Province of Manitoba

DEPARTMENT OF MINES AND NATURAL RESOURCES

MINES BRANCH

PUBLICATION 53-3

GEOLOGY

of the

CALIFORNIA LAKE AREA

Oxford Lake Mining Division

Northern Manitoba

by

M. D. Moorhouse and J. H. Shepherd

Winnipeg
1954

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THE CALIFORNIA LAKE AREA

INTRODUCTION

LOCATION AND ACCESS

The California Lake Area lies across the east-west boundary between the Cross Lake and Oxford Lake Mining Divisions. The map-area comprises approximately 230 square miles, and lies between 55° 00' and 55° 20' north latitude and between 95° 30' and 95° 45' west longitude.

The most convenient mode of entry into the area is by air from Norway House (approximately 120 miles), or Ilford on the Hudson Bay Railway (approximately 60 miles).

The best canoe route originates at Oxford House. From Semple (Sucker) Bay on Oxford Lake, the route follows the Semple River with three short portages to Semple Lake, in the extreme southern portion of the area. Continuing into the central portion, from the north shore of Semple Lake the route follows a stream with two short portages to Powstick Lake. From the northeast corner of Powstick Lake, a one-mile portage leads to California Lake, and from the north shore of California Lake, a three-quarter mile portage terminates at the south shore of Bear Lake. Access to the northern part of the area is gained by following the Bigstone River from its point of origin on the north shore of Bear Lake, over one short portage to Bigstone Lake. Utik Lake, in the extreme northwest corner of the map area, may be reached by a one-half mile portage from the north shore of Bigstone Lake.

GENERAL CHARACTER OF THE AREA

The topography of the area is dominated by monotonous stretches of muskeg and swamp which are separated by broad gently sloping belts of glacial clays, whose long axes lie in a northeasterly direction. Throughout the area to the east of Bear Lake, and from there south to Semple Lake, there are many glacial ridges of greater height, composed

of sand and boulders. These ridges are thickly covered with second-growth jack pine, and occasionally spruce, and differ from the lower ground which, where previously burned, is sparsely dotted with spruce. In general, good rock exposures are not associated with this sort of topography. Over most of the area, outcrops are concentrated on the shores of the larger lakes. The area of most extensive outcrop and also of greatest relief (up to 100 feet), lies between the Bigstone River and the eastern portion of Bear Lake.

In the past, fires have destroyed much of the timber in the area. Many of the burned trees still stand in a tangle of second-growth spruce and jack pine. The most recently burned area is located on the south shore of Bear Lake at the mouth of the creek flowing from Dobbs Lake. The average diameter of the living trees is from four to six inches and only rarely were any found having a diameter over ten inches. Timber for mining operations or extensive construction could not be found in quantity in the area.

GLACIATION

Pleistocene glaciation is chiefly responsible for the present topography of the region. The icecap, retreating in a northeasterly direction, has left extensive deposits of clay, sand, gravel, and boulders. The general character of these deposits has been described above. A few eskers of short extent were also found. These deposits have been a major factor in limiting rock exposures away from the lake shores.

PREVIOUS WORK

Prior to 1951, little work had been done in the area. Wright (1925)[1] examined the Oxford and Knee Lakes area, and in the same year, Merritt made a track survey of the Bigstone and Fox rivers. The latter survey crossed the present map-area from south to north.

PRESENT WORK AND ACKNOWLEDGMENTS

Field mapping was conducted in the California Lake area from May 26 to September 15, 1953. Traverses were run, where feasible, at intervals of 1,500 to 2,000 feet.

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[1] Numbers in parentheses refer to bibliography.

Outcrops were located by pace and compass and on vertical aerial photographs. A base map, on a scale of two inches to one mile, was compiled by the Manitoba Surveys Branch from vertical aerial photographs, using slotted template and sketchmaster.

This work is part of a mapping project which covers a volcanic-sedimentary belt extending from near the Nelson River to the present map-area.

Capable and willing help was provided in the field by G. Johnson, H. Harris, and D. Brett, all students at the University of Manitoba. G. C. Milligan and his assistants rendered invaluable aid in the last month of the field season, during which they mapped a considerable portion of a greenstone belt in the southern part of the area. Thanks are also due to members of the Manitoba Forest Service for relaying radio traffic during the field season. Mr. T. McEwan, Hudson's Bay Company Post Manager at Norway House, was very helpful in providing supplies and mail throughout the summer. The many courtesies extended by Mr. N. C. McCoy, of the Manitoba Government Air Service, were greatly appreciated.

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GENERAL GEOLOGY

All consolidated rocks in the area are of Precambrian age. The oldest rocks are two belts of metamorphosed sediments and volcanics. Andesites and basalts are the dominant rocks of these belts. Associated with them are some sedimentary and minor acid volcanic rocks. Granitic rocks, which extend over the major part of the area, include alaskite, a northern granodiorite intrusive, porphyritic granodiorite, pink massive quartz monzonite, and grey to buff quartz monzonites, granodiorites, and quartz diorites. The age relationships of these granitic rocks are not clearly established.

A persistent diabase dyke, the youngest rock type in the region, extends for several miles in a northeasterly direction across the northern part of the area.

Small-scale faulting is common throughout the area. Some of the faults are recent enough to have displaced diabase dykes. One major fault extends across the southwest part of the map area. This fault is believed to be an extension of the Bear Lake fault, mapped by Milligan to the west.

The southern greenstone belt is apparently continuous with greenstone at Oxford and Knee lakes mapped by Wright (1931) as belonging to the Hayes River group.

The rock types of the map-area and their postulated relative ages are summarized in the following table of formations.

TABLE OF FORMATIONS

Recent and Pleistocene	Swamp and muskeg. Glacial deposits; clay, sand, gravel and boulders.
PRECAMBRIAN	Basic Dykes
	Intrusive Contact
	Alaskite. Northern granodiorite and quartz monzonite; gneissic marginal phases. Porphyritic granodiorite. Pink massive quartz monzonite. Grey and buff quartz monzonite, granodiorite and quartz diorite.
	Intrusive Contact
	Greywacke, impure quartzite, conglomerate, and derived schists and gneisses. Plagioclase amphibolite derived from andesites and basalts; acid volcanics and tuffs. Derived schists.

NORTHERN VOLCANIC-SEDIMENTARY BELT

Volcanic Rocks

Distribution

This belt of volcanic rocks extends in an east-west direction from the eastern end of Utik Lake, across Bigstone Lake for an unknown distance east of the map-area. The rocks are a continuation of the volcanic belt mapped by Milligan (1954), although they have been separated from this belt by an intrusion of alaskite at the western edge of the area. The belt has a width of about one mile. The best exposures occur at the eastern end of the south arm of Utik Lake, and along the north shore of Bigstone Lake. A small isolated area of volcanics occurs about two miles to the south of the east end of the main belt.

Character

Rocks of this group are basic in composition. Originally andesitic and basaltic flows, they have been metamorphosed, for the most part, to rocks of the plagioclase-amphibolite facies.

The texture varies considerably, ranging from an extremely fine-grained and dense mixture of either aligned or unaligned hornblende with plagioclase, to a coarse-grained aggregate composed chiefly of equidimensional crystals of hornblende and plagioclase of about 5mm. diameter. Porphyritic greenstone occurs in two outcrops about five miles apart. Subhedral phenocrysts of plagioclase (An78), ranging from 1/4 inch to 1 1/2 inches long make up at least 50 per cent of the total volume. These are surrounded by a finer grained matrix of hornblende and plagioclase. The weathered surface of these flows ranges from very dark green to black in colour. Some have a "pepper and salt appearance", due to distinct grains of dark hornblende and greyish plagioclase.

The steep dip of the rocks has exposed the flows in cross-section. Pillow structures, although often present, are mostly long and thin so that it was almost impossible to use these structures for top determinations, although this was done in a few places.

In thin section, the lavas are seen to consist of 50 per cent to 80 per cent of green to faintly bluish hornblende

with plagioclase and 1 per cent to 2 per cent scattered magnetite grains. The plagioclase ranges in composition from andesine (An42) to bytownite (An72). Twinning is not common, and when present is usually irregular. Some grains are zoned. Rarely, a small amount of quartz is present, although one specimen, taken from the greenstone at the contact of a granitic dyke, contains about 15 per cent quartz. Brown biotite forms a small percentage of a few thin sections. Cummingtonite was identified in one section.

The only outcrop of tuff that was seen is located at the extreme southwest corner of the main lava belt, in contact with the grey granodiorite. Here, sharply defined beds range in thickness from a fraction of an inch to 4 inches, and average about 1 inch. A few volcanic bombs indicate tops to the south. Metamorphism, due to the adjacent granitic rocks, has entirely recrystallized the tuff to a very fine, even-grained rock. Dark grey beds are rich in dark blue-green hornblende, with pale green pyroxene rimmed with epidote, plagioclase, abundant grains of sphene, and some magnetite. Finer bands which are richer in either hornblende or pyroxene, alternate with these dark bands. Light grey beds contain mainly plagioclase and quartz with about 20% blue-green hornblende and scattered grains of sphene and, very rarely, a few microline grains.

Origin and Metamorphism

Extensive development of pillow lavas indicates that during at least part of the volcanic period, this area was submerged. The absence of interbedded tuffs and agglomerates is typical of these fluid basic flows, and many mean a rapid accumulation of lavas, or merely that they were deposited in an area free from sedimentation.

Metamorphism on a regional scale has produced rocks of the plagioclase-amphibolite facies. The granodiorite in contact with the tuff has thermally metamorphosed that rock to a moderately high grade, as shown by the presence of pyroxene.

Sedimentary Rocks

Distribution

Sedimentary rocks of the northern belt lie mainly to the south of the greenstones, and are best exposed on the

islands and the south shoreline of western Bigstone Lake. At the eastern side of the area, outcrops of a similar sedimentary rock are exposed along the shore of a narrow lake. A narrow band of cordierite schist outcrops to the north of the main greenstone belt, on the south shore of the south arm of Utik Lake.

Character

The main sedimentary type is a highly metamorphosed greywacke. This greywacke has been extensively intruded by buff-coloured granodiorite. Some outcrops consist mainly of granodiorite containing large contorted zenoliths of the sediment. The width of this sedimentary band is greatly increased by concordant granitic intrusions.

Most outcrops weather to a rusty brown, so that their sedimentary character is easily seen, even though the grains are usually 1 mm. or less in diameter. However, where not extensively weathered, the rock, if very fine grained, resembles the plagioclase amphibolite.

Quartz, plagioclase, and biotite, in roughly equal amounts are the chief minerals, making up about 90 per cent of the total volume. Potash feldspar is absent. The metamorphic minerals, present in certain areas in amounts less than 5 per cent, are cordierite, sillimanite, and garnet. Hornblende forms 13 perccent of one sample. Accessory minerals, which are not present in every specimen, include magnetite, apatite, zircon, sphene, and rutile. Quartz grains are clear and rounded. Occasional grains have a diameter of 3 mm. Plagioclase grains are rarely twinned, and as they are only slightly sericitized, they closely resemble the quartz. Biotite is of the strongly pleochroic brown variety. Biotite flakes usually are not aligned, but they locally have a general parallelism, giving the rock a poor schistosity.

On the north shore of the narrows at the western end of Bigstone Lake, there are a few outcrops containing minerals which show the rock was originally a lime-rich sediment. The rock has been injected by pegmatitic granite and aplite and is highly contorted. Late hydrothermal activity has introduced considerable epidote. The weathered surface of this sedimentary rock is grey to dark green, and, because of its fine grain size, it closely resembles the greenstone. In thin section, hornblende, pyroxene (probably diopside), quartz, plagioclase, zoisite, sphene, microcline, and carbonate are usually seen.

Biotite occurs where quartz is abundant. Apatite, magnetite, sulphides, and zircon are present as small scattered grains. Garnet was found in only one section.

The sedimentary rock at Utik Lake is exposed on a few outcrops over an area about 600 feet by 100 feet, in contact with the greenstone. It grades from an exceedingly fine-grained mixture of quartz, plagioclase, and biotite, with a few small red garnets, to a coarser-grained rock, which contains, along with quartz, biotite, and plagioclase, abundant metacrysts of cordierite and garnet. Cordierite grains have a maximum length of 1/2 inch, and some garnets have a diameter of 3/8 inch. Also present are small grains of magnetite and rare grains of apatite, sphene, and zircon. Milligan (1952) describes a sediment "included with the volcanic rocks...on the south side of the peninsula in Utik Lake", which appears very similar, except that it does not usually contain garnet. Much more of this type of rock was mapped on the adjacent map sheet to the west (Milligan, 1954).

Origin and Metamorphism

The greywacke is free from interbedded volcanic material and has therefore probably been deposited during a period of quiet sedimentation. The cordierite schist on Utik Lake is found interbedded with volcanics in the adjacent map area to the west.

Fairly high grade metamorphism has been reached, as is indicated by the presence of garnet and sillimanite. Cordierite, a thermal metamorphic mineral, indicates that there has been only a weak shearing stress during the latter part of the metamorphism.

Age Relations

Rare top determinations on the pillow lavas indicate that the tops of the flows face south. This means that the sedimentary rocks are younger than the lavas and represent a period of quiet sedimentation, following a period of volcanic activity. The cordierite schist is in contact with the lavas on the north side, indicating that it is one of the oldest rocks in this area. To the west this rock type is interbedded with the volcanics, and therefore must be of the same general age.

SOUTHERN VOLCANIC-SEDIMENTARY BELT

Distribution

This belt of rocks, extending across the width of the map-area, crosses the southern boundary of the area at the eastern edge and extends in a northwesterly direction to the western boundary, where it continues into the adjacent map-area to the west. The width of the belt varies from place to place, but averages about two miles. Outcrops are not very abundant, and are always small. The best exposures occur along the shores of the central part of Semple Lake, and western end of Powstick Lake.

Character

Volcanic rocks, mainly basic lavas, are the predominant rock type. Interbedded with these flows are minor tuffs and agglomerate, rhyolite and dacite flows, greywacke, impure quartzite, and conglomerate. Where the acid flows and sedimentary rocks are of sufficient extent, they have been shown on the map. However, over a considerable part of the area, and especially the eastern half, these rock types do not form deposits thick enough to be shown separately. The lavas just south of the fault at the southeast corner of the area contain considerable amounts of interbedded greywacke and tuff. Near their contact with granitic rocks, volcanic and sedimentary rocks are intruded by pegmatitic and aplitic dykes.

This series is in distinct contrast with the northern greenstone belt, which does not contain any interbedded sedimentary rocks or acid flows.

Volcanic Rocks

Andesites and basalts, now recrystallized by metamorphism, form the bulk of the volcanic rocks. Schistosity is developed over most of the area, although unsheared massive flows and unsheared pillowed flows are common. Vesicular lavas were occasionally seen.

The weathered surface ranges in colour from a very dark greenish black to a lighter greyish green. Weathering of the strongly schistose areas produces a rough surface

which resembles fine bedding. Very fine grain size is characteristic, although on the south shore of Powstick Lake northeast of the conglomerate horizon, and again on islands in the lake, there are exposures of a much coarser basic rock. These rocks are composed of hornblende, with subordinate plagioclase and biotite. Hornblende grains average 1/4 inch in diameter and have a maximum diameter of 1/2 inch. The fresh surface of most of the flows has a uniform dark green to greenish black appearance, and individual minerals are usually indistinguishable.

Thin sections show that metamorphism has produced a rock containing from 60 to 90 per cent of fine, elongate, often irregular, blue-green hornblende crystals. Plagioclase makes up most of the remainder, usually as minute recrystallized granules, although primary laths remain to some extent. Chlorite, in the form of sinuous patches, is common. Magnetite, as minute elongate specks, is abundant, making up 5 per cent of some sections. Carbonate is usually present, probably as a product of the regional metamorphism, although metasomatic carbonate accompanying quartz has formed abundant irregular veins near the west end of Powstick Lake. Biotite is rare, and occurs as tiny flakes. The coarse basic rock north of the conglomerate consists almost entirely of blue-green, equidimensional, metamorphic hornblende crystals, with some biotite and plagioclase. Minor amounts of scattered sulphides are present.

A thin section made from some coarse-grained rock that occurs in the flows near the west end of Powstick Lake is different in that it apparently contains primary hornblende. The rock consists of about 50 per cent hornblende in ragged blocky crystals 1.5 to 2mm. in diameter. The borders of these crystals are strongly pleochroic in blue to green, but the main part of the crystal is moderately pleochroic. The matrix is a fine recrystallized aggregate, mainly of plagioclase, with chlorite, epidote, and small patches of calcite, but outlines of plagioclase crystals up to 1 mm. long are still visible. This coarse-grained rock is apparently a sill intruded between flows. Metamorphism has started to change the hornblende to the typical blue-green metamorphic type, and has saussuritized the plagioclase.

Acid flows are not common in the area. Rhyolite is exposed just south of the large island near the centre of Semple Lake. The rhyolite weathers dirty white to pink, with feldspar phenocrysts up to 3/4 inch in diameter visible on the weathered surface. The fresh surface is greyish pink.

In thin section, phenocrysts of plagioclase, orthoclase, and corroded quartz are seen. The matrix is cryptocrystalline and contains a small amount of magnetite and carbonate.

Other flows, having the approximate composition of dacite, are exposed to the east of the rhyolite. These rocks are porphyritic, and contain from 30 to 80 per cent plagioclase phenocrysts with about 5 per cent orthoclase or microcline phenocrysts. Phenocrysts range in size from 0.1 to 4 mm., and average from 1 to 2 mm. The matrix is a very fine aggregate of quartz and plagioclase. Abundant fine sericite, biotite, or hornblende may be present. Magnetite is a common accessory. A few grains of apatite were seen.

Tuffs form a minor part of the assemblage. The best exposures occur on the southeast shore of the large island in central Semple Lake, and on the shores of the mainland to the south. Other tuffs are exposed adjacent to the fault at the western edge of the area. The tuffs at Semple Lake weather brownish to dark greenish black. On the weathered surface tiny fragments are sometimes visible to the eye. The rock is brittle and breaks with a slate-like cleavage to expose a shiny dark grey to black siliceous looking fresh surface. Thin sections reveal that the main part of the tuff is so fine grained that individual grains are all but indistinguishable under the microscope. Tiny fragments of plagioclase are more easily seen. The more siliceous looking tuffs contain a large percentage of sericite and a little magnetite in the matrix. The more basic tuffs have begun to recrystallize to an aggregate of very fine biotite and hornblende, with some chlorite, abundant specks of magnetite and carbonate, and what is probably quartz and feldspar. These tuffs are typically more siliceous than the surrounding lavas. The tuffs at the western edge of the area are somewhat different than the others. Here, the rock weathers dark greenish black. Individual beds range in thickness from very thin to 1/4 inch. The rock is composed of hornblende and plagioclase with a little magnetite. The bands contain from 60 to 100 per cent aligned blue-green hornblende needles.

Agglomerates are rare in the area. The best exposures are on the shoreline just north of the conglomerate near the centre of Powstick Lake. Fragments range from very small to two feet long and average in size from 1/2 inch to 2 inches. Shearing has in part elongated and flattened the fragments, but some still retain their original angular shape. Fragments are mainly of basic lava, but pieces of brownish grey chert are common. There are also rare fragments of feldspar porphyry (dacite).

Sedimentary Rocks

As previously mentioned, most of the sedimentary rocks occur as small lenses within the other rocks, but there are exposures of greywacke of mappable dimensions near the southeast corner of the area. This greywacke weathers brownish to very dark grey and has a black fresh surface. Thin sections show it to be composed of very fine scattered fragments of quartz and feldspar in a matrix containing abundant tiny flakes of biotite with some magnetite. Also present are cryptocrystalline grains which are probably quartz and feldspar.

Conglomerate occurs in two places: one small outcrop on the south shore near the centre of Semple Lake, and one large outcrop on the southern shore of central Powstick Lake. The Semple Lake conglomerate is composed of approximately 30 per cent pebbles, which range in size from very small to 12 inches long by 4 inches wide. The pebbles are mostly well rounded. Fine- and medium-grained grey granitic pebbles containing biotite are the predominant type, but there are also pebbles of feldspar porphyry, quartz, quartzite, and greenstone. The matrix is a typical greywacks, black in colour, which under the microscope is seen to consist of abundant fine subangular fragments of quartz and feldspar in a matrix of fine quartz, feldspar, and biotite, with a little hornblende.

The Powstick Lake conglomerate contains pebbles and boulders making up from 20 to 90 per cent of the rock. The pebbles range from very small up to 18 by 23 inches. Grey to buff biotite-bearing granitic pebbles are the predominant type. Pebbles and boulders of a porphyritic granitic rock, containing feldspar phenocrysts often about 3 inches square, are also common. Other pebbles are of quartz, quartzite, chert, greywacke, grit, micaceous schist, feldspar porphyry, and greenstone. The grey coloured matrix may be very fine, or may have the appearance of a grit and contains mainly recrystallized grains of quartz with some feldspar and blue-green metamorphic hornblende set in a fine siliceous matrix.

Origin and Metamorphism

Pillow lavas, tuffs, and greywacke indicate a probable underwater environment during the development of these rocks. The different rock types are interbedded and are of the same general age. Along with the northern greenstone belt they represent the oldest rocks of the area.

Metamorphism is not so intense as in the northern belt. Primary textures, extensive development of fine biotite,

and absence of garnets indicate a grade of regional metamorphism of about the biotite zone as defined for argillaceous rocks (Epidote - amphibolite facies).

GRANITIC ROCKS

Grey and Buff Quartz Monzonite, Granodiorite, and Quartz Diorite

This unit includes the buff and grey "granodiorites" which were mapped separately by Milligan (1954) to the west.

These are the most extensive of the granitic rocks. They outcrop chiefly in the area between Bigstone and Bear Lakes in a belt extending across the map-area, and are best exposed in the region to the north of Bear Lake. Scattered outcrops are also found around the southern and eastern portions of Semple Lake.

Most of the rocks of this unit weather to a dark grey or greyish-white. Near Semple Lake, and in the region southeast of Bigstone Lake west of the Bigstone River, the rocks have a buff colour, due primarily to the feldspars. A white weathering massive variety, closely associated with the greenstone-sedimentary complex,occurs southeast of Bigstone Lake at the eastern boundary of the area. The granitic rocks may locally assume a pink colour, due to the presence of pink feldspar. Where this pink feldspar was found to be dominant, the rock was mapped in the field as a pink "granite". Each of these pink "granite" areas is surrounded by an aureole of grey granitic rocks which contain some pink feldspar. Pink feldspar is common in the rocks between Bear Lake and the Bigstone River.

The colour of the fresh surface is similar to that of the weathered surface. On most specimens, a bleached zone extends about 1/8 inch from the weathered surface. Below this a brownish band, which may attain a maximum thickness of 1/2 inch, grades imperceptibly into the fresh rock. The fresh surface shows grey to greyish-white feldspar grains, closely intermingled with darker grey anhedral quartz. Twinning striations can be seen on some of the plagioclase. Ferro-magnesian minerals, usually biotite, make up 5 to 10 per cent of the rock. Hornblende may accompany or take the place of biotite in areas of much contamination and in the vicinity of greenstone contacts.

Rocks of this unit display a primary alignment of biotite over most of the area. A notable exception is the white weathering massive rock mentioned above. In addition

to the alignment of biotite, the greyer rocks usually have a distinct primary foliation, caused by the aggregation of biotite into sinuous bands, ranging from less than one inch to more than one foot in width. Rocks having this foliation are best exposed on the extreme western shore of Bigstone Lake.

Microscopically, this rock unit exhibits a similar texture throughout the area, but the composition varies considerably. Typical granitoid texture was found in all specimens examined. The grain size of the major constituents ranges from 1.5 mm. to 5 mm. and averages from 2.5 mm. to 4 mm. Quartz grains are always anhedral, and except where recrystallized, show strain shadows. Plagioclases are anhedral, and are corroded where they come in contact with quartz. They are slightly sericitized. This alteration has attacked the plagioclase twins differentially. Commonly, only alternate twin lamellae are affected. Where twinning is absent, this alteration occasionally affects certain concentric zones. Saussuritization is locally extensive. Potash feldspar is mostly microline, although in some specimens, orthoclase is dominant. Potash feldspar is interstitial, clear and unaltered. Most thin sections show a few grains of quartz-plagioclase myrmekitic intergrowths.

The mineralogical composition of the unit was determined by means of Rosiwal analysis, using specimens from various parts of the area. Buff-coloured rocks are mostly quartz monzonites, on the basis of Grout's classification. (All igneous rock names used in this report are based on this classification). The large mass of buff quartz monzonite which is extensively exposed around the rapids at the upper end of Bigstone Lake, has the range of composition shown below:

Quartz	25-30%
Plagioclase (An_{25}-An_{35})	45-50%
Potash feldspar	15-20%
Biotite	4-9%

The grey phases are quartz diorites and granodiorites, the distinction being based on the ratio of potash feldspar to total feldspar. Twelve analyses gave the following range of composition for the major constituents:

Quartz	20-30%
Plagioclase (An_{27}-An_{37})	50-65%
Potash feldspar	2-8%
Biotite	2-10%

It is suggested that the buff quartz monzonite represents the original intrusive, and that the grey granitic rocks have become more basic by contamination, caused by reaction with the greenstones which they have intruded. This is borne out by the presence, in the rocks north of Bear Lake, of many basic xenoliths. Here the rock is predominantly grey, except for the widespread occurrence of pink stringers. To the north, south of Bigstone Lake, the buff quartz monzonite contains few xenoliths, and these are mostly of siliceous sedimentary material, which could easily be digested by the magma without rendering it more basic.

Pink Massive Quartz Monzonite

An attempt has been made to indicate rocks of this type as a distinct unit on the map. In the field, it was difficult to decide where the rock ceased to be grey "granite" cut by numerous pink stringers, and became a pink "granite". The boundaries, as marked on the map, should therefore be regarded as approximate. As has been mentioned before, it was noted that in the outcrop belt of the grey granodiorites, the bodies of pink quartz monzonite are surrounded by an aureole of numerous pink stringers and dykes.

Pink massive quartz monzonite outcrops in the region around Bear Lake near the western border of the area. Minor occurrences are found in the central and eastern portions.

Both fresh and weathered surfaces are brownish-pink in colour. The rock is generally massive, and on the fresh surface shows a medium-grained equigranular aggregate of pink potash feldspar, grey plagioclase feldspar, and quartz. In thin section, the quartz monzonite has a granitoid texture. Quartz has corroded the earlier formed, sericitized, and partially saussuritized, plagioclase (An25-An35). Potash feldspar is mostly microcline. Myrmekitic quartz-oligoclase intergrowths are more common than in the grey and buff granodiorite and quartz monzonites. Greenish-yellow biotite is partially altered to chlorite. Accessory minerals are magnetite, apatite, and zircon. Rosiwal analyses of three specimens from the west-central Bear Lake portion of the map-area give the following range of composition.

Quartz	21-31%
Plagioclase	35-51%
Potash feldspar	17-33%
Biotite	4-5%

Porphyritic Granodiorite

Porphyritic granodiorite outcrops at several widely scattered localities between Bear Lake and Powstick Lake. Good exposures are found on the portage between Bear Lake and California Lake. Strongly sheared porphyry outcrops on two islands in Powstick Lake. Outcrops are very scarce in this region.

The rocks weather to a light reddish-pink. On the weathered surface, tabular, subhedral phenocrysts of pink microcline up to 1 inch long are clearly visible. The phenocrysts rarely show primary alignment. The fresh surface exhibits grey plagioclase, clear grey quartz, green biotite, and magnetite, in addition to the phenocrysts.

Microscopically, the groundmass of the porphyritic granodiorite has a granitoid texture. The average grain size is 1.5 - 2.5 mm. Subhedral plagioclases are only slightly corroded by quartz. Potash feldspar is mostly microcline and apart from the phenocrysts, is of interstitial occurrence. Greenish-yellow biotite commonly occurs in non-oriented aggregates, along with epidote. Magnetite is a common accessory mineral, and can easily be seen in hand specimen in anhedral grains 1 or 2 mm. in diameter. Other accessories are apatite, sphene, and zircon.

The contact between the porphyry and the pink massive quartz monzonite is exposed for a few feet on the shore of a rapids on the creek flowing from Dobbs Lake to Bear Lake at the western edge of the area. The contact is sharp with no apophyses or other criteria to indicate any age relationship.

Rosiwal analyses of three specimens from different locations give the following range of composition:

Quartz	19-35%
Plagioclase	48-59%
Potash feldspar	11-17%
Biotite	2-4%
Accessories and Alteration products	1-4%

It should be noted that the presence or absence, by chance, of microcline phenocrysts in thin sections must have its effect on the accuracy of the analyses. It is felt, however, that the analyses give a reasonably true value of the unit.

Where large phenocrysts of microline are only an inch or two apart, a Rosiwal analysis would probably indicate a lower percentage of microline than is actually present.

Northern Quartz Monzonite and Granodiorite

Rocks of this unit outcrop in a belt extending across the extreme northern part of the area. Exposures in this region are very scarce; consequently, all but a few outcrops occur on the lake shores. Some good exposures are located on the shore and on small islands in the northeastern part of Bigstone Lake. Others occur on the south shore of the north arm of Utik Lake and on the shore of the small lake immediately to the south.

The weathered surface ranges in colour from brownish-grey to pink. The average grain size is from 1 mm. to 2 mm., which is less than that of the grey buff granodiorites and quartz monzonite. Most outcrops are fairly massive. This is especially true of the exposures along the shores of northeastern Bigstone Lake.

The fresh surfaces of the rocks are usually pinkish, although a decrease of pink feldspar towards the western part of the area causes a darkening of colour. Locally, the presence of hematite in fractures and grain boundaries adds a reddish tinge. Where exposed on Bigstone Lake, the rock has a medium-grained saccharoidal texture. Here, the ferromagnesian content is very low, and consists mostly of clusters of granular epidote and biotite, which give the rock a spotted appearance.

In thin section, the rock shows a granitic texture, and consists of an equigranular aggregate of irregular quartz, plagioclase (A_{n27}-$An34$), and potash feldspar. Small flakes of greenish biotite are partially altered to chlorite and epidote. Muscovite is found in minor amounts in some specimens. A characteristic of this unit is the large variety of accessory minerals, which include magnetite, limonite, hematite, muscovite, apatite, sphene, and zircon.

Mineralogical composition varies considerably within the unit. Rosiwal analyses of specimens show that with a few exceptions, the pink rocks, which are found mostly in the central and eastern portions of the outcrop belt, are quartz monzonites, having the following range of composition:

Quartz	21-29%
Plagioclase	36-51%
Potash felspar	13-20%
Biotite	2-10%

The greyer phases, which are found mostly near the western edge of the area, are granodiorites and locally, quartz diorites. A typical quartz diorite has the composition:

Quartz	16%
Plagioclase	70%
Potash feldspar	2%
Biotite	8%
Alteration products (epidote)	2%
Accessories	2%

Gneissic Granodiorite

This unit, which is gneissic biotite-hornblende granodiorite, was mapped as a marginal phase of the quartz monzonite and granodiorite, and is indicated separately on the map. The width and lateral extent of this unit are not accurately known. The best exposures are located on the shores of the narrows on the southern arm of Utik Lake.

Both weathered and fresh surfaces are dark grey, and both are distinctly gneissic, with a strong alignment of mafic minerals. Granulation of some quartz grains indicates that this alignment is a metamorphic effect. Examination under the microscope reveals a granitic texture. Greenish-yellow biotite and green hornblende, with associated epidote, are scattered through an interlocking aggregate of sericitized plagioclase, potash feldspar, and partially recrystallized quartz. In some specimens, hornblende is absent. Well formed sphene crystals, up to 1 mm. long are common. Other accessories are magnetite, apatite, and zircon. A typical specimen has the composition:

Quartz	29%
Plagioclase	46%
Potash feldspar	8%
Hornblende and biotite	10%
Alteration products and accessories	7%

The rock is probably a product of reaction with the basic lavas which lie to the south.

Alaskite

Excellent exposures of alaskite are found on the height of land between Bigstone Lake and Utik Lake at the western edge of the area. Alaskite is also found on several islands in Bigstone Lake, and again near the eastern boundary in the area.

The rock weathers grey to light grey, and is extremely coarse grained. Anhedral crystals of alkali feldspar over one foot in diameter were found on several outcrops. The rock consists of quartz and alkali feldspar, the latter commonly having graphic intergrowths with quartz. Muscovite and biotite are present but rarely exceed 5 per cent of the total composition. It was possible to examine finer-grained phases under the microscope. These specimens may contain considerable plagioclase feldspar. Where the alaskite is fine grained, it shows some resemblance to the buff granodiorite. No evidence was encountered to throw further light on age relationships.

BASIC DYKES

One basic dyke, about 200 feet in width, can be traced from the northeast corner of the map-area in a southwesterly direction for a distance of about 9 miles. The texture is partially ophitic and partially intergranular, formed by plagioclase laths and augite with some magnetite. The augite is partially uralitized. Other diabase dykes in the area are short and have a maximum width of 10 feet.

STRUCTURAL GEOLOGY

The general scarcity of exposures in the map area makes it impossible to arrive at any clear structural picture.

FOLDING

Folding over most of the northern belt is probably of an isoclinal type. All the lava flows have nearly vertical dips.

The structure in the small area of sediments and volcanics at the eastern edge of the area to the south of the main northern belt appears more complex. Folding may be important here but intrusions of granitic rocks and the absence of any structural criteria make it impossible to say whether the structure is due to tight folding or to interbedding of the sediments and lavas.

Important folding in the southern sedimentary-volcanic belt was not recognized although, occasionally, sharp changes in strike were noticed over short distances.

FAULTING

Late faulting has affected the large diabase dyke on Bigstone Lake in two places with apparent displacement of 150 and 2,000 feet. This dyke has also been faulted just off the northeast corner of the map-area on Bigstone Lake. Only two other, apparently minor, faults were mapped on Bigstone Lake.

Faulting is more extensive in the southern volcanic sedimentary belt. Three long faults have been mapped. The fault at the southwest corner is an extension of the Bear Lake fault mapped by Milligan (1954) to the west. Another fault extends down the centre of Powstick Lake. This is recognized by shearing in the coarse amphibolite north of the conglomerate and by mylonitized granite on the small island just west of the conglomerate. A third fault is shown on the map at the southeast corner of the area, mainly because of the pronounced linear topographic feature striking northwest. The fault may be an extension of the Bear Lake fault and has numerous small shears associated with it. These three major faults are all younger than at least some of the granitic rocks.

GEOLOGICAL HISTORY

Only a very generalized picture of the geological history can be given.

The oldest rocks in the area comprise the sedimentary-volcanic series. The high proportion of quartz in the major part of the sediments suggests that they may have been derived from some pre-existing land surface. The main sedimentary rocks of the northern belt overlie the lavas and are therefore younger. The sediments, lavas, and pyroclastics of the southern belt are interbedded, indicating that they are of the same general age. The conglomerate has been derived from an older terrain but does not appear to mark a major unconformity within the present map-area.

Orogenic movements, accompanied by granitic intrusions, have tilted the series on edge and have caused a regional metamorphism. The granitic rocks have been mapped as five types although there is some doubt regarding their relative ages.

Diabase dykes are the latest intrusives in the area. Late faulting has displaced these dykes in places.

It is not known if Paleozoic or Mesozoic rocks were deposited in the area. Certainly, there is no trace of them now. Cenozoic deposits in the form of Pleistocene glacial debris and Recent swamp and alluvial deposits cover an extensive part of the area at present.

ECONOMIC GEOLOGY

The northern band of volcanic and sedimentary rocks is an extension of the Utik Lake belt in which showings of chalcopyrite have been found in recent years. Fault zones provide possible channels for mineralization.

Sulphide mineralization is scarce throughout the area. One grab sample taken at the location marked 1 on the map assayed 0.02 ounces in gold per ton.

Intrusive bodies of basic rocks such as gabbro, peridotite, and pyroxenite were not found, nor were the exposed shear zones in the volcanic and sedimentary rocks well mineralized. However, large sections are covered by overburden and, as far as can be ascertained, very little prospecting has been done. Four very old claim posts were seen on the north shore of Powstick Lake near the western edge of the area.