GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

PAPER 61-22

CROSS LAKE MAP-AREA, MANITOBA

63 I

(Report and Map 32-1961)

C. K. Bell

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INTRODUCTION

Location and Access

The Cross Lake area is bounded by longitudes 96 and 98°W, and latitudes 54 and 55°N; it comprises 5,600 square miles. Norway House, at the northernmost end of Lake Winnipeg, lies in the southwest corner of the area; Cross Lake Indian Reserve is at the west-central edge.

Access is by summer steamboat service from Selkirk on Red River to Warren's Landing at the northeast corner of Lake Winnipeg. Warren's Landing is the transshipment point for Norway House and Cross Lake traffic. The area is serviced by aircraft from Wabowden and other points on the Hudson Bay line of the Canadian National Railways. These aircraft may be chartered, although there are weekly scheduled flights from Wabowden to Cross Lake, Norway House, and Oxford Lake to the east. In winter, freight is supplied by cat-trains from Wabowden and Thicket Portage. The Nelson River system and Echimamish and Hayes Rivers are the main canoe routes through the region.

History and Previous Work

To handle traffic along the fur-trade canoe route from York Factory on Hudson Bay to Lake Winnipeg, via Hayes, Echimamish, and Nelson Rivers, the post at Norway House was founded in 1800 and the Cross Lake post in 1884. The initial means of transportation—the native canoe—was supplanted by the York boat; but by 1920 the York boat had become obsolete and canoes again plied the passage.

The original dams that once controlled water levels on Echimamish River have been breached and the river is now stagnant, weed clogged, and just navigable by small canoe. The portages are growing over and this once-busy water route has been almost abandoned; in fact not one native canoe was seen along it during the summer of 1960.

The first geological investigation in the area was by Bell (1879, 1881)[1]. A track survey was made of the Nelson River from Playgreen to Cross Lakes and of part of Cross Lake. Geological observations were made along the Nelson, Echimamish, and Hayes River systems and around Cross, Walker, and Molson Lakes. In 1890 and 1896, Tyrrell (1903) made a track survey of Little Playgreen, Pipestone, and Cross Lakes and Nelson River. His early notes were compiled by Dowling (1901).

[1] Dates or names and dates in parentheses refer to publications listed in the References.

Brock (1911) made geological notes about Nelson, Echimamish, and Hayes Rivers while accompanying the Governor General, Earl Gray, to Hudson Bay. McInnes (1913) compiled the known information of the area in a memoir, and his geological map outlining the main lithological features has been little changed by more recent work.

The first detailed survey and geological mapping was by Alcock (1920). He mapped Pipestone Lake and the western half of Cross Lake. In 1931 and 1932 reconnaissance mapping of Cross Lake map-area was undertaken by Horwood (1934, 1935, 1936). Some of Horwood's findings have been incorporated into the present report and map. Tanton (1937) examined a number of showings along Echimamish River. The more important of these are described here.

Barry (1959, 1960) mapped the Carrot River area and the Oxford Lake area immediately to its west, at a scale of 1 inch to 1 mile. These reports contain detailed descriptions of the regional rock types. Detailed mapping of the area surrounding the Cross Lake Indian Reserve is presently being done by D.H. Rousell for the Manitoba Department of Mines and Natural Resources.

Reconnaissance maps of the surrounding areas are (a) to the northwest—Nelson House, GSC Paper 54-13; (b) to the north—Sipiwesk, GSC Paper 51-3; (c) to the northeast—Knee Lake, GSC Paper 55-8; (d) to the east—Oxford House, GSC PS Map 21-1961 (in press); (e) to the southeast—Island Lake, GSC PS Map 26-1960; and (f) to the south—Norway House, GSC Map 423A, east and west halves.

The following aeromagnetic maps—Wolf 11, 12, 13, 14, 15, 24, 25, 26—which cover much of the area, are available from the Manitoba Department of Mines and Natural Resources, Mines Branch, Winnipeg.

Present Work and Acknowledgments

The purpose of the project undertaken during the summer of 1960 was to revise and complete the geological mapping of Cross Lake map-area.

Except for Porcupine Hill Creek and Breland Lake, which are in drift-covered areas, the shorelines of all the larger lakes and water routes were examined; observations were made at approximately 1/2-mile intervals. Pace and compass traverses were run at 2-mile intervals across accessible areas underlying magnetic anomalies and along the volcanic belts. A Cessna aircraft was used at the end of the season to examine regions inaccessible from the main water routes. As the Cross Lake Indian Reserve area is being mapped in detail by the Manitoba Department of Mines, the writer made only a cursory examination of the local geology.

The author was ably assisted in the field by L.I. Benton, C.A. Cullingworth, R.G. Findlay, W.O. Mackasey, and K.E. Northcote.

PHYSICAL FEATURES

Rock outcrops as low undulating hills which have a relative relief of up to 100 feet. Large drift areas are flat, relatively wet, and contain rare scattered outcrops that mostly occur in the ubiquitous shallow lakes. The southwestern part of the area is low-lying outcrop-free marshy ground that outlines part of the bed of glacial Lake Agassiz. Large regions of swampy ground within this and other areas are impassable on foot in the summer. Outcrops are abundant around the larger lakes and along the river systems, even where these are surrounded by lake and glacial deposits. South and east of Molson Lake there is 60-per-cent exposure of the granitic gneiss.

The northwest half of the area is drained by the Nelson River system, which includes Echimamish River and Walker and Cross Lakes. Carrot and Lawford Rivers eventually drain into Hayes River, whose headwaters occur south of Molson Lake. Hayes River at Painted Stone Portage is 3 feet above the Echimamish, but an outcrop dam permits only a small trickle of water to the west, the main flow being to the east. Drainage is controlled by pre-Glacial topography. The volcanic belts underlie relatively straight rivers and lakes whereas the irregularly shaped drainage patterns in the granites are expressions of joints and faults. Exceptions are the drift-covered areas where the lakeshores are rounded and drainage is irregular.

Glacial features are abundant. Striation directions average S55°W. Large crevasse-filling kames made up of unsorted sand and gravel rise about 75 feet above the surrounding land as flat-topped, tree-covered ridges. These are up to 2 miles wide, and one is 34 miles long. A part of one occurs as a long, steep-faced gravel cliff along the northwest shore of Molson Lake. Southwesterly trending drumlins and eskers are abundant in places and are shown on the map. Some shorelines have cliffs of flatly bedded clay, sand and gravel glacial-lake deposits. An area of sand that lies south of Molson Lake was probably derived from the crevasse-filling kame across the lake and from the esker that crosses the sand plain.

DESCRIPTION OF MAP-UNITS

HAYES RIVER GROUP (1-3)

Volcanic Rocks (1)

The northern arm of the bifurcated belt of volcanic rocks (1e), which outcrops northeast of Logan Lake, strikes east for 6 miles along the north shore of Max Lake. The southern arm widens and continues east into Oxford House map-area. At Logan Lake, transition rocks (3) border the volcanic rocks, and the contact is arbitrarily drawn so that map-unit 1e contains less than 25 per cent introduced secondary material. Massive, slightly fissile andesites, biotite-hornblende-plagioclase schist, and chlorite schist are the most widespread volcanic rocks. In places thin intercalated beds of acid sedimentary or pyroclastic material result in pronounced layering. The pitted weathering of some of these beds suggests that the rocks were originally limy. Injections and secretions of granitic material, colourless to milky quartz, and epidote result in minor but omnipresent layered and veined migmatites. In places this secondary material has been deformed into boudinaged structures. Most of it contains disseminated sulphides. Where these migmatites occur the rock tends to be highly drag-folded and crenulated. This complex deformation, the result of regional stresses, has combined with recrystallization and the addition of secondary material to eradicate all evidence of primary structures in the volcanic rocks, and they are considered here as greenstones.

A belt of well-banded basic to intermediate volcanic rocks crosses Hayes River at Painted Stone Portage and continues west to form a narrow ridge that parallels Echimamish River. The rock is sheared, but ghost remnants of pillows are preserved. Beds of dacitic composition and narrow, pink aplite sills occur in the andesite, amphibolite, and hornblende-biotite gneiss. Colourless quartz occurs in these rocks as lit-par-lit lenses and ptygmatically folded veins.

The largest continuous band of volcanic rocks parallels Echimamish River from the first dam west to Butterfly Lake, where it veers northwest through Pipestone Lake to Cross Lake. In places it is 3 miles wide. Its northern contact with the gneisses (8) is sharp and well defined. Tops face south and the exposed upper members are interbedded with sediments (2b). The southern contact, where seen, is gradational into the transition rock (3), augen gneiss (8g), and biotite granodiorite-gneiss (8d). Large swampy areas south and west of Butterfly Lake make it difficult to establish the exact location of this contact. The rocks are largely andesites with accompanying biotite-hornblende schist, amphibolite, porphyritic amphibolite, and hornblendite. More acidic phases are rare, as are the isolated narrow interbeds of agglomerate, tuff, and black cherty quartzite. These greenstones are generally dark green to black, medium to coarse grained, and massive through gneissic to schistose or thinly layered; they are probably recrystallized andesite. Many of the massive andesites have a pitted weathered surface and are carbonitized. Pillow lavas, primary flow breccia and vesicular bands occur. Deformation is so intense that individual pillows are stretched to 30 feet long or more and the rock appears bedded. In places these stretched pillows are so contorted that they are difficult to recognize. Hornblende metacrysts up to 1/4 inch long occur in some of the more basic recrystallized flows and constitute up to 40 per cent of the rock.

The volcanic rocks contain leucocratic sills and dykes, milky-white to colourless quartz veins and lit-par-lit lenses, carbonate veins, and minor epidote patches and bands. Pyrite is the major opaque accessory and scattered limonitic patches dot the volcanic rocks, especially where they are schistose. Massive quartz diorite, diorite, and fine-grained gabbro are interbanded with these rocks. They are probably contemporaneous with the volcanic rocks and intrude them as sills and irregular tabular dykes, although they could be massive flows. Similar mafic sills have been recognized in many of the surrounding areas of northern Manitoba.

At Butterfly Lake the volcanic rocks are less deformed and are predominantly massive andesites with some pillow structures and rare amygdaloidal bands. South of the conglomerate (2c) at the east end of the lake, rhyolite and dacite schists (1d) are interbedded with agglomerate and sheared carbonatized andesites. A coarse-grained feldspar porphyry flow occurs between pillow lavas at the east end of the lake. White plagioclase crystals up to 3/4 inch wide form 75 per cent of this rock; the matrix is dark green with a trachytic texture. Dacite porphyry dykes intrude the surrounding basic lavas and may be related to these porphyritic flows.

Most of the volcanic rocks at Pipestone Lake are intermediate to basic lavas. Pillow structures are preserved but most of the rock is recrystallized to amphibolite and hornblende-biotite schist. Grey, thinly bedded, gritty crystal tuff and ash beds, pebble-conglomerate and conglomerate beds, flow breccia and amygdaloidal bands are minor components. The proportion of sediments in the volcanic rocks increases near some of the contacts between sedimentary and volcanic rocks and the contact itself is gradational; elsewhere there is a sharp break between the two rock types.

Cross Lake Indian Reserve is at the nose of a large anticlinal structure. The rocks at the crest are complexly folded and it is difficult to determine whether the interbeds of sediments and volcanic rocks are the result of sedimentation or infolding. Dykes, sills, and stock-works of pegmatite, aplite, and granite replace up to 100 per cent of these rocks, altering any remnants to a garnetiferous biotite-hornblende gneiss. Despite such extreme metasomatism, a few exceptionally good pillow structures are still preserved. These garnetiferous gneisses continue northeast up the centre of Cross Lake forming the northern limb of the anticline. The northern belt is narrow and composed of garnetiferous hornblendite, amphibolite, and hornblende-biotite schist.

The geology of the Carrot River volcanic belt has been described in detail by Barry (1960). The basic volcanic rocks (1e) consist of massive to schistose and highly contorted andesite with minor amphibolite, hornblendite, and chloritized equivalents. Pillow structure, where preserved, has been deformed to the point where top determinations are not reliable. Colourless to milky quartz veins and stringers intrude all these rocks. In the highly schistose phases the amount of accessory pyrite increases and the rock is spotted with limonite stain. The intermediate lavas (1d) are massive to schistose dacite, sericite schist with quartz eyes and rare plagioclase metacrysts, and porphyritic dacite flows or sills. Minor acidic agglomerate and tuff beds, thin rhyolitic chert beds, and rare lenses of actinolite schist occur intercalated within these intermediate flows.

A 5-mile section of rock, here considered part of the Hayes River group, outcrops between Carrot Bay and Lynx Bay on Oxford Lake. These rocks are unlike most of the other volcanic rocks of the Hayes River group seen in Cross Lake map-area.

The northernmost belt outcrops along the south shore of Carrot Bay. It is 3/4 mile wide and consists of dacitic lava (1d). The fabric of these rocks varies from massive, through gneissic to schistose. Interbanded with these rocks are minor amounts of amphibolite, chlorite schist, sericite 'quartz eye' schist which probably was originally a rhyolite, and a stretched agglomerate. The latter is composed of light-coloured rhyolite fragments in a darker green dacitic matrix that contains abundant colourless quartz crystals.

South of this is a 2-mile-wide band of 'quartz eye' schist and gneiss (1c). Twenty per cent of the schist consists of rounded, colourless, 3/16-inch quartz eyes enclosed in a light grey, cryptocrystalline to crystalline, sericitic matrix. These schists appear to be gradational along strike into light-coloured quartz-feldspar, feldspar-quartz, and feldspar porphyries and gneisses. Pyrite is omnipresent in these rocks. Farther west they grade into a hypidiomorphic granular rock that is similar in many respects to the 'quartz eye' granite of the Flin Flon area. Continuing along strike the rocks lose the conspicuous quartz eyes and their colour changes from grey-green to pink. Three miles west of Hyers Island the rock has changed to the tonalite gneiss so common in the region. Barry (1960, p. 15) included these rocks in the Oxford group and identified them as arkoses with interbeds of arkosic quartzite and quartzite. He mentioned that other workers identified them as sheared quartz porphyries and as altered Hayes River group basalt and dacite flows. With the limited field observations possible it could not be determined whether these schists are the result of metamorphism and recrystallization of pre-existing tonalite gneiss, or of deformation and granitization of a volcanic-sedimentary complex. The latter origin is suggested by the occurrence of identifiable arkose beds within the schists that outcrop east of the area (Barry, 1960, p. 15) and the presence of interbeds of similar 'quartz eye' schist within agglomerates to the south. The writer includes these rocks in the Hayes River group because they are flanked to the south by structurally conformable agglomerate, volcanic breccia, and basic lava, and by intermediate extrusive rocks to the north. They are much like the acid volcanic rocks lying south of Butterfly Lake. If they are included in the Hayes River group, the interpretation of the aerial distribution of Oxford group sediments on Oxford Lake is simplified.

The above schists have been separated on the map from a 3/4-mile sequence of interbedded agglomerate and sericite schist (1b) that lies along the south half of Hyers Island and extends west to the mainland. Extreme shearing and metasomatism of rock whose matrix and fragments are of similar composition makes identification of these agglomerates difficult. They are seen best when glacially polished outcrops are wetted to bring out ghost fragment outlines. The best section is exposed along the shores of the largest bay southwest of Hyers Island. The agglomerate occurs as beds up to 100 feet thick separated by zones of sericite and 'quartz eye' schist. Up to 90 per cent consists of chaotically distributed, angular to subrounded fragments of leuco-rhyolite and dacite, 'quartz eye' schist, quartz-feldspar porphyry, a holocrystalline phase of this porphyry, breccia and tuff. The fragments average 4 inches in length; the largest measured 18 inches. They are elongated by plastic deformation, and lineation plunges S45°W at 40° parallel with the regional structure. The agglomerate matrix is an aggregate of the above volcanic material and quartz and feldspar crystals in a foliated mesh of biotite and chlorite. Many of the rock chips have been partly assimilated by this matrix, suggesting welding at the time of deposition.

South of these agglomerates is a mile-thick belt of massive grey-green pyroclastic fall material. Cursory examination of outcrops hundreds of feet wide offered no evidence of bedding, banding, or even directional fabric that would suggest more than one period of deposition. Up to 25 per cent of the rock is chaotically distributed, subrounded to angular, 1/4-inch or smaller fragments of feldspar, quartz, and lithic material. The feldspar is semi-opaque saussuritized plagioclase, with matrix material filling the highly corroded crystal rims. The quartz has undulatory extinction and occurs as rounded single crystals, single crystals surrounded by a rim of recrystallized quartz fragments, crushed quartz aggregates, and rare shard-shaped 2-mm quartz crystals. Matrix material fills the highly indented, corroded edges of the quartz grains. Accidental lithic fragments are rare and are composed of feldspar and quartz. More than half the matrix is a cryptocrystalline aggregate of clear quartz with undulatory extinction. These quartz grains are separated by a mixture of mesh or needle sericite, biotite laths, and patches of stubby to acicular chlorite. Secondary carbonate with minor muscovite replaces up to 5 per cent of the matrix. Small amounts of pyrite, hematite, and leucoxene are the opaque minerals. Devitrification has removed any relict vitroclastic textures that would help identify this rock. The overall surficial appearance, the high quartz content, the small median grain size, the chaotic distribution of fragments and the equigranular matrix all suggest that the rock was originally an ash flow or welded tuff.

To the south, these rocks are in contact with a 1/2-mile band of sericitic dacite (1d). In places these intermediate flows are as dense and fine-grained as jade, but elsewhere they appear shattered and brecciated. Interbedded with them are 'quartz eye' schists and granites and occasional greenstone bands. They are in contact with the regional granodiorite-tonalite-gneisses.

Sedimentary Rocks (2)

Sediments form a minor part of the Hayes River group. They are separated from the Cross Lake group because of their interformational relationship with the volcanic rocks. They may represent older members of an interrupted sedimentary series, the younger members of which have been separated into the Cross Lake group.

Interbedded slate, sericite schist, and schistose greywacke (2b) outcrop along the northwest shore of Max Lake. Quartz segregations along bedding planes suggest that the original chert or quartzite beds were recrystallized and deformed into boudin structures. These rocks are cut by numerous colourless quartz veins. The belt of schistose andesites (1e) to the north contains a few quartzitic bands up to 3 feet wide.

Grey-weathering conglomerate (2c) appears to underlie granitized volcanic rock north of the west end of Robinson Lake. The band is more than 6 miles long and, where examined, has a maximum thickness of 850 feet and a minimum of 300 feet. Boulders and cobbles comprise 30 to 50 per cent of the rock. Most are tonalite- and granodiorite-gneiss, 5 per cent are leucogranite, quartz, (quartzite?), and green cherty rhyolite. They are plastically elongated down dip with the average ratios of the parameters being 1:5:10. Their size varies from 1 inch to 2 feet along the maximum axis and averages 6 inches. The lineation of the boulders parallels crenulations in the matrix and plunges N85°W at 50°. Irregular horizontal cross-sections of some of the boulders suggest that their pre-deformation shape was angular to subangular. Despite extreme deformation, a primary gneissosity that does not always parallel the regional structure is in some places preserved within the stretched boulders. This suggests that the boulders had a gneissic fabric when deposited. The matrix ranges from a fragmental rhyolite-like sericite schist, through biotite schist, to biotite-hornblende schist. It is medium to fine grained, green to black, and the platy minerals wrap around the boulders. The schistosity parallels the elongation of the cobbles and the gneissosity in the biotite granodiorite-gneiss (8a) to the north. A 20-foot band of sugary-textured quartz-feldspar gneiss occurs within this conglomerate and is probably a recrystallized bed of intercalated sedimentary material. This paragneiss bed is similar to some of the transition rocks that lie south of the conglomerate. The conglomerate is intruded by rare quartz veins but not by granitic material, so that there is no evidence that the underlying gneiss is intrusive into the sediments in this area. The granite-gneiss - conglomerate contact is obscured, but it is possible that the conglomerate is unconformable, because the boulders and the underlying rocks are similar. Absence of mafic volcanic boulders suggests that the conglomerate is one of the older members of the Hayes River group.

A narrow 20-mile interformational belt of sediments lies in volcanic rocks and parallels Echimamish River from just west of Painted Stone Portage to south of Butterfly Lake. The eastern members are grey impure quartzite with interbedded conglomerate, dacite, and greywacke. The quartzite is thinly bedded and slightly schistose with primary sedimentary structures still preserved. The conglomerate occurs as 2-foot beds containing, in order of decreasing abundance, pebbles and cobbles of granodiorite-tonalite-gneiss, white quartz, rhyolitic chert, and green slate in a quartzitic matrix that forms 75 per cent of the rock. The pebbles are stretched, and the length to width ratio on the horizontal plane is 3:1. Dense, black, glassy dacite occurs as 30-foot interbeds. At the southern contact with transition rock (3) the upper beds are schistose greywacke. At the west end of the belt there is a sedimentary facies change to quartzite, argillaceous schist, siltstone, and shale. Porphyroblasts of feldspar occur scattered through these sediments.

A lens of sediments (2b) outcrops north of this band at the third dam on Echimamish River. The basal member is a 200-foot-thick conglomerate zone which is separated from the underlying massive andesite by a 10-foot layer of chlorite schist. The conglomerate is thickly bedded and contains intraformational gravel and grit lenses. Two thirds of the rock comprises stretched cobbles; of these, 70 per cent is granodiorite-tonalite-gneiss, 20 per cent is dense black chert, and the rest consists of various rock types with rare white quartz pebbles. The matrix is a sheared mixture of biotite, chlorite, quartz, and rock particles. Overlying the conglomerate is 1,500 feet of thinly bedded mudstone, siltstone, and black quartzite. At the contact they are tightly folded and brecciated but are undeformed at the top of the section. The upper members are best exposed at the dam.

Stretched, water-worked agglomerate (2c) lies within andesitic lavas on Butterfly Lake. A 200-foot bed is exposed on the east shore of the lake. Half the rock consists of boulders, 90 per cent of which are medium- to fine-grained rhyolite porphyry. The rest are grey granitic phases of this porphyry, amphibolite, and rare quartz pebbles. The matrix looks like schistose greenstone and contains a high proportion of hornblende and biotite. As the andesite is approached to the north the basic boulders increase in number until most are andesite, amphibolite, or diorite. Separating these conglomerates are 10- to 20-foot bands of thinly bedded pebble-conglomerate, sandstone, greywacke and argillite. The conglomerate is intraformational and contains angular fragments of rock from the adjoining beds. Despite severe regional deformation, primary structures are still preserved. The parameters of elongated boulders were measured on an island outcrop in the eastern part of the lake. The average ratios were 1 :5.25: 11.00; the average intermediate length was 7.26 inches.

Iron-formation occurs interbedded with the volcanic rocks on a small peninsula in Cross Lake, 3 miles south of Ebb and Flow Rapids. It is narrow and does not show as an anomaly on the aeromagnetic map. Where exposed it forms a band at least 10 feet wide, composed of alternating 1/2-inch beds of quartzite, actinolite schist, and magnetite (20 per cent). The beds are highly contorted. Adjacent to it is a pebble-conglomerate bed containing greenstone, sandstone, and quartz pebbles in a gritty, chlorite-schist matrix. The southern contact of the iron-formation is with garnetiferous amphibolite of volcanic origin. Barry (1960, p. 27) described similar iron-formation on Carrot River and included it in the Hayes River group. Tanton (1937, p. 7) described a band of iron-formation found in andesite near the south shore of the small lake that is 1 1/2 miles northeast of Dam No. 3 on Echimamish River. He claimed: "it is 40 feet wide and traceable for 1,000 feet. It consists of magnetite banded with chert or other highly siliceous rock that make up the greater part of the volume."

Transition Rocks (3)

Adjacent to, within, and replacing Hayes River group volcanic rocks are rocks that form a zone gradational to the granodiorite-tonalite-gneiss complex (8). These are best developed along Hayes and Echimamish Rivers, in the Carrot River region, and at Cross Lake. Included in this group are all mappable mafic masses of unknown origin that are found within the gneisses (8). Three phases are recognizable in the field, but all are included in map-unit 3. They are rocks containing still recognizable volcanic rock, rocks in which the original volcanic features are preserved as scattered relics, and a 'layered gneiss' of intermediate composition.

The first phase occurs adjacent to the basic volcanic rocks (1e). It is a layered rock composed of recrystallized volcanic material (chlorite and biotite schist, amphibolite, etc.) and secondary lit-par-lit layers and veins of quartz, epidote, pegmatite, aplite, and leucogranite. This acidic material may have been partly derived by secretion from the surrounding extrusive rocks or partly from an outside source (where the secondary materials make up less than 25 per cent of the rock it is mapped as unit 1e). The resulting rocks are the injection, lit-par-lit, composite, or mixed gneisses and migmatites that are so common to geological literature.

These migmatites grade with further metasomatism into a layered gneiss (phase two) in which the structural features of the original volcanic rocks are still preserved as in situ relics (skialiths) and amphibolite bands. Individual layers have a sugary, through granitic to augen, texture but the overall rock can be considered as a banded paragneiss.

The final phase is a rock with granitic texture, preserved gneissosity, and relic mafic lenses. They are considered by some field workers as banded gneiss, hybrid gneiss, ghost-like migmatite, or nebulitic granite. The contact between these rocks and rocks from the granodiorite-gneiss complex (8) is gradational and vague, and is arbitrarily placed at the point where layered gneiss is superseded by a more massive, unlayered gneiss. Detailed descriptions of the physico-chemical alteration of andesite into granodiorite are given by Horwood (1936, p. 102).

CROSS LAKE GROUP (4-6)

Horwood (1934, 1935, 1936) separated the sediments at Cross Lake from those of the Hayes River group on the basis of a minor angular unconformity and the presence of mafic boulders of volcanic origin in the basal members of the conglomerate. He equated these sedimentary rocks with the lithologically similar Oxford group sediments described by Barry (1959, 1960) and gave them the name 'Cross Lake group' for geographical reasons only.

The Cross Lake group outcrops at the nose of the large anticlinal structure in the region of Pipestone and Cross Lakes. In places the sediments are interbedded with Hayes River volcanic rock; elsewhere the two types of rock appear to be infolded in structures that resemble tight, steeply plunging isoclines. These highly contorted rocks have been recrystallized to gneiss and intruded by granitic material. This has made age relationships and stratigraphic thicknesses and sequences difficult to determine.

The basal members of the group are made up of interbedded conglomerate, pebble-conglomerate, and grit with minor arkose and feldspathic greywacke. All have been mapped as conglomerates (4). Overlying these are various types of arenites and argillites (5). Regional and contact metamorphism has altered these rocks to paragneiss and schist (6b). West of Cross Island, granite, aplite, and abundant pegmatite replaces up to 75 per cent of the sediments, forming an injection breccia (6a) consisting of fragments of Cross Lake sediments surrounded by granitic rock. Brief descriptions of these sediments are given by Alcock (1920, p. 15d) and Horwood (1934, p. 53; 1935, p. 140).

Sedimentary Rocks (4, 5)

Horwood (1934, p. 55) claimed that "Certain beds believed to be near the base of the series are composed of boulders and matrix of volcanic materials.....When such a rock is sheared it completely loses its conglomeratic nature and cannot be recognized from a normal sheared flow." He recognized an upward change in boulder composition from mainly volcanic material at the base to predominantly tonalite in stratigraphically higher beds. Similar mafic conglomerates are found on an island south of the east channel of the outlet of Nelson River from Cross Lake (97°44'45"W, 54°42'25"N). The matrix there is composed of feldspar, quartz, biotite and calcareous material. These andesitic conglomerates are not abundant and probably represent diastems or depositional breaks assumed to be of minor duration.

A well-exposed cross-section is visible on the islands between Pipestone and Cross Lakes. Garnetiferous andesitic pillow lavas and biotite-hornblende gneiss of the Hayes River group are overlain by 10-foot beds of garnetiferous cobble-conglomerate. At the base, 15 per cent of the rock consists of cobbles, most of which are quartzite. Other cobbles are of amphibolite containing white plagioclase metacrysts, dacite with porphyroblastic hornblende needles, and rare tonalite gneiss. None of the cobbles is over 6 inches in diameter and all are stretched to the point where they are oval-shaped rods with a steep plunge. The matrix is a recrystallized aggregate of garnet, hornblende, and biotite, with minor feldspar and quartz.

Higher in the sequence, imbricately arranged, angular black greywacke and siltstone fragments become abundant. They are associated with intraformational, tan-coloured clay chips. A thousand feet above the contact, 85 per cent of the conglomerate beds are pebbles and small cobbles which average an inch in diameter. Sixty per cent of the pebbles are siltstone and lithic greywacke, 20 per cent are milky quartz, and 18 per cent are tonalite-gneiss, with minor sandstone, quartzite, and pegmatite. The argillaceous sediments are stretched more than the quartz and granite, which remain as round boulders. The conglomerate matrix is mainly quartz with 15 per cent lithic fragments and minor feldspar. Higher in the sequence, conglomerate decreases until it only occurs as rare small beds. The intervening strata are meta-quartzite and lithic greywacke. A few beds are dense and black, weather to a pitted surface, and are limy; others are now biotite schist and crenulated thinly bedded quartzite.

At Pipestone Lake, the upper members of the sediments contain recrystallized bands of volcanic rocks which form up to 20 per cent of the strata. These grade into the overlying andesites that outcrop along the south shore of the lake. These andesites contain beds of pyroclastic and sedimentary material. The sequence, from volcanic through sedimentary and back to volcanic rock, may be the result of folding.

Sediments overlie volcanic rocks along the north limb of the anticline. These are well exposed on the islands south of the west inlet on Nelson River which leads to Ebb and Flow Rapids. Thick beds of conglomerate are composed of 75 per cent boulders and cobbles. Eighty per cent of the boulders are grey biotitic granodiorite, 10 per cent are tonalite and diorite, about 10 per cent are hornblendite and a fine-grained mafic rock of presumed volcanic origin, and a few are quartz. Boulders up to 3 feet long are exposed there but most average 6 inches across. The matrix is a garnetiferous hornblende-biotite gneiss which is quartzitic in places. Higher in the sequence the rocks are pebble-conglomerates, grits, arkoses, greywackes, and rarely argillites.

In the finer-grained sediments, crossbedding, channelling, and grain gradation are common. In a number of instances two sets of graded bedding lying a few tens of feet apart on a single outcrop appear to indicate reversed tops. Similar anomalous grain relationships have been described by Cooke (1931). This primary feature was therefore not used within the Cross Lake group for structural determinations. Pre-consolidation load pressure of sand on thin mud beds has resulted in primary features similar to those called 'flame structures' by Walton (1956) and Kelling and Walton (1957). The soft underlying mud bed was squeezed into the overlying sand in ripple-like projections that look like flames in cross-section. The flame peaks have an amplitude of a few inches and can be used for top determinations. Examples of this structure are preserved in thinly bedded sediments that outcrop on the small island 5,000 feet north of the south shore, at the west end of Pipestone Lake.

The pebbles and boulders of the Cross Lake group are everywhere flattened, stretched, and rodded until the maximum length is 20 times the width. The mafic pebbles are elongated more than the acid granodioritic pebbles. In places chlorite- and biotite-rich boulders have wrapped around the more stable, relatively undeformed granitic boulders. Elsewhere the flattened cobbles are dragged into Z-shaped objects, whereas nearby large granodiorite boulders remain undeformed. In most places the plane of intermediate and maximum elongation of the boulders intersects the bedding plane at an angle. This phenomenon might be useful, in much the same manner as flow cleavage, as an aid in determining the detailed structural geology of the sediments.

Paragneiss and Agmatite (6)

With further deformation these sediments recrystallize into banded paragneiss and schist (6b) composed of quartz, mica, feldspar, hornblende, staurolite, sillimanite, garnet, and tremolite. The tremolite is probably derived from recrystallization of thin beds of impure magnesium limestone. At the nose of the 'anticline' west of Cross Island, granite, aplite, and pegmatite stock-works displace up to 75 per cent of the sediments and paragneiss. The structure of the sediments is preserved, and the resultant rock—an injection breccia (agmatite, 6a)—is included in the Cross Lake group. The term 'agmatite' is a nongenetic field designation for a composite rock containing rock fragments surrounded by granitic material. If the granite is intrusive the rock is an injection breccia; if granitized, the rock is a replacement or rheomorphic breccia. For a discussion of the granitization of the arkose members see Horwood (1936, p. 106).

The writer examined an unconformity described by Horwood (1934, p. 67) which is on the west end of the second large island between Pipestone and Cross Lakes, 7,000 feet south of the 17th base line. No conclusive field evidence for this unconformity was seen nor were any other discordant relationships noticed between the two groups in the areas examined. Where seen, the overlying and underlying beds paralleled the contact. The presence of sedimentary rocks within the Hayes River group and volcanic rocks within the Cross Lake group suggests that the latter may be conformable upper members of the former. The relationships of the two groups may be solved by the detailed geological mapping now being done by the Manitoba Department of Mines and Natural Resources at Cross Lake.

INTRUSIVE AND GRANITIZED ROCKS (7-11)

Basic and Ultrabasic Rocks (7)

Peridotite (7c), serpentinite (7c), gabbro (7b), diorite (7b), labradorite porphyry (7a), and anorthosite (7a) intrude volcanic rocks of the Hayes River group as sills. Field evidence suggests that most are differentiates of an original ultramafic magma.

Along the southwest shore of Pipestone Lake, differentiated rocks overlie volcanic rocks and separate them from the tonalite-granodiorite-gneiss to the south. At its thickest point the belt is 4,000 feet wide and it pinches out at both ends. Two hundred feet of massive gabbro lies at the base of the series. The size of the plagioclase crystals increases upward in this gabbro until they are 1 inch across and the rock is a gabbro porphyry. Above this the feldspar phenocrysts coalesce into lenses 3 inches thick and tens of feet long, and the rock is layered. These lenses are enclosed in coarse-grained gabbro similar to the matrix of the underlying porphyry. This lensed rock changes abruptly upwards into a thickly stratiformed rock composed of 2- and 3-foot zones of euhedral 3-inch labradorite-bytownite (An_{70}) crystals in a hornblende-rich matrix. Thin hornblendite bands intercalate this coarse-grained porphyry across a 100-foot thickness before they thin and disappear. This stratiform porphyry is overlain by 300 feet of very coarse grained labradorite porphyry composed of round to columnar, single plagioclase (An_{70}) crystals up to 12 inches across. Some may be spherical aggregates of feldspar. These phenocrysts are regularly distributed and comprise from 50 to 100 per cent of the rock. The matrix is chloritized hornblende and epidote. For field purposes this rock is identified as 'football anorthosite'. It may be compared with the 'leopard rock' of the Labrador trough (Baragar, 1960, p. 1607).

The sequence of rocks between the gabbro-lava contact and the top of the football anorthosite varies in width with a maximum of 1,000 feet. Massive lenses and disseminations of vanadium-bearing magnetite occur within each rock type in this 'transition zone'. The lenses are up to 10 feet wide and have been traced for thousands of feet with the aid of a ground magnetometer. The cumulative width of the magnetite is about 100 feet at the widest part of the 'transition zone'. It is a product of magmatic differentiation and segregation. Above the football anorthosite the plagioclase crystals coalesce and form a band of massive anorthosite that varies from a few feet to 3,000 feet wide. Ninety-five per cent of this rock consists of labradorite fragments in a granulated matrix of similar feldspar and 5 per cent chlorite. Minor amounts of secondary plagioclase join the cracked primary crystals. The texture of the rock suggests that it originated as a dry crystal mush, with granulation being a primary feature. Leucoxene is the opaque mineral. The closest contact of this anorthosite with the tonalite-gneiss to the south is obscured by a 3-foot draw.

Similar football anorthosite and anorthosite outcrop on Hairy Lake, Little Hairy Lake, and on the south shore of Butterfly Lake. These three masses are separated by a drift-covered area, and it is not known whether they are connected or represent more than one body.

Peridotite and serpentinite (7c) outcrop within the volcanic rocks at the west end of Pipestone Lake (hence the name) and at two places along Carrot River. For a description of the latter see Barry (1960). Associated with the easternmost peridotite on Carrot River is a gabbro porphyry with 2-inch phenocrysts of completely silicified plagioclase, a slightly serpentinized medium- to fine-grained diorite, and a hornblende gabbro. These appear to be members of a differentiated series.

A swarm of diabase-diorite sills intrude the Hayes River volcanic-sedimentary sequence between Carrot River and Lynx Bay on Oxford Lake. Individual and composite sills are up to 500 feet thick and make up about 5 per cent of the rock across the 5-mile section. They are too small and numerous to show on the map. It is thought that these are older than the late diabase dykes that strike northward throughout the map-area. They may be contemporaneous with the larger mafic bodies found along Carrot River.

Granodiorite-tonalite-gneiss Complex (8)

More than 90 per cent of the map-area is underlain by rocks whose composition ranges from tonalite through granodiorite granite. Horwood (1934, p. 69; 1935, p. 139) considered these rocks in some detail, and Barry (1960, p. 18) described similar rocks in the Oxford Lake area. There is a regional abundance of plagioclase (An_{25-40}) and quartz, and an overall scarcity of potash feldspar in these rocks. Biotite and hornblende are the mafic constituents. Exceptions at both the acid and basic ends are found, but most of the rocks have the composition of granodiorite or tonalite. Rarely, gneissosity is absent and the rocks are massive.

It is impossible to classify these rocks more precisely on the basis of megascopic examination. All gradations are present between acid granodiorites and basic tonalites. In many places their contacts are sharp, either one intruding the other; elsewhere the contacts are diffuse and gradational. The field classification is therefore based on the presence or absence of gneissosity, biotite, hornblende, phenocrysts, skialiths (relic in situ remnants of the original country rock) and inclusions of basic material.

The most common rock in the area is biotite granodiorite-gneiss (8a). It is a pink to grey, medium- to coarse-grained gneiss containing up to 50 per cent oligoclase, 25 per cent quartz, 15 per cent potash feldspar (microcline), and 10 per cent biotite, with minor hornblende and muscovite. Gneissosity in most cases is the result of an alignment of the quartz into lenticular masses and a rude parallelism of platy minerals. Banded gneissosity is rare.

In a few areas the gneiss loses its directional components and the rock becomes massive and intrusive looking. It is there mapped as biotite granodiorite (8b).

Linear belts of porphyritic biotite granodiorite (8c) lie within the gneisses near Molson Lake and on the north shore of Walker Lake. Phenocrysts of pink microcline up to 2 inches long occur in a hypidiomorphic granular to gneissic matrix of granodioritic composition. Many isolated patches of porphyry occur scattered through the gneisses and are too small to map. In some places the phenocrysts are plagioclase and are in a tonalitic matrix.

Biotite granodiorite-gneiss with inclusions and relic fragments of mafic material (8d) is ubiquitous in certain regions. The mafic fragments vary in composition from true greenstone through a sugary-textured, medium-grained aggregate of quartz, feldspar, biotite, and hornblende, to amphibolite and biotite or chlorite schist. At two places on islands near the western and eastern ends of Molson Lake, the remnant material appears to have originally been arenaceous sediments. The inclusions and relics vary in extent from areas of recognizable volcanic rocks (3) large enough to map, to small patches a few feet across. Where abundant they constitute up to 10 per cent of the country rock. Over large areas, both the planar orientation and the direction of banding or gneissosity within the skialiths parallel the regional gneissosity of the host granodiorite. This suggests that they have not been transported any distance and are in fact relics of the pre-granitization substratum. Elsewhere the remnant material is rotated out of the plane of regional gneissosity, suggesting that the enclosing granodiorite was at one time in a plastic or fluid state. Outward from these contaminated areas the enclosing gneiss is a mixed rock characterized by indistinct streaky inhomogeneties or ghost-like remnants of the former darker rocks. There is no sharp boundary between the component parts of the light and dark varieties, and the resultant rock may be termed 'nebulitic' or hybrid gneiss. Larger inclusions are in places surrounded by a hybrid-gneiss aureole of tonalitic composition. It is possible that many of the compositional differences between these gneisses are the result of granitization of pre-existing materials of different composition.

Hornblende occurs as the major mafic mineral in the hornblende tonalite-gneiss (8e) over large areas. It occurs in a medium-grained grey gneiss that has abundant visible plagioclase. The average tonalite contains about 35 per cent quartz, 45 per cent plagioclase (andesine), 5 per cent potash feldspar (microcline), and up to 15 per cent hornblende with minor biotite.

Hornblende tonalite-gneiss with inclusions and relic fragments (8f) contains the same kinds of substratum remnants as the granodiorite-gneisses described above; the composition of the host rock is hornblende tonalite.

The origin of what is here called 'augen gneiss' (8g) is uncertain. The rock is grey, medium to coarse grained, and invariably gneissic. The 'augen' vary from white, 3/16-inch, rounded feldspar eyes which give the rock a gritty appearance, through true 'augen' shaped, 3/4-inch feldspar crystals, to a very coarse-grained gneiss that contains 2-inch, augen-shaped, pink orthoclase porphyroblasts. These rocks are all biotite-rich and are all cut by leucocratic granite (10). They suggest an intermediate stage in the regional granitization process.

Origin of Gneisses

In most places the contact between gneisses and Hayes River group rocks is knife sharp where it parallels the regional structure, and gradational where it crosses it. In all cases the gneissosity in the gneiss parallels the banding in the older rock. Sharp crosscutting relations exist for distances of a few feet but the contacts there are marked by a 2-inch zone of breccia and chlorite schist and appear to have formed during post-granitization movement. Granodiorite apophyses were seen intruding greenstone schist on a peninsula jutting into the northeast end of Cross Lake at 97°03'W, 54°53'N. On Echimamish River at a point half-way between the mouth of Fairy Creek and the inlet to Hairy Lake, granodiorite dykes and stock-works intrude the Hayes River sediments. The surrounding gneiss contains sedimentary inclusions and the contact is intrusive. It could not be established whether these intrusive rocks are the same age as the regional gneisses (8), or younger.

Horwood (1935) noted the similarity in mineral content of the tonalite boulders in both the Hayes River and Cross Lake conglomerates and in the regional gneisses. He concluded that the tonalitic boulders "must have been derived from a tonalite formation older than either the Hayes River or Cross Lake formations" and he suggested that the tonalite was pre-Hayes River. The writer agrees that pre-Hayes River granitic rock must have existed, but no evidence was seen to prove that the present regional gneiss is this rock.

It is concluded that most of the granodiorite-tonalite-gneiss is a granitized rock derived from material of Hayes River age or older. The regional gneissic structure and the planar mafic relics enclosed in the gneiss both parallel the trends in the volcanic belts and probably represent the pre-granitization fabric of the regional substrata. Only in certain places has the pre-existing material become mobile enough to recrystallize in an end product that could be called a magmatic rock.

Agmatite (9)

A belt of composite rock consisting of basic fragments surrounded by granodiorite-tonalite occurs along the south arm of Playgreen Lake and extends east to the Sugar Falls area on Nelson River. The 'tonalite' occurs as a stock-work-like matrix enclosing such diverse mafics as greenstone, amphibolite, gabbro, and diorite which contains hornblendite inclusions. The resultant rock is an agmatite (injection breccia). This belt has been mapped separately from the Hayes River group transition rocks (3) because the tonalite is not gneissic nor does it occur as lit-par-lit masses in the mafic rock. In addition, some of the mafic rock may have been stocks of hybrid diorite which are not related to the Hayes River group. Horwood (1934, p. 72) found that the intruding tonalite "contains about twenty per cent hornblende; fifteen per cent biotite; fifty-eight per cent andesine ($Ab_{60}An_{40}$); and seven per cent quartz."

Other agmatitic areas, consisting of tonalite-granodiorite fragments surrounded by a stock-work of pink leucogranite and leucogranodiorite, have been included with the late, pink granodiorite (10).

Leucogranite, Leucogranodiorite, Aplite, and Pegmatite (10)

Locally, massive pink to grey leucogranite or leucogranodiorite outcrops as stocks or small batholiths. In places they form the only rock type; elsewhere they occur as stock-works intruding the regional gneisses. Phases of these intrusives are found cutting all the aforementioned rocks. Dykes of pink granite, aplite, or pegmatite are ubiquitous, and outcrops that have not been intruded by one of the above rocks are rare. The massive bodies at Robinson Lake and in the central part of Carrot River are stocks. Sixty per cent of the outcrop on the south half of Fairy Lake and in the northeast corner of Playgreen Lake is late leucogranite. Late granites have been described from the Flin Flon and Knee Lake areas. Barry (1960, p. 20) found late intrusions at Oxford Lake and identified them as 'massive pink granodiorites'. Horwood (1934, p. 75) gave their average composition as 27 per cent quartz, 54 per cent potash feldspar (microcline with minor microperthite and orthoclase), 16 per cent plagioclase (An_{35} to An_{25}) and 3 per cent biotite or rare hornblende.

Pegmatite dykes are abundant in the agmatite (6a) area west of Cross Island. They range from a few inches to hundreds of feet in width. Some are very coarse grained and are composed of pink potash feldspar, milky quartz, muscovite, black tourmaline, and minor biotite. A few contain spodumene, lepidolite, and possibly small apatite crystals. The lithium minerals do not appear to be present in commercial quantities.

Diabase (11)

Late basic dykes are not common but they do outcrop in many parts of the area and intrude all the rocks described in the foregoing. Their strike is generally between N30 and N40°E; their dips are vertical. Most are a few tens of feet wide but three were found to be more than 600 feet wide. Their scale is exaggerated on the map. A swarm of dykes outcrops along Nelson River between Bladder Rapids and Ebb and Flow Rapids. The dyke at Pipestone Lake may be the continuation of the one on Cross Lake east of the principal meridian. Another large dyke outcrops on islands in the eastern part of Molson Lake. Horwood (1934, p. 81) found that in "the wide dykes there is a considerable variation from the edge to the centre in both texture and composition. The borders are very fine grained and dark green whereas the centres are coarse grained and greenish grey. As the majority of the dykes are narrow, they have a composition similar to the borders of large dykes and contain about fifty-two per cent hornblende; forty-four per cent labradorite $Ab_{35}An_{65}$, and four per cent magnetite. They may be termed melagabbros or diabases."

STRUCTURAL GEOLOGY

South of the Echimamish - Hayes River lineament the regional strike of the gneisses is east with 20-degree variations to the north or south, especially along Nelson River. In the Lawford Lake - Fairy Lake area the gneisses strike northwest; elsewhere they trend east to northeast.

FOLDS

The major geological feature is the fold structure formed by the Hayes River group. Steeply plunging folds at Cross Lake settlement suggest that the structure is a truncated, abnormal anticlinorium whose axial trace strikes east from the settlement. Structural details indicate that the tops of beds face south along the Echimamish limb and north along the Cross Lake limb. Most lineations along the south limb plunge S75°W at 30-90°, but anomalous northeast plunges indicate that at least two orogenies took place. At Cross Lake settlement, Cross Lake group sediments are tightly infolded with Hayes River group rocks to form the crest of the anticlinorium. North of the 17th base line the folds plunge southwest and the axial traces trend northeast up Cross Lake. South of the base line the axial traces trend southeast, and at least one plunges to the southeast.

It is not known how the Carrot River belt fits the regional structure. There are suggestions that tops face south along part of the belt and lineations plunge southwest. This belt may be a preserved remnant of the larger anticlinorium. If the sequence of granitized gneisses between the Hayes and Carrot Rivers faces south, the axial trace of the anticlinorium at Cross Lake must swing from east to northeast and pass through Walker Lake.

Evidence from which the tops of strata may be determined is too rarely preserved for the stratigraphic succession to be worked out with certainty. In many places, Hayes River group rocks are overturned and may even be tightly folded, for closely spaced beds facing in opposite directions are common at the nose of the anticlinorium.

The northward 'peak' in the andesite band east of Birch Lake and Fairy Creek is accompanied by a sympathetic parallelism in the gneissosity of the gneisses as far northeast as Lawford Lake and in the immediate vicinity west of Fairy Creek. It forms a steeply-south-plunging syncline with a south-trending axial trace. Parallel folding may explain why the syncline dies out so rapidly to the south. A longitudinal fault lies within the gneiss and parallels the western contact of the 'peak'. It does not appear to offset the andesite west of Birch Lake and may be post-folding.

LINEAMENTS AND FAULTS

Two systems of lineaments were recognized. In one the lineaments strike northeast and are preserved as lake-filled topographic depressions in such widespread areas as south of Molson Lake, along the southeastern edge of the map-area, at Walker Lake, and west of Whiterabbit Lake. Where examined, the closely associated rocks are sheared and epidotized. If these lineaments are faults, the offset appears to be small.

The lineaments and faults in the second, and major, system trend west. The most important crosses Carrot River and continues east to Oxford Lake. If the southern contact of the volcanic flow rocks is used as a horizon marker, this fault has a strike separation of 6.5 miles; if the northern contact is used, the strike separation is 5.2 miles. Faults in the vicinity of Hyers Island parallel this major break and are associated with local mineralization.

ECONOMIC GEOLOGY

Early in the century the area around Hyers Island was staked and explored for iron and copper. Pyrite-bearing rock was staked in the Painted Stone Portage area in 1926, and local samples were assayed for gold. Visible gold in quartz veins and gold-bearing sulphides were discovered east of Birch Lake, north of Echimamish River, in 1934 and 1935 respectively. This resulted in the establishment of the Echimamish Gold property in July 1936. At that time the surrounding area was extensively prospected and staked. During the last few years there has been some prospecting on copper, nickel, lithium, and vanadium-bearing magnetite showings in the Cross Lake area. In 1956-57 Allcop Mines Limited drilled copper-bearing shear zones on Hyers Island. Nothing of economic importance appears to have been found to date.

Hyers Island - Carrot River Area

Barry (1960, p. 29) gave the location and a complete description of the asbestos, copper, and sulphide occurrences along Carrot River and in the vicinity of Hyers Island.

Echimamish River - Birch Lake Area

The following descriptions of the O'Day and Echimamish Gold showings have been summarized from Tanton (1937).

The O'Day property is 1/8 mile northeast of the east bay of Birch Lake (97° 00'W, 54° 26'N); it was discovered in 1934. Within a schistose greenstone-amphibolite complex is a 4-foot zone of "calcite-chlorite schist locally replaced by nodular aggregates of epidote and fine-grained feldspathic material and sparingly mineralized with disseminated grains of arsenopyrite. Within this zone, and locally occupying the greater part of its width, is a lenticular quartz vein varying in width from a fraction of an inch to 4 feet, composed of finely granular, white and blue quartz. The blue quartz over a length of at least 20 feet is visibly mineralized with grains of gold up to 1/20 inch in diameter. At some places along the vein there are platy inclusions of chloritic schist in the quartz, and the rock in and near these inclusions contains sparsely disseminated grains of arsenopyrite, pyrrhotite, and chalcopyrite." A channel sample across a 4-foot width of the vein is reported to have assayed 2.25 ounces gold per ton.

The Echimamish Gold property is 2,000 feet north-northwest of Dam No. 2 (96° 54'W, 54° 24'N). It was staked in 1935, optioned by R.J. Jowsey and associates in 1936, and drilled the same year. The highest concentration of mineralization is in a complex of pillow lava and tuff that has been cut and locally silicified and feldspathized by quartz porphyry and lamprophyre dykes. Small lenticular quartz veins replace the metasomatically altered volcanic rock.

Finely disseminated grains of pyrrhotite, arsenopyrite, and minor pyrite occur as replacement bodies in the alteration zone and locally in some of the narrow quartz veinlets. Adjacent to sericite schist, inclusions in the altered volcanic rock are lenticular replacement bodies of finely crystalline sphalerite, galena, chalcopyrite, jamesonite, and freibergite containing blebs of blue quartz. Assays from this zone are said to have carried commercial quantities of silver and gold. These mineralized zones are on the order of a few feet in length and inches in width.

Conx Group—This showing is located a mile northeast of the east bay of Birch Lake (96° 59'W, 54° 26'N). It was discovered by Gunner Berg in 1958 in a composite shear zone of biotite-sericite schist that lies within massive andesites. The schist may have originally been a greywacke bed. Sphalerite, chalcopyrite, and pyrite occur as segregations in quartz veins within the shears. The mineralized zone is 100 feet long and a few feet wide. Two grab samples from this zone were assayed at the Mines Branch, Ottawa, with the following results:

(a) Au - 0.005 oz/ton; Ag - 0.38 oz/ton; Cu - 14.50 per cent.
(b) Au - 0.015 oz/ton; Ag - 2.89 oz/ton; Cu - 3.51 per cent.

Other Showings—Tanton observed twenty-two other showings of sulphides in schist, alteration zones, and quartz veins. None is important enough to warrant description.

Cross Lake Area

The X-L Syndicate property is located on islands near the north shore of Cross Lake, 7 1/2 miles west of the principal meridian (97°39'W, 54°43'N). Pyrite, pyrrhotite, and chalcopyrite occur within shears in greenstone and paragneiss. These were drilled in 1958.

The Noranda Exploration Company Limited property is on the south shore of Pipestone Lake, east and west of the diabase dyke (97°43'W, 54°30'N). Vanadium-bearing magnetite formed by magnetic differentiation was drilled in 1959. The geology of these deposits is described here under "Basic and Ultrabasic Rocks (7)".

Other Showings—Sulphides occur in paragneiss at the northwestern end of the large bay, 4 miles north-northwest of the north end of Whiskeyjack Portage (97°58'W, 54°32'N).

Spodumene-bearing pegmatites occur on the south shore of the first island south of Cross Island (97°51'W, 54°34'N). The spodumene does not appear to be present in commercial quantities.

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