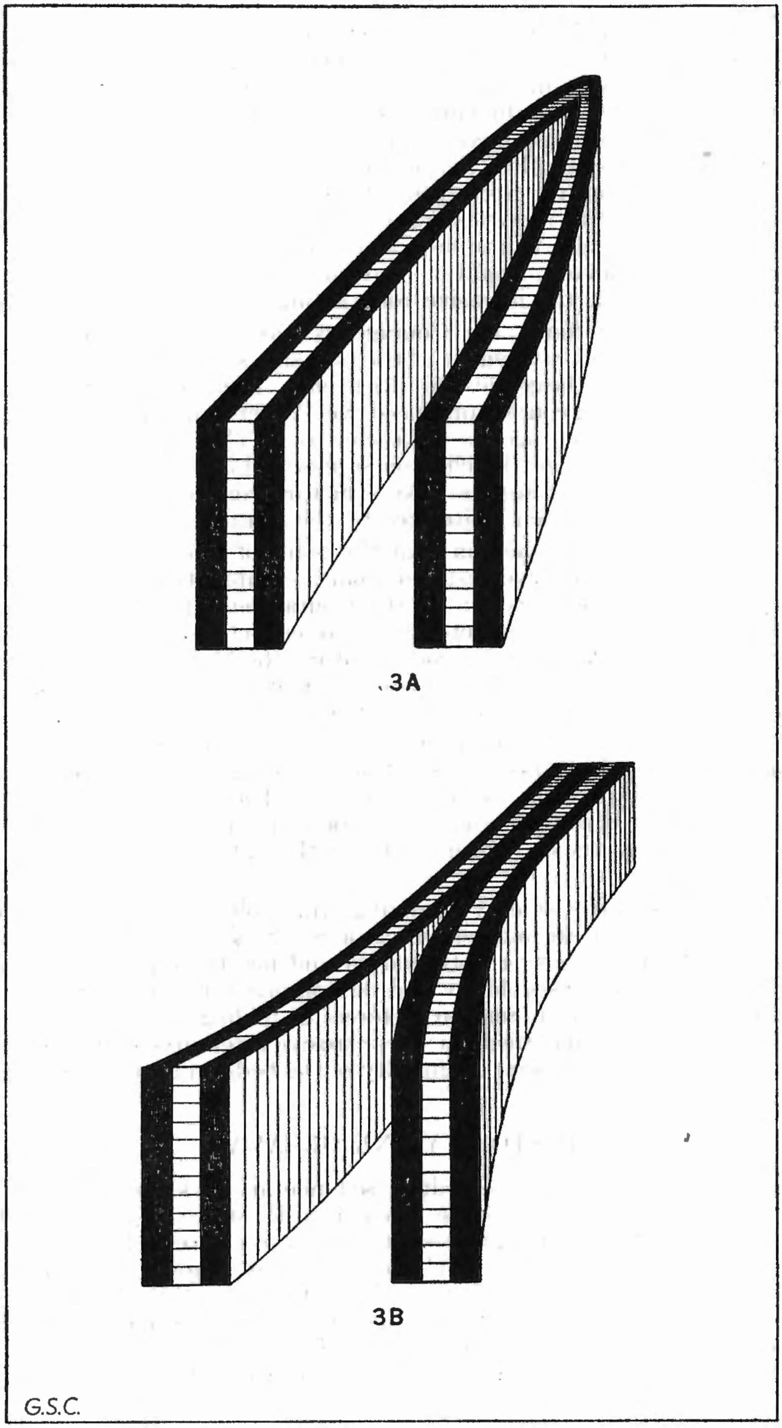


Figure 3. Diagram of possible interpretation of chevrons.

result of stoping and the intrusive force of the magma. Figure 4 illustrates the character of a contact that might form by stoping alone and one modified by the force of intrusion in addition to stoping. In the field the position of the contact of granite and sedimentary rocks cannot be fixed precisely because of scarcity of outcrops. If this contact is assumed to extend in a more westerly to southwesterly direction than that drawn on Figure 1, an approximate end-on intrusive force from the north could have bent the chevron to produce a strike-slip component to form the dextral drag-folds on the west limb, and a component perpendicular to the beds to form the flexure of the crest. The west limb of this chevron, however, could have been bent by post-intrusive strike-slip forces with the intrusive rock acting as a buttress on the east.

If, on the other hand, the Courageous Lake chevron is of the type illustrated in Figure 3A movement of the east side south relative to the west side could produce a large dextral drag-fold. Henderson (1943, p. 445) concluded that shearing couples produced even larger drag-folds in the Gordon Lake area than the Courageous Lake chevron. The relation of cleavage to bedding on the limbs of the chevron supports this concept. In this case the east limb of the Courageous Lake structure continues around the east side of the stock or has been obliterated by the intrusion.

The Matthews Lake chevron is at the point of intersection of two sets of structures that could have resulted from a combination of the intrusive forces produced by the injection of the Courageous and Matthews Lakes stocks. The stocks are interpreted as representing granitic magma forcefully injected, and both the Courageous Lake and the Matthews Lake chevrons are interpreted as resulting from forces in connection with the intrusion of these bodies of granite or as drag-folds formed by a shearing couple.

The force to produce the synclinal cross-fold possibly originated from the south and may have been active before, during, or after the intrusion of the granite and granodiorite of the region. The south limb of the fold appears to have been rotated from a position of parallelism with the general strike of the nearby beds, counter-clockwise through an angle of about 100 degrees.

In conclusion, the steeply plunging drag-folds of the Courageous-Matthews Lakes area are interpreted as a result of strike-slip movements, the chevrons by forces acting both end-on and nearly perpendicular to the folded beds and the cross-fold by end-on compression. The final pattern thus is the result of a combination of forces of folding and intrusion. The forces from intrusions modified the pre-intrusive structures and except at a few localities produced general conformity of the beds and intrusive contacts.

SCHISTOSITY AND CLEAVAGE

The volcanic rocks and the nodular sedimentary rocks are schistose over wide areas. The schistosity of the volcanic rocks strikes between north 30 degrees east and north 40 degrees west, with a more westerly strike in the northwesterly part of the area. Schistosity thus is almost parallel in strike with that of the contact of the Courageous Lake batholith to the west. The schistosity is more prominent than the bedding in the nodular schists where the two structures commonly are parallel. In all cases the schistosity dips vertically or steeply to the west with dips as low as 55 degrees at only a few places.

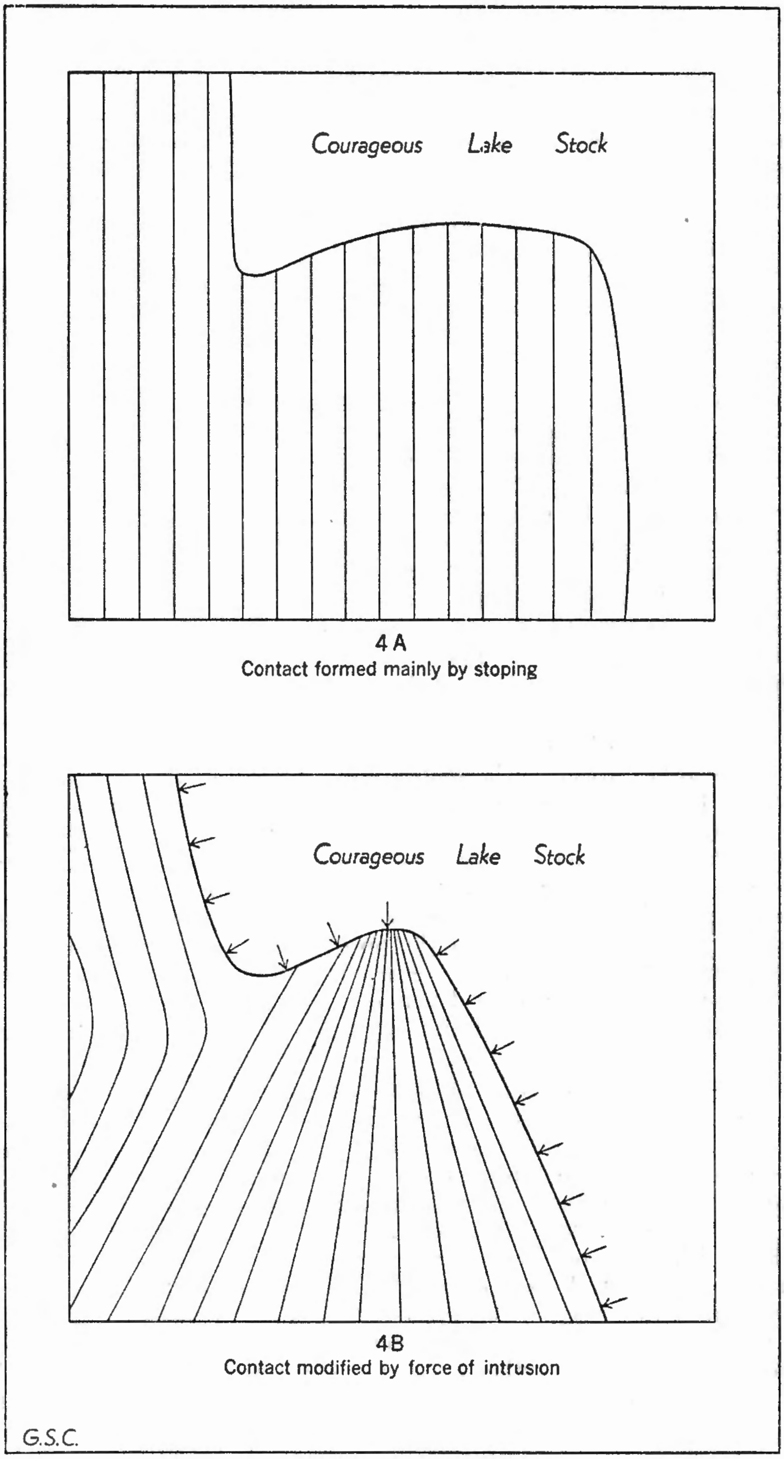


Figure 4. Diagram of possible distribution of forces during stages of formation of Courageous Lake chevron.

Cleavage is best developed in the slates and slaty members of the sedimentary rocks. It is flow cleavage because the minerals have been granulated, recrystallized, and orientated with their long axes essentially parallel with the cleavage. It is a regional flow cleavage because only in a few places is the strike of the cleavage parallel with that of the beds and the axial trace of the folds. The cleavage commonly intersects the horizontal projection of the fold axis at an angle of less than 30 degrees, and because of this, probably is not related in origin to the forces that caused the primary folding but to a later deformation that may have been caused by the granitic intrusions. The known dips of the cleavage are steep but some south of the Matthews Lake fault are at about 75 degrees. The line of intersection of cleavage and bedding, therefore, plunges steeply, as do the axes of drag-folds where the plunge is known.

North from the central part of the area the strike of the cleavage changes from about north 30 degrees east to northwesterly and this change in trend corresponds roughly with the change in strike of the contact of the Courageous Lake batholith with volcanic rocks (*see* Figure 1). East of Matthews Lake the cleavage strikes both northeasterly and northwesterly and the pattern is complex with some cleavage striking north 70 to 80 degrees east whereas south of the Matthews Lake fault the cleavage strikes northerly. At a few places, as near latitude 64°11′30″ and longitude 111°14′30″, the strike of the cleavage departs from these general regional trends, and although such local variations may represent remnants of an earlier cleavage they more probably are the result of a local deviation of the same force that produced the regional pattern.

Cleavage in the Yellowknife group sedimentary rocks has been described from a few other areas of the district in some detail by Swanson (1941), Fortier (1946, 1947), and Tremblay (1952). Fortier (1947) shows that the strike rarely parallels the fold axis. He also describes (1946) a cleavage the strike of which is parallel with the axis of a series of cross-folds and apparently not related in origin to the regional folds. Tremblay (1952) distinguishes two cleavages: the first, nearly parallel in strike and dip with the steeply dipping beds and especially so at the nose of folds; and the second, with a regional strike of about 15 degrees east of north and crossing the folds. He interprets the first cleavage as developing when the steeply plunging folds formed and the second as a result of forces associated with the granitic intrusions.

All cleavage in the rocks of the Courageous-Matthews Lakes area is interpreted as shear cleavage resulting from bedding-plane slip later than the regional folding. The northwesterly striking cleavage in the Courageous Lake area could have been produced by a force from the north shearing the sedimentary rocks against the volcanic rocks on the west, and this force could have originated during the emplacement of the part of the Courageous Lake batholith at the northeast corner of the area (*see* Figure 1). The cleavage striking north 30 degrees east in the Courageous Lake area could have been produced by a force from the south in a like manner, and this force could have originated with the emplacement of the Courageous Lake stock. The northeasterly and northerly striking cleavage in the Matthews Lake area could have been produced likewise by forces from the intrusion of the

Courageous and MacKay Lakes stocks. Thus the Courageous Lake batholith, the Courageous Lake stock, and the MacKay Lake stock, during their emplacement, could have produced couples to cause the cleavage with the various orientations presently known.

FAULTS

The known major faults and shear zones strike north to northwest and are nearly parallel with the trend of beds, cleavage, and schistosity. This appears a persistent direction of weakness and the shears are followed by the gold-bearing quartz veins and parallel fractures are occupied by diabase and gabbro dykes. Those dykes striking north 80 degrees east are offset by movement along the northerly trending faults. The total displacement after the easterly trending diabase was intruded is unknown because of lack of outcrops at critical localities, and possibly the dykes in some places changed from one fracture to another towards the north. Just north of Matthews Lake nine inferred faults suggest a horizontal separation of 4,400 feet of an easterly trending dyke, and along a fault 7,500 feet south of the south end of Matthews Lake the sedimentary-volcanic contact is horizontally separated left-hand 1,500 feet.

An inferred northeast striking fault, known as the Matthews Lake fault, is exposed at its east end as a series of parallel shear zones across a width of 100 feet in some places. The dip of this fault could not be determined from a study of the broken schist along the shear zone. Diabase dykes, the contact between mafic and felsic volcanic rocks, and a porphyritic zone in the mafic volcanic rocks are horizontally separated left-hand about 1,000 feet along this fault. A diabase dyke is horizontally separated left-hand about 400 feet along another easterly striking fault near latitude 64°05′30″ and longitude 111°12′30″.

The faults and the shear zones in slate and greywacke outcrop as zones of brecciated, crumpled, and sericitized rock containing lenses of quartz. Such zones are in places 15 to 20 feet wide and alternate with beds of massive greywacke and slate. Most shear zones in the volcanic rocks follow valleys and the few small outcrops and the float indicate that many such bodies are of silicified schist containing pyrite and some chalcopyrite that weathers to produce a rusty gossan.

EMPLACEMENT OF GRANITIC ROCKS

CHARACTER OF CONTACT WITH VOLCANIC ROCKS

The contact of the Courageous Lake batholith with volcanic rocks on the east was mapped for about 20 miles along the strike together with an area up to 1 mile wide within the granite. In detail this contact is marked by irregular embayments, particularly at the north where small bodies of granite are developed nearby in the volcanic rocks. The general trend, however, parallels that of the schistosity and flow contacts of the adjacent volcanic formation (*see* Figure 1).

The contact of the granitic rocks with the volcanic rocks where exposed is sharp at most places. At a few localities, however, xenoliths of volcanic rock having an exposed area of 20,000 square feet occur in massive coarse-grained granite 3,000 feet from the contact. Along the contact for 4 miles south from Courageous Lake and in a small area along the northernmost bay of Courageous Lake the contact is characterized by a zone wherein grano-

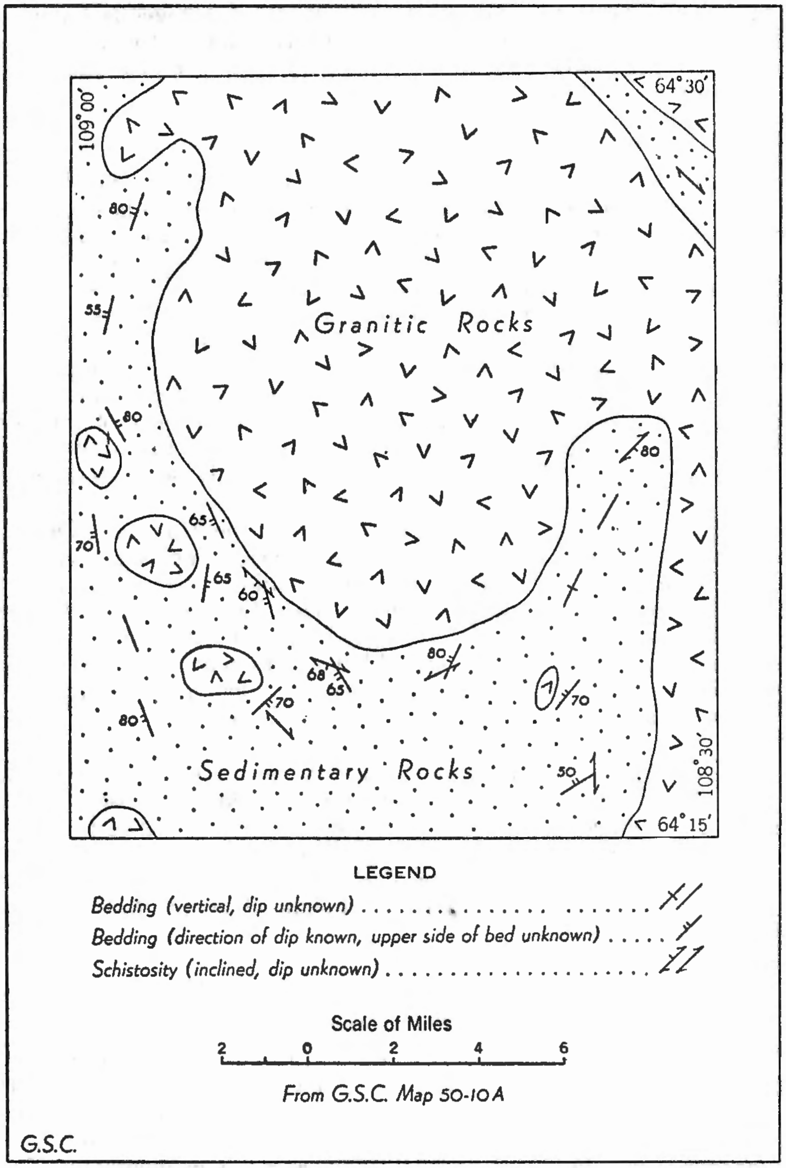


Figure 5. Detail of contact between sedimentary rocks and granitic rocks.

diorite with inclusions of volcanic rock passes outward to volcanic rocks cut by granodiorite. In such areas the contact was mapped at the point where granodiorite represented 50 per cent or over of the country rock. In parts of such zones and elsewhere quartz-hornblende diorite is present within the granodiorite.

About 3 miles, or 15 per cent, of the length of the contact zone is characterized by scattered areas of fine- to medium-grained gneissic granite, which at one place attains a width of 500 feet. This gneissic zone, in the southwest part of the Matthews Lake area, parallels the shore of MacKay Lake. About 50 per cent of the granite along the contact is massive fine to medium grained and seemingly devoid of inclusions. The fine-grained variety extends, at places, into the granite body for ½ mile. The exposed contacts of the Courageous Lake and MacKay Lake stocks are sharp and no hybrid zone was noted about these bodies.

Hybrid zones between granite and volcanic rocks have been described from a number of areas within the Canadian Shield. Todd (1926) states "a considerable area . . . is occupied by hybrid rock in which there are many masses of basic rock which with a great amount of work could be mapped separately". At Gordon Lake, 100 miles southwest of Matthews Lake Henderson (1941) notes scattered areas of mixed rocks in the granite at least 5 miles away from the contact, and such areas are related in distribution only in a general way to the exposed contact. In Carp Lakes area (Moore, Miller, and Barnes, 1951) a discontinuous belt of hornblende-feldspar gneiss up to 5 miles wide follows the contact of granite and volcanic rocks. Where the granite of this same body cuts sedimentary rocks a typical injection gneiss is developed.

CHARACTER OF CONTACT WITH SEDIMENTARY ROCKS

The contact of sedimentary rocks with granite was mapped around part of the Courageous Lake stock and part of the MacKay Lake stock. The contact was sharp where exposed, and on a small island in Courageous Lake a few small fragments of sedimentary rocks were observed in the granite. Nodular schist, described under metamorphism, characterizes part of the contact; this zone of nodular schist is in contrast with many areas where the borders of granite bodies are marked by gneissic granite and injection gneiss.

ORIGIN

Evidence of granitization and replacement during the formation of the granites is lacking at most points in the Courageous-Matthews Lakes area. The gneissic biotite granodiorite occurring along some 15 per cent of the length of the contact of the granitic bodies studied may represent replaced sedimentary rocks interbedded with the volcanic rocks. Contacts of the granitic bodies with the older volcanic and sedimentary rocks are in general concordant. This general concordant characteristic extends over a considerable area in this part of the Shield as indicated on the maps of Lac de Gras (Folinsbee, 1949), Aylmer Lake (Lord and Barnes, 1954), (Figure 5), and MacKay Lake (Henderson, 1944) map-areas. This combination of widespread general concordance and local discordance of granitic contact and structures within the intruded rocks could result from forces active before, during, or after the granitic intrusions. The details of the local structures, however, are best explained on the basis of forces of local origin, and active outward from the area of granitic intrusion. Either intrusion or post-intrusion forces would require an irregular distribution to produce the local details as presently known. In conclusion, the intrusive force of the plutons, therefore, is regarded as the most important factor in determining the concordant structure and local discordance in the Courageous-Matthews Lakes area. The stocks and batholiths of this area are interpreted as forming by piecemeal stoping accompanied by forceful intrusion and with granitization effective only on a small scale as is characteristic of magmatic intrusion of some other areas.

CHAPTER IV

ECONOMIC GEOLOGY

GENERAL STATEMENT

Gold was discovered in Courageous-Matthews Lakes area in 1939 by Territories Exploration Limited under the direction of W. L. Brown. Tungsten is reported on some of the gold-bearing veins and showings containing copper and molybdenum are known.

In 1945 Mike Mitto and J. W. Mathews each staked a group of mineral claims east and southeast of Matthews Lake and these properties in 1954 were held by Salmita Consolidated Gold Mines Limited and Bulldog Yellowknife Gold Mines Limited, respectively. Underground exploration of the gold deposit on the Salmita Consolidated Gold Mines Limited property consists of a vertical two-compartment shaft 145 feet deep with 55 feet of crosscutting, and 61 feet of drifting along B vein zone at 125 feet in depth (Singer, 1951, 1952). On Bulldog Yellowknife Gold Mines Limited property a shaft, planned to be 400 feet deep, was reported as 38 feet deep (*Northern Miner*, October 30, 1952) when work was discontinued to await more favourable operating conditions. Both deposits were explored by a series of diamond drill-holes from the surface. Lord (1951) describes the gold deposits of the area and their surface exploration in considerable detail. The known gold deposits occur as quartz veins or as a series of stringers and quartz lenses in shear zones, most of which are along or within 1,000 feet of the contact between the volcanic and the sedimentary rocks. These deposits on the basis of their geological setting are grouped as follows:

Veins along the contact of the sedimentary and the volcanic rocks, as B vein and South showing of Salmita Consolidated Gold Mines Limited and the Matthews vein of Bulldog Yellowknife Gold Mines Limited; veins along shear zones in mafic volcanic rocks, as the South showing of Bulldog Yellowknife Gold Mines Limited; deposits of Newnorth Gold Mines Limited, and those on the TMK group of claims; veins in felsic volcanic rocks as C and T veins, Salmita Consolidated Gold Mines Limited; veins that strike parallel with the beds of sedimentary rocks as the Southeast showing, Salmita Consolidated Gold Mines Limited, some of the Kennedy veins, and the main Payne showings; and veins that transect the beds of sedimentary rocks as some of the Kennedy showings.

CHARACTER OF GOLD DEPOSITS

Deposits carrying gold are known at intervals over a distance of 22 miles along the strike of the contact of the volcanic and the sedimentary rocks. The most promising of the known deposits are along or near this contact, but gold is known in veins 3 miles within the sedimentary rocks and within the volcanic rocks $1\frac{1}{2}$ miles from this contact. This main contact of the volcanic and the sedimentary rocks, however, appears important as a regional structural control in localizing the deposits. The results of exploration to date suggest that the veins away from this contact zone are of irregular shape, erratic in distribution, and commonly lack the continuity of the deposits explored along or near the contact.

The quartz occurs as fairly persistent veins and as a series of veinlets and lenses in shear zones. The gold-bearing quartz is white, light grey, blue, or black. Metallic minerals at only a few places exceed 5 per cent of the deposit and include arsenopyrite, pyrrhotite, scheelite, ferberite, pyrite, galena, sphalerite, and chalcopyrite. Tourmaline is fairly widespread and rusty weathering carbonate is present in many outcrops. This group of minerals places these deposits in the hypothermal zone of Lindgren's classification of ore deposits.

The reasons for the localization of the known main bodies of gold-bearing quartz at certain places along the contact of the sedimentary and the volcanic rocks cannot be given precisely with the limited data available. Many gold deposits of the Canadian Shield, however, occur at or near a contact between rocks of different competency, and by many authors such a contact is described as a zone of weakness along which shear zones are concentrated to form channels for the access of metal-bearing solutions. Slight local changes in the competency of strata along the contact between the sedimentary and the volcanic rocks on the properties of Salmita Consolidated Gold Mines Limited and Bulldog Yellowknife Gold Mines Limited may be important in controlling the location and size of certain quartz veins along or near this contact. In addition to structure, lithological control may also be important because all known deposits on these properties, except the Matthews and Southeast veins, are in the volcanic rocks. Of the volcanic rocks mafic types contain most of the known deposits although this may only reflect the fact that mafic types are more widespread in the area studied than are felsic types. Shear zones away from the contact are more plentiful in the sedimentary rocks than in the volcanic rocks, as would be expected, for under the same conditions the bedded and thinly layered strata are more favourable for the formation of shear zones than the thick massive flows. The schists derived from sedimentary rocks also may be more permeable than those from volcanic rocks, hence the vein-forming solutions would tend to be dispersed along shear zones in the sediments. This may explain the occurrence at many places of the small irregular-shaped veins and their erratic distribution along shears in the sedimentary rocks away from the main contact.

DESCRIPTION OF GOLD DEPOSITS AND OTHER METAL PROSPECTS

SALMITA CONSOLIDATED GOLD MINES LIMITED

This company controls thirty-one mineral claims on the east side of Matthews Lake. Since the property was geologically mapped in 1948 an airstrip 3,500 feet long and 125 feet wide has been constructed on a nearby esker, a mining plant installed, and underground work undertaken.

Five deposits are known on the property (*see* Figure 6, in pocket). Three of these are near each other, close to the shore of Matthews Lake at the main point on the east shore of the lake. The bedrock at this locality is felsic volcanic rocks with layers of ropy mafic lava, slate, and greywacke. The ropy lava belt is 80 feet wide at the north of the three showings and at some places contains garnet. The two bands of slate and the one of greywacke are each about 80 feet wide. The felsic rocks are in part fragmental but some of the massive rock may represent intrusive porphyry. At the only place the beds are recognizable they strike north 40 degrees west, whereas the regional strike nearby is north 15 degrees west. This local strike is parallel with that of the contact of the beds and felsic rock. If it is a flow the variation from the regional strike of the beds may represent only a local change in the slope of the flow surface before the deposition of the sediments. The present dip of this surface is nearly vertical. If the felsic rock is an intrusinve rock the local change in strike of the wall-rock could be due to the effects of the intrusion.

The B vein of the north group (*see* Figure 6) strikes about north 20 degrees west and dips steeply east. This vein is exposed 70 feet along the strike and in this distance ranges in width from a seam to 9 feet. The hanging-wall is a mafic volcanic rock and the foot-wall is slate. On the 125-foot level a narrow band of felsic agglomerate is reported by Singer (1951) to form the foot-wall. The contact of the vein and wall-rock is sharp except where quartz veinlets penetrate the altered wall-rock. The quartz is fine to coarse grained, white, grey, and black, and contains small fragments of wall-rock, and grains of pink feldspar, tourmaline, sericite, epidote, arsenopyrite, pyrite, galena, and sphalerite. The sulphides probably make up less than 1 per cent of the vein. Lord (1951) sampled some of the surface exposures of the vein and reports: 0.60 ounce of gold a ton across 9 feet; 0.75 ounce of gold a ton across 6 feet; and 1.35 ounces, gold a ton across 4.3 feet. The sampling of the level at 125 feet in depth returned, as reported by Singer (1951), an average of 0.70 ounce of gold a ton over an average width of 5.5 feet for a length of 61 feet along the vein.

The T vein is about 300 feet southeast of the B vein and the deposit is described by Lord (1951, p. 256) as follows:

"The adjacent formations are light grey, well cleaved, streaked, rhyolitic rocks, probably sheared rhyolitic agglomerate. The cleavage planes strike north 10 to 20 degrees west and are nearly vertical. The vein strikes north 20 degrees west and dips easterly at about 80 degrees. It is exposed by a trench 150 feet long. Lenticular quartz, up to 1 foot in width, is exposed at intervals between 10 and 45 feet north of the south end of the trench. The vein is continuously exposed in the next 90 feet of the trench and has an average width of about 1 foot. It ends before reaching the north end of the trench. The walls of the vein are sharp and free. In places the vein parallels the cleavage of the adjacent rocks; elsewhere it cuts the cleavage at small angles. The quartz is fine grained and grey, and contains a very little arsenopyrite, pyrite, and tourmaline. Pale, visible gold is common. The schistose wall-rock contains a little arsenopyrite. Bulk samples along a length of 115 feet and across an average width of 17 inches are reported to have averaged 1.42 ounces of gold a ton. Prior to the writer's visit, the vein had been explored for a length of 500 feet by about twenty-three shallow diamond drill-holes. Encouraging intersections, some of high grade, are reported to have been encountered for a length of about 325 feet."

The C vein is about 120 feet east of the T vein. C vein also is in felsic volcanic rock slightly more schistose than that at T vein. The strike of the vein is parallel with that of the T vein and the dip is nearly vertical. The vein is exposed in trenches for a length of 90 feet and the average width is less than 1 foot and the maximum width is 2 feet. Metallic minerals were not seen in the quartz although assays are reported to show some gold to be present.

The South zone is about 1¾ miles southeast of B vein and about 500 feet east of Matthews Lake (*see* Figure 6). A quartz vein in this zone is exposed 90 feet along its strike of north 40 degrees west. The dip is 80 degrees northeasterly, and the width from 1 foot to 3½ feet. This vein is in fragmental volcanic rocks and slate near the contact with the sedimentary rocks on the east. The contact of the vein and wall-rock is sharp with a series of veinlets from the main vein at places extending into the wall-rock that also locally contains small lenses of vein quartz. The foot-wall for 20 feet west of the vein is thin-banded, buff weathering fragmental volcanic rock and slate. The fragmental rocks probably are a part of a ropy zone exposed at points 200 and 400 feet south of the vein and which extends discontinuously the length of the area mapped. Felsic volcanic rocks outcrop 50 feet west of the vein and their schistosity strikes about north 25 degrees west and dips about 85 degrees northeasterly. The beds and cleavage of the slate east of the vein strike parallel with these structures west of the vein and also dip steeply easterly.

The quartz of the vein is a bluish white to grey, sugary to coarse-grained type containing a few fragments of slate, scattered crystals of arsenopyrite up to 2 mm. long, tourmaline, and visible gold. The slate adjacent to the quartz carries a few grains of arsenopyrite, pyrite, and tourmaline. The vein zone has been explored by a series of diamond drill-holes for a length of 500 feet.

The southeast deposit, known as the New Discovery vein, is about 1,800 feet northeast from the south showing described in the preceding paragraph (*see* Figure 6). This deposit is exposed across 26 feet in one trench. The nearest rocks exposed are slate, greywacke, and mica schist. The quartz is sugary and grey and contains scattered bits of pyrite and a few grains of sphalerite. Chip samples taken by Lord (1951) from the 26 foot long exposure averaged 0.12 ounce of gold a ton. The vein structure is reported by Singer (1951) to have been traced 140 feet along the strike and cut by three diamond drill-holes with assays from the core somewhat higher than those taken from the surface exposure.

BULLDOG YELLOWKNIFE GOLD MINES LIMITED

The property of this company comprises fifty-four mineral claims at the south end of Matthews Lake and along the contact of the volcanic and the sedimentary rocks. Of the deposits known on the property the Matthews vein has been explored in some detail and follows a pronounced and persistent shear zone striking north 15 degrees west and with an average dip of about 75 degrees easterly. The main shear zone is bordered nearby on the east or hanging-wall side by a number of minor parallel and intersecting shear zones.

A gold-bearing quartz vein in this shear zone has been traced along the strike 1,100 feet by surface exploration and a series of diamond drill-holes. The quartz is fine to coarse grained, banded, and most of it is dark blue or grey but some is white or black. The quartz is in sharp contact with a narrow band of schist between it and the sedimentary wall-rock. The vein varies in width from a seam to 6 feet and narrows and widens within short distances to form a series of lenticular bodies. Part of the vein consists of a series of stringers in schist. Along the strike the vein zone is offset a few feet by northeasterly striking faults. The quartz contains on the average probably less than 5 per cent of metallic minerals of which arsenopyrite is predominant; visible gold occurs at a number of places; galena, pyrrhotite, and scheelite are recognizable megascopically and ferberite was identified in polished sections. Tourmaline also is present. The gold and the scheelite appear more plentiful in the hanging-wall side of the vein than in the foot-wall part. An ore length of 613 feet is reported to have been indicated by diamond drill-hole intersections, the cut grade being 1.10 ounces of gold a ton across an average true width of 3.6 feet.

The South zone deposit is about $\frac{1}{4}$ mile south of the southernmost known part of the Matthews vein. This zone is in mafic volcanic rocks and consists of a series of parallel shears exposed across a width of 220 feet. The schistosity of the mafic volcanic rocks strikes north 15 degrees east and dips between 75 and 85 degrees easterly. At this locality, however, the strike of the schistosity is variable from point to point and changes from north to north 30 degrees west.

The shear zones contain quartz veins and lenticular bodies of silicified and mineralized schist with or without stringers of vein quartz. In the quartz arsenopyrite follows fractures and in the schist occurs both disseminated and in massive streaks. Some of the stringers of quartz contain scheelite, pyrrhotite is fairly widespread, and pyrite and chalcopyrite are present in small amounts. Shear zones in the sedimentary rocks east of the contact with the volcanic rocks at this locality contain quartz veins carrying some pyrite and arsenopyrite. Gold was not observed in these veins but the company reports some gold as determined by assay.

Gold occurs in a deposit on the south shore of a small lake about $2\frac{1}{2}$ miles south of the Matthews vein. There one trench 6 feet long and another 15 feet long expose bodies of quartz in a layered mafic lava. The layers strike north 20 degrees east and dip easterly at 80 degrees. The nearest exposed sedimentary rocks are 350 feet east of the trenches. Vein quartz forms about 50 per cent of the material exposed in the trenches and is light grey to black in colour. Both the quartz and the host rock contain scheelite, arsenopyrite, pyrrhotite, and pyrite. Of the sulphides, arsenopyrite is the most abundant and is localized chiefly to the vein quartz. Other trenches expose quartz veins at intervals for 2,000 feet along the strike of the contact of the volcanic rocks and the sedimentary rocks but gold was not seen in these veins.

NEWNORTH GOLD MINES LIMITED

A group of thirty-six unsurveyed mineral claims in the northernmost part of the Courageous-Matthews Lakes area was prospected by Newnorth Gold Mines Limited. A number of shear zones from a few inches to 8 feet in width were stripped and trenched. The shear zones are in mafic volcanic rocks and meta-gabbro and contain quartz veins in some of which gold, arsenopyrite, and pyrite occur. Matheson (1945) reports one vein averaged 1.44 ounces of gold a ton across an average width of 2 feet for a length of about 110 feet.

TMK GROUP

This group of nine mineral claims in the northern part of the Courageous-Matthews Lakes area was optioned to Frobisher Exploration Limited in 1945. The claims include an area about $\frac{3}{4}$ mile along the strike of the contact between the volcanic rocks on the west and the sedimentary rocks on the east. One showing explored is in massive, mafic volcanic rock and consists of a shear zone from 1 foot to 2 feet wide followed by lenticular veinlets of white and blue to black vein quartz. This deposit contains visible gold, arsenopyrite, and chalcopyrite. Matheson (1945) reported this vein as averaging 1.98 ounces of gold a ton across an average width of 20 inches for a length of 115 feet.

KENNEDY SHOWINGS

These showings are about 2 miles east of the northeast bay of Courageous Lake and consist of veins and stringers of pink and milky to grey quartz most of which are less than 3 inches wide but a few up to 1 foot wide. The quartz veins and stringers occur in moderately to highly sheared zones both in slate and greywacke. Such zones at some places are marked by a gossan. The beds dip steeply and some veinlets parallel these; in some places the veins dip as low as 70 degrees and cross the dip of the beds but parallel their strike; and at other places the veins follow fractures that cross both the strike and dip of the beds. Gold is visible in the veins, along the cross-fractures, and also is reported to occur in veins parallel to the strike of the beds. Other minerals noted in these veins include arsenopyrite, pyrite, chalcopyrite, galena, and ankerite. Veinlets of a pinkish, apparently barren quartz, cut the gold-bearing quartz.

PAYNE YELLOWKNIFE GOLD MINES LIMITED

This company completed stripping, trenching, and diamond drilling to explore deposits in the sedimentary rocks about Courageous Lake. One deposit situated about 1,500 feet north of the point of intersection of latitude 64°11′ and longitude 111°17′ is in slate forming a part of a series of alternating bands of slate, greywacke, and felsic rock. The deposit is a network of quartz veinlets of variable thickness up to 6 inches along a zone 3 feet wide at places. This zone dips approximately vertical and crosses the beds of slate that dip 80 degrees. Gold and arsenopyrite are visible, most of the arsenopyrite occurring as scattered crystals in the slate up to 6 inches away from the quartz veins. Other deposits explored by this company include quartz veins and shear zones that are capped by gossan.

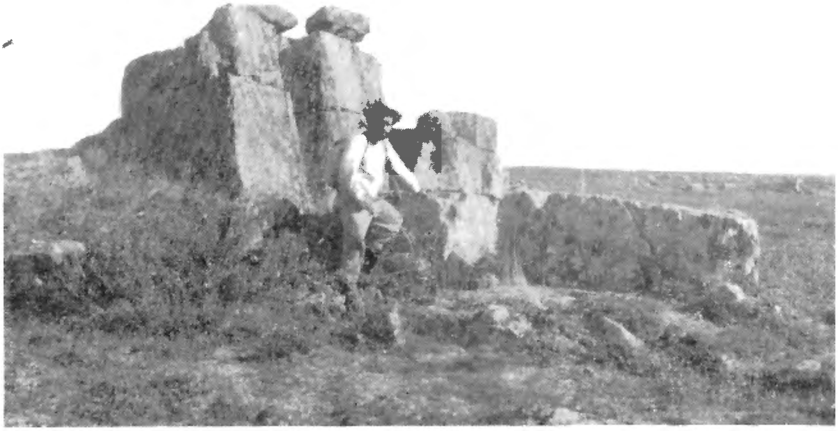
COPPER OCCURRENCES

About 1½ miles west from the south end of Matthews Lake a grab sample taken from an area of about 3 square feet of gossan assayed 5 per cent copper and 0.01 ounce of gold a ton. Bedrock of this part of the area is mafic volcanic rocks but the gossan zone contains some feldspar porphyry. Veinlets of quartz in a gossan zone 5 feet wide beside the small lake 1,000 feet north-northwesterly from the intersection of latitude 64°02′ and longitude 111°15′ contains small amounts of pyrite, pyrrhotite, and chalcopyrite. At about 2,700 feet north-northwesterly from the intersection of latitude 64°02′ and longitude 111°15′ a gossan averaging at least 10 feet wide and more than 60 feet long consists of 75 per cent or more of sugary, vuggy quartz containing scattered bits of pyrite, pyrrhotite, chalcopyrite, and galena. These three showings probably are along the same zone of gossan.

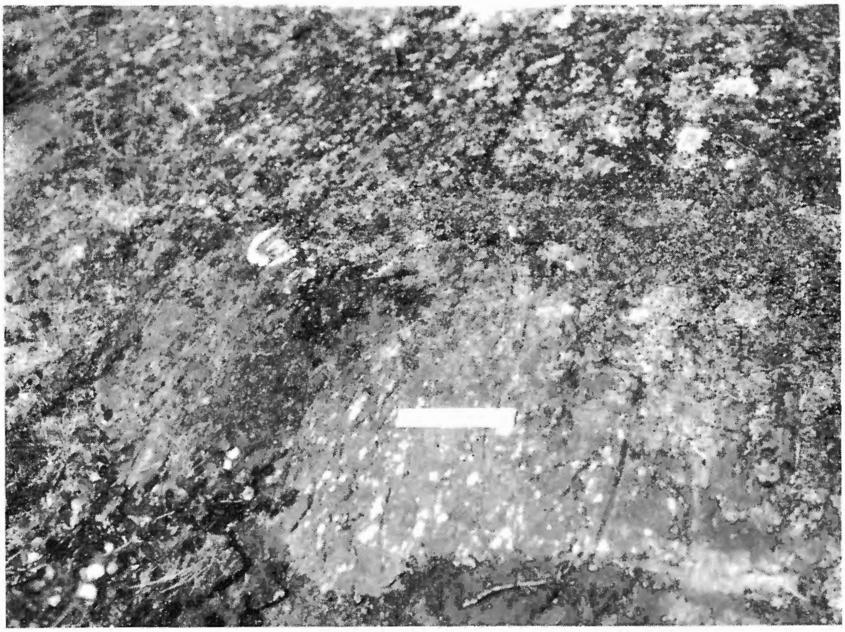
MOLYBDENUM OCCURRENCES

Near the northeast bay of MacKay Lake at a point about 300 feet north of the intersection of latitude 64°01′ and longitude 111°14′ veinlets of quartz in mafic volcanic rocks are estimated to contain about 4 per cent molybdenite.

A. Frost-thrust sedimentary rocks. *J. C. M. 4-1-49*

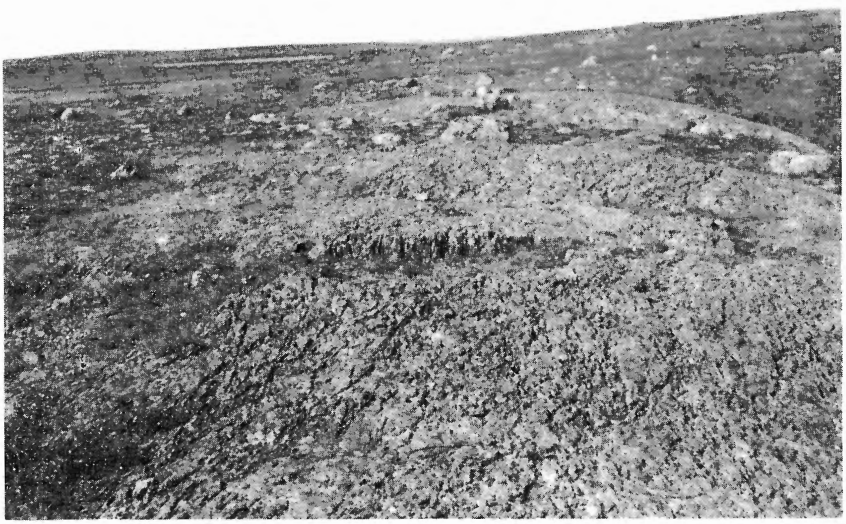


B. Frost-thrust felsic lava. *J. C. M. 5-1-49*



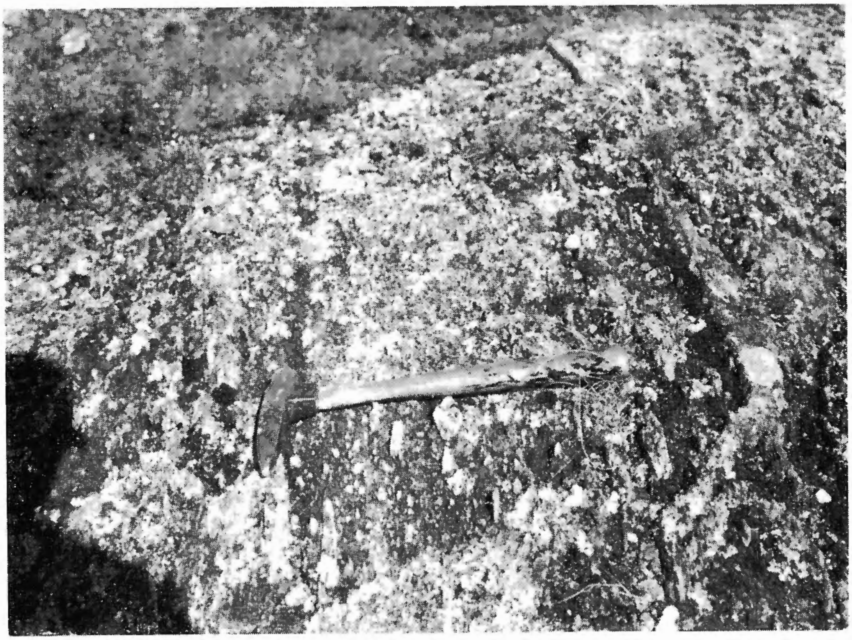
J. C. M. 3-11-49

A. Lichen-free area on typical lichen-covered outcrop. Porphyritic mafic lava, possibly pillowed. Scale is 6 inches long.



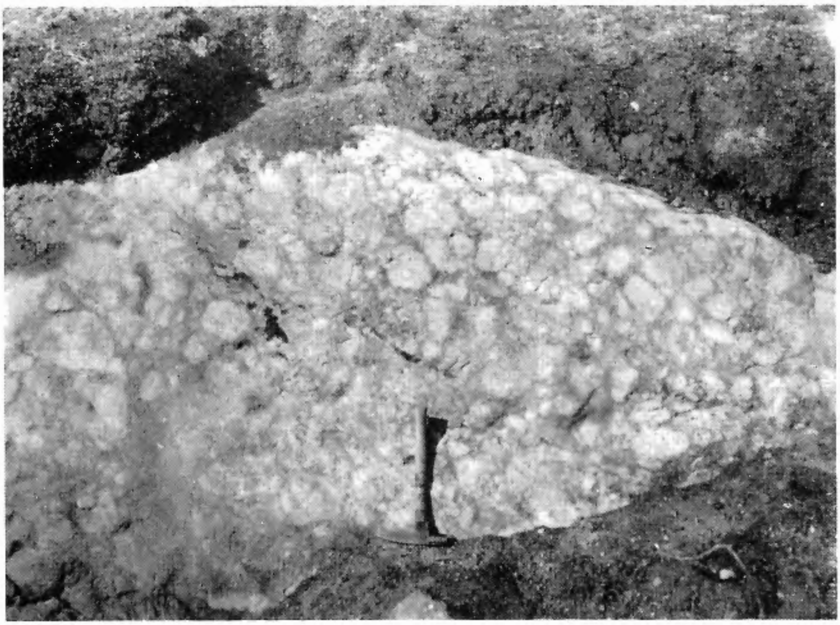
J. C. M. 2-7-49

B. Sheared ropy and fragmental lava.



J. C. M. 2-5-49

A. Felsic fragmental lava. Fragments stand in relief owing to weathering of carbonatized matrix. Hammer is 12 inches long.



J. C. M. 3-2-49

B. Porphyritic meta-gabbro. Hammer is 12 inches long.

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