CANADA
DEPARTMENT OF MINES
HON. W. A. GORDON, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

GEOLOGICAL SURVEY
W. H. COLLINS, DIRECTOR

MEMOIR 167

Fort William and Port Arthur, and Thunder Cape Map-areas, Thunder Bay District, Ontario

BY

T. L. Tanton

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1931

Price, 30 cents No. 2268

View of port, Fort William, Ontario

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CHAPTER I

INTRODUCTION

GENERAL STATEMENT

The commercial importance of the cities of Fort William and Port Arthur, which are by far the largest settlements on the Canadian side of lake Superior, is due to their position at the head of lake navigation (Plates I and II) on the main trade route across Canada. Fort William was originally an important fur-trading post and in the early days of canoe travel, when fur was the chief article of commerce, the trade routes were along rivers. Of all those giving access to the west, the Kaministikwia, for a considerable distance back from the shore of the lake, has the gentlest gradient. It flows through a broad lowland, of which two lines of transcontinental railways have taken advantage in that part of the route connecting the Great Lakes with the prairies. The greater part of the grain exported from the prairies is brought to elevators in the twin cities, for shipment to the east.

The lowland through which Kaministikwia river flows, is bordered by rocky uplands such as characterize the greater part of the north shore of lake Superior, whereas the lowland is largely floored with unconsolidated deposits. There is a larger farming community in this district than elsewhere adjoining the north shore of lake Superior. Originally the entire district was forested, and, though a considerable part of the forest has now been cleared away or lumbered over, an important forest products industry is maintained at the twin cities, drawing its supplies chiefly from stands of coniferous trees in the highlands in the upper part of Kaministikwia River basin and around the shore of lake Superior.

Hydroelectric power is developed from falls on Nipigon, Kaministikwia, and Current rivers and supplied to the two cities. A fishing industry is carried on along the shore of lake Superior and boats from the twin cities collect the catch from pond nets set around Thunder bay, Black bay, and the shore between Black bay and Nipigon strait.

Mineral deposits of several different kinds occur in the district adjacent to Thunder bay; silver to the amount of several million ounces has been produced from veins in this district, and the mining of non-metallic minerals has been carried on in recent years.

The present report gives an account of the geology of a considerable district adjacent to Fort William and Port Arthur and assembles all pertinent information relating to veins of the silver-bearing type in the general district. A considerable part of the information regarding veins has been drawn from the classic report by E. D. Ingall[1]. The most productive silver mine in this district was the now-abandoned Silver Islet mine. A geological investigation of an area in the vicinity of this mine was made in 1921 and the results obtained were incorporated in a map (No. 1902) published in 1924. The field work on which the present report is largely based was done during the field seasons of 1923 and 1927, when the Fort William and Port Arthur, and the Thunder Cape map-areas were studied and an examination was made of mineral deposits in the silver-bearing district between Nipigon and Gunflint lake; in the course of the latter work some areal geological mapping was done in the areas embraced by the Kakabeka and the Loon sheets. Fort William and Port Arthur, and Thunder Cape map-areas embrace a rectangular area of about 782 square miles, lying between north latitudes 48° 15′ and 48° 30′ and west longitudes 88° 30′ and 89° 30′. The area is 46 miles in an east and west direction and about 17 miles north and south.

Fort William and Port Arthur, and Thunder Cape sheets (which are the map-areas referred to in the title and are those meant where, in the body of this report, "the two map-areas" are mentioned) and also Kakabeka and Loon sheets, which are on a scale of 1 inch to the mile, are not enclosed with this volume, but may be had upon application to the Director, Geological Survey, Canada, Ottawa. In their stead a geological map, No. 2282, scale 1 inch to 4 miles, embracing a somewhat more extensive area, accompanies the memoir.

The writer was assisted, during the field season of 1921, by M. F. Goudge, G. Swartman, and C. G. Brennand; in 1923, by C. S. Hanes and R. Thomson; and in 1927, by E. K. Fockler, G. Ward, and H. S. Hicks.

PREVIOUS WORK

Earlier investigations of the geology of the district were made in the course of reconnaissances covering wide areas of country or during the study of individual mineral deposits. Much remained unknown regarding the distribution of the rocks; and due to changes, which have occurred with the passing of time, in systems of geological classification and in the meanings of geological terms, the relationships of the rocks to one another and to the mineral deposits were in need of reinterpretation or, at least, restatement in modern terms.

The most notable early contributions to geological knowledge were made by Sir William Logan, Thomas Macfarlane, and E. D. Ingall. The published contributions of these and other investigators are noted in the following list of publications and elsewhere in the body of this report.

[1] "Mines and Mining on Lake Superior"; Geol. and Nat. Hist. Surv. of Canada, Ann. Rept. 1887-88, pt. H.

BIBLIOGRAPHY

Allen, R. C., and Barrett, L. P.: "A Revision of the Sequence and Structure of the Pre-Keweenawan Formations of the Eastern Gogebic Iron Range of Michigan"; Jour. Geol., vol. XXIII, No. 8, pp. 689-703 (1915). *See also* Discussion of Correlation by Leith, C. K., and Allen, R. C.: Idem., pp. 703-729.

Anrep, A.: "Investigation of Peat Bogs in Ontario"; Geol. Surv., Canada, Sum. Rept. 1921, pt. D, pp. 7-12.

Bayfield, H. W.: "Outlines of the Geology of Lake Superior"; Trans. Lit. and Hist. Soc., Quebec, vol. I, 1829, pp. 1-43.

"On the Junction of the Transition and Primary Rocks of Canada and Labrador"; Quart. Jour. Geol. Soc., London, vol. I, 1845, pp. 450-459.

Bell, Robert: "On the Geology of the Northwest Coast of Lake Superior and the Nipigon District"; Geol. Surv., Canada, Rept. of Prog. 1866-1869, pp. 313-364.

"On the Country Between Lake Superior and Winnipeg"; Geol. Surv., Canada, Rept. of Prog. 1872-3, pp. 87-111.

"The Mineral Region of Lake Superior"; Can. Nat. and Geol., 2nd ser., vol. VII, pp. 49-51 (1875).

"Geology of Ontario, with Special Reference to Economic Minerals"; Rept. Roy. Com. on Min. Res. Ontario, Toronto, 1890, pp. 1-70.

Bigsby, John J.: "Notes on the Geography and Geology of Lake Superior"; Quart. Jour. Sci., Lit. and Arts, vol. XVIII, 1825, pp. 1-34, 222-269.

"On the Physical Geography, Geology, and Commercial Resources of Lake Superior"; Edinburgh New Phil. Jour., vol. LIII, 1852, pp. 55-62.

Blue, A.: "The Story of Silver Islet"; Ont. Bureau of Mines, vol. VI, pp. 125 (1896).

Bowen, N. L.: "Silver in Thunder Bay District"; Ont. Bureau of Mines, vol. XX, pt. 2 (1911).

Chadbourn, C. H.: "Ores on the Silver Islet Mine"; Econ. Geol., vol. 18, pp. 77-82 (1923).

Chamberlin, T. C.: "The Copper-bearing Series of Lake Superior"; Science, vol. I, 1883, pp. 453-455.

Cole, L. H.: Mines Branch, Dept. of Mines, Canada, Sum. Rept. 1918, p. 55.

Coleman, A. P.: "Copper Regions of the Upper Lakes"; Rept. Ont. Bureau of Mines, vol. VIII, pt. 2, 1899, pp. 121-174.

"Upper and Lower Huronian in Ontario"; Bull. Geol. Soc. America, vol. XI, 1900, pp. 107-114.

"Iron Ranges of Northwestern Ontario"; Rept. Ont. Bureau of Mines, 1902, pp. 128-151.

"Pre-Cambrian Nomenclature"; Jour. Geol., vol. XIV, 1906, pp. 60-64.

"The Huronian Question"; Am. Geol., vol. XXIX, 1902, pp. 325-334.

Cooke, H. C.: "Progress of Structural Determinations in the Archæan Rocks of Ontario and Quebec"; Trans. Roy. Soc., Canada, 3rd ser., vol. XIX, sec. IV, pp. 1-20 (1925).

Courtis, W. M.: Trans. Am. Inst. Min. Eng., vol. 2, p. 89.
Idem., vol. 5, p. 483.
Idem., vol. 15, p. 671.
Eng. and Min. Jour., vol. 26.

Forster, John H.: Mich. Pioneer and Hist. Soc., vol. 14, 1889, pp. 197-205.

Gill, J. E.: "Gunflint Iron-bearing Formation"; Geol. Surv., Canada, Sum. Rept. 1924, pt. C, pp. 28-88.

"Origin of the Gunflint Iron-bearing Formation"; Econ. Geol., vol. XXII, No. 7, pp. 687-728 (1927).

Hille, F.: "Genesis of the Animikie Iron Range, Ontario"; Jour. Can. Min. Inst., vol. VI, 1904, pp. 245-287.

Hotchkiss, W. O.: "The Lake Superior Geosyncline"; Bull. Geol. Soc. Am., vol. XXXIV, pp. 669-678 (1923).

Hunt, T. Sterry: "The Geognostical History of the Metals"; Trans. Am. Inst. Min. Eng., vol. I, 1873, pp. 331-345; vol. II, 1874, pp. 58-59.

Trans. Am. Inst. Min. Eng., vol. 2, 1874, p. 59.

2nd Geol. Ser. of Pennsylvania, Azoic Rocks, pt. 1, E, p. 240.

Ingall, E. D.: "Report on Mines and Mining on Lake Superior"; Geol. and Nat. Hist. Surv., Canada, Ann. Rept. for 1887-8, N.S., vol. III, pt. H, pp. 1-131.

Irving, R. D.: "The Copper-bearing Rocks of Lake Superior"; Mon. U.S. Geol. Surv., vol. V (1883).

Third Ann. Rept. U.S. Geol. Surv., 1883, pp. 89-188.

Science, vol. I, 1883, pp. 140, 359, 422; Am. Jour. Sci., 3rd ser., vol. XXVIII, 1884, p. 462; vol. XXIX, 1885, pp. 67-68, 258-259, 339-340.

"On the Classification of the Early Cambrian and Pre-Cambrian Formations"; Seventh Ann. Rept. U.S. Geol. Surv., 1888, pp. 365-454.

Keele, J.: "Preliminary Report on the Clay and Shale Deposits of Ontario"; Geol. Surv., Canada, Mem. 142, pp. 125-129.

Lane, A. C.: "Report of the Special Committee for the Lake Superior Region," personal comments; Ann. Rept. Geol. Surv., Mich., for 1904, 1905, pp. 143-153; Jour. Geol., vol. XIII, 1905, pp. 457-461.

Lawson, A. C.: "The Internal Relations and Taxonomy of the Archæan of Central Canada"; Bull. Geol. Soc. Am., vol. I, 1890, pp. 175-194.

"Lake Superior Stratigraphy"; Am. Geol., vol. VII, 1891, pp. 320-327.

"The Laccolithic Sills of the Northwest Coast of Lake Superior"; Bull. Geol. And Nat. Hist. Surv., Minn., No. VIII, 1893, pp. 24-48.

Sketch of the Coastal Topography of the North Shore of Lake Superior"; 20th Ann. Rept. of the Nat. Hist. Surv. of Minnesota, 1893.

"The Eparchæan Interval; a criticism of the use of the term Algonkian"; Bull. Dept. Geol., Univ. California, vol. III, 1902, pp. 51-62.

"A Standard Scale for the Pre-Cambrian Rocks of North America"; Inter. Geol. Cong., XII Session, pp. 349-370 (1913).

Leverett, Frank: "Moraines and Shore Lines of the Lake Superior Region"; U.S. Geol. Surv., Prof. Paper 154A.

Logan, W. E.: "On the Geology and Economic Minerals of Lake Superior"; Geol. Surv., Canada, Rept. of Prog. 1846-7, pp. 8-34.

"On the Age of the Copper-bearing Rocks of Lakes Superior and Huron, and Various Facts Relating to the Physical Structure of Canada"; Rept. Brit. Assoc. Adv. Sci., 21st meeting, 1851, pp. 59-62, Trans.; Am. Jour. Sci., 2nd ser., vol. XIV, 1852, pp. 224-229.

Rept. to the Commissioner of Crown Lands, 1846.

"Geology of Canada, 1863," pp. 22-86.

Lowe, F. A.: Eng. and Min. Jour., vol. 32, p. 251.

Idem., vol. 34, p. 321.

McDermott, W.: Trans. Am. Inst. Min. Eng., vol. 3, 1874-75, pp. 359-60.

Eng. and Min. Jour., vol. 23.

Macfarlane, Thos.: On the Laurentian, Huronian, and Upper Copper-bearing Rocks of Lake Superior"; Geol. Surv., Canada, Rept. of Prog. 1863-66, pp. 115-164.

"On the Geological Formations of Lake Superior"; Can. Nat., 2nd ser., vol. III, 1866-68, pp. 177-202, 241-256.

"On the Geology and Silver Ore of Wood's Location, Thunder Cape, Lake Superior"; Can. Nat., 2nd ser., vol. IV, pp. 37-48, 459-463.

"Remarks on Canadian Stratigraphy"; Can. Nat., 2nd ser., vol. IX, 1879, pp. 91-102.

McInnes, Wm.: "The Geology of the Area Covered by the Seine River and Lake Shebandowan Map Sheets, Comprising Portions of Rainy River and Thunder Bay Districts, Ontario"; Geol. Surv., Canada, Ann. Rept., vol. X, pt. H, pp. 13-51 (1899).

McKellar, Peter: "The Correlation of the Animikie and Huronian Rocks of Lake Superior"; Proc. and Trans. Roy. Soc., Canada, vol. V, sec. 4, 1887, pp. 63-73.

"Mining on the North Shore of Lake Superior"; Toronto, 1874.

"Early Mining"; Thunder Bay Hist. Soc., Ninth Ann. Rept., pp. 15-17 (1918).

"Prehistoric Relics"; Idem., pp. 29-31.

Miller, W. G.: "Iron Ranges of Northern Ontario"; Rept. Ont. Bureau of Mines, 1903, pp. 304-317.
"Lake Superior Silver Deposits"; Rept. Ont. Bureau of Mines, vol. XIX, pt. 2, chap. 3, 1913.

Moore, E. S.: "Sources of Carbon in the Pre-Cambrian Formations"; Trans. Roy. Soc., Canada, 3rd ser., vol. XIX, sec. IV, pp. 21-28 (1925).

Murray, Alexander: "On the Geology of the Kaministiquia and Michipicoten Rivers"; Geol. Surv., Canada, Rept. of Prog. 1846-47, pp. 47-57.

Nicholson, H. A.: "The Geology of the Thunder Bay and Shebandowan Mining Districts of the North Shore of Lake Superior"; Quart. Jour., London, Geol. Soc., vol. 29, p. 16.

Parsons, A. L.: "Economic Deposits in Thunder Bay District"; Ont. Dept. of Mines, vol. XXX, pt. 4, pp. 27-38 (1921).
"Calcite from Shangoina Island near Thunder Cape, Lake Superior"; Univ. of Tor. Studies, Geol. Ser., No. 12, 1921, p. 51.

Parsons, A. L., and Thomson, E.: "Animikite and Macfarlanite from Silver Islet, Thunder Bay, Lake Superior"; Univ. of Tor. Studies, Geol. Ser., No. 12, 1921, p. 23.

Roland, Walpole: "Algoma West"; published by Warwick and Sons, Toronto, 1887, pp. 1-190.

Selwyn, A. R. C.: "Notes of a Geological Reconnaissance from Lake Superior to Fort Garry"; Geol. Surv., Canada, Rept. of Prog. 1872-73, pp. 8-18.
"On the Geology of Lake Superior"; Trans. Roy. Soc., Canada, vol. I, sec. 4, 1883, pp. 117-122.
"Age of the Rocks of the Northern Shore of Lake Superior"; Science, vol. I, 1883, pp. 11, 221.
"Notes on Observations, 1883, on the Geology of the North Shore of Lake Superior"; Trans. Roy. Soc., Canada, vol. II, sec. 4, 1885, p. 245.
"Tracks of Organic Origin in Rocks of the Animikie Group"; Am. Jour. Sci., 3rd ser., vol. XXXIX, 1890, pp. 145-147.

Shepherd, Forrest: Rept. to the Trustees of the Montreal Mining Co., Nov. 27, 1846.

Silver, L. P.: "The Animikie Iron Range"; Rept. Ont. Bureau of Mines, vol. XV, 1906, pt. 1, pp. 156-172.

Smith, W. N.: "The Animikie or Loon Lake Iron-bearing District"; Min. World, vol. XXII, 1905, pp. 206-208.
Rept. Ont. Bureau of Mines, vol. XIV, pt. 1 (1905).

Stauffer, C. R.: "Age of the Red Clastic Series of Minnesota"; Bull. Geol. Soc. Am., vol. XXXVIII, pp. 469-478 (1927).

Tanton, T. L.: "Shore of Lake Superior between Port Arthur and Nipigon"; Geol. Surv., Canada, Sum. Rept. 1919, pt. E, pp. 1-7.
"Silver Islet and Vicinity"; Trans. Can. Min. Inst., vol. XXIII, 1920, pp. 402-418.
"Thunder Bay District, Ontario"; Geol. Surv., Canada, Sum. Rept. 1920, pt. D, pp. 1-2.
"An Exploration North of Thunder Bay, Ontario"; Geol. Surv., Canada, Sum. Rept. 1921, pt. D, pp. 1-7.
"Iron Formation at Gravel Lake, Thunder Bay District, Ontario"; Geol. Surv., Canada, Sum. Rept. 1923, pt. C I, pp. 1-5.
"Eastern Part of Matawin Iron Range, Thunder Bay District, Ontario"; Geol. Surv., Canada, Sum. Rept. 1924, pt. C, pp. 1-27.
"Stratigraphy of the Northern Subprovince of the Lake Superior Region"; Bull. Geol. Soc. Am., vol. XXXVIII, pp. 731-748 (1927).

Taylor, Frank B.: "Notes on the Abandoned Beaches of the North Coast of Lake Superior"; Am. Geol., vol. XX, pp. 111-128 (1897).
"The Glacial and Post Glacial Lakes of the Great Lakes Region"; Smithsonian Report for 1912, pp. 291-327.

Uglow, W. L.: "Lead and Zinc Deposits in Ontario and Eastern Canada"; Rept. Ont. Bureau of Mines, vol. XXV, pt. 2 (1916).

Whitney, J. D.: "Remarks on Some Points Connected with the Geology of the North Shore of Lake Superior"; Proc. Am. Assoc. Adv. Sci., vol. IX, 1856, pp. 204-209.

Willmott, A. B.: "The Nomenclature of the Lake Superior Formation"; Jour. Geol., vol. X, 1902, pp. 67-76.

Wilson, Alfred W. G.: "Geology of the Nipigon Basin, Ontario"; Geol. Surv., Canada, Mem. 1 (1910).

Wilson, M. E.: "The Significance of Recent Developments in the Precambrian Stratigraphy of the Lake Superior-Lake Huron Region"; Jour. Geol., vol. XXI, No. 5, pp. 385-398.

"Some Problems of Classification in the Canadian Precambrian Shield"; Geol. Mag., vol. LXIV, No. 751, pp. 1-7 (1927).

Winchell, N. H.: "Crucial Points in the Geology of the Lake Superior Region"; Am. Geol., vol. XV, 1895, pp. 153-162, 229-234, 295-304, 356-363; vol. XVI, 1895, pp. 12-20, 75-86, 150-162, 269, 274, 331-337.

Winchell, N. H., and Winchell, H. V.: Geol. and Nat. Hist. Surv., Minn., Bull. No. 6 (1891)).

Van Hise, C. R.: "An Attempt to Harmonize Some Apparently Conflicting Views of Lake Superior Stratigraphy"; Am. Jour. Sci., 3rd ser., vol. XLI, 1891, pp. 117-137.

"An Historical Sketch of the Lake Superior Region to Cambrian Time"; Jour. Geol., vol. I, 1893, pp. 113-128.

"Report of the Special Committee for the Lake Superior Region"; Jour. Geol., vol. XIII, 1905, pp. 89-104; Rept. Ont. Bureau of Mines, vol. XIV, pt. 1, 1905, pp. 269-277; Rept. Geol. Surv., Mich., for 1904-5, pp. 133-143.

Van Hise, C. R., and Leith, C. K.: "The Geology of the Lake Superior Region"; Mon. U.S. Geol. Surv., vol. LII (1911).

Descriptive Catalogue of a Collection of the Economic Minerals of Canada; Phil. Inter. Exhib., 1876.

CHAPTER II

GENERAL CHARACTER OF THE DISTRICT

GENERAL STATEMENT

Fort William and Port Arthur, and Thunder Cape map-areas embrace a deeply embayed part of Lake Superior basin and an adjacent land area on which there are three distinctly different types of topography: hummocky uplands developed on crystalline Early Precambrian rocks; tablelands developed on Late Precambrian rocks; and lowlands underlain by Pleistocene deposits.

DETAILED ACCOUNT

HUMMOCKY UPLANDS

The hummocky uplands are continuous with and form part of a very extensive area, the Canadian Shield, of moderate elevation above the sea, and devoid of great valleys and high hills, although the surface in detail is extremely uneven. The surface truncates highly folded, schistose rocks and plutonic masses which, presumably, at one time were in the lower parts of lofty mountains. This surface of low relief truncating the structures of the rocks is characteristic of a mature stage of physiographic development and has been commonly referred to as a peneplain.

The peneplain is variously developed and preserved in Fort William and Port Arthur area. In the zone near the contact between the Early Precambrian and the Late Precambrian, the peneplain is remarkably smooth and of low relief. In parts of this zone where the Late Precambrian strata presumably form only a thin layer over the Early Precambrian there are no "islands" of Early Precambrian rocks such as would occur if there were hills on the underlying peneplained surface. The peneplain was evidently formed before Late Precambrian deposition occurred in this region and, presumably, the smooth surface of low relief, which can be seen sloping lakeward near the border of the Late Precambrian strata, continues with a general south-southeasterly slope beneath these strata out into the area occupied by lake Superior.

The peneplain rises northerly from the zone near the edge of the Late Precambrian strata, if ever overspread by these strata it has been exhumed, and has been modified by erosion since Late Precambrian time. There is no direct evidence that the peneplain was ever submerged during the long interval between Late Precambrian and Pleistocene time; it may have remained as a land area. In Pleistocene time the surface was modified by glaciation and was also subjected to warping during and after the retreat of the ice.

The greater part of the hummocky, rocky uplands included in the northern part of Fort William and Port Arthur map-area has elevations ranging between 900 and 1,400 feet above the sea; locally in the vicinity of Wild Goose point they descend to the level of lake Superior, 602 feet above the sea.

TABLELANDS DEVELOPED ON LATE PRECAMBRIAN ROCKS

Lapping on the hummocky uplands on the south are Late Precambrian rocks consisting of nearly flat-lying sediments, with horizons of hard, resistant strata interbedded with soft strata easily susceptible to erosion and with sheets of intrusive diabase at various horizons. The intrusive sheets conform to the stratification of the rock over considerable distances, but locally curve across the bedding.

This assemblage has been subjected to warping and faulting. The surfaces on the fault blocks as originally exposed would possibly appear as plains sloping gently in various directions and in general lakeward, in agreement with the general dip of the strata. Erosion by streams and atmospheric agencies developed broad valleys and tabular uplands where nearly horizontal layers of resistant rocks lay over weaker strata. It has been inferred by Martin[1] that the depressions now occupied by Thunder, Black, and Nipigon bays were broad valleys formed during a period of subaerial erosion, and that the waters of lake Superior have subsequently risen to occupy their floors.

The tabular uplands which rise above the broad valleys are cuestas and mesas. The former have long, gentle slopes in one direction and terminate abruptly in cliffs in the other direction; the latter are bounded on all sides by cliffs or very steep slopes. Vertical and steeply dipping faults occur on the cuestas and between groups of mesas and are prominently expressed in the topography. The surface of the upland on one side of each fault is at a different elevation from that on the other; and a linear depression bounded by cliffs extends along the fault and terminates in a notch or jog in the cliff forming the side of the upland.

It is possible that the cliffs along the edges of mesas and cuestas where they front on drift-covered lowlands or submerged areas are fault line scarps. Some of them more than 200 feet high are remarkably straight for distances of many miles. Lawson interprets features of this sort on the east side of Thunder bay as fault scarps, but Martin[2] regards them as products of normal subaerial denudation. A linear escarpment submerged in lake Superior, and which passes through Thunder Cape map-area and extends from the vicinity of Duluth to St. Ignace island, is interpreted by Martin[3] as a fault scarp.

The surface on the tabular uplands is characteristic of a youthful stage of physiographic development. Presumably their major features were already in existence before Pleistocene time and any modifications since developed are believed to be of a minor nature. Erosion forms character-

[1]U.S. Geol. Surv., Mon., vol. LII, p. 100.
[2]Op. cit., p. 101.
[3]Op. cit., pp. 112-114.

istic of glacial action are to be seen on the solid rocks of the uplands; there was a selective removal of talus from the bases of cliffs, much more appears to have been removed beneath northerly facing cliffs than from those facing southerly; and the surface of the uplands was somewhat modified by a deposit of ground moraine of irregular thickness. The surface was also somewhat modified by the action of great lakes which formed during and after the recession of the ice; beaches and terraces were formed on the uplands up to an elevation of 850 feet above sea-level, and there has been pronounced differential erosion of resistant and soft rocks at various elevations between 850 feet above the sea and present lake-level, resulting in the development of caves and rock benches, and vertical or steeply inclined diabase dykes stand up as ridges, and project laterally as groynes into lake Superior. The latter features provide sheltered harbours for small boats.

The highest parts of the several cuestas and mesas in the map-areas range from an elevation of 710 feet above the sea, as on Welcome islands, to 1,805 feet above the sea on the Sleeping Giant, Thunder cape. The highest and most prominent cuestas and mesas are capped by diabase sheets. A diabase sill about 250 feet thick slopes upward from the lowlands at Moose Hill post office, elevation 750 feet, in the southwest corner of Fort William and Port Arthur map-area, and reaches an elevation of 1,600 feet at mount McKay. This tabular form is deeply dissected, particularly in its higher parts, and its northern boundary is fretted and locally divided into detached mesas. Mount McKay is the most northerly of a local group of four such mesas.

Diabase sills about 250 feet thick form capping sheets on the groups of high mesas that occur on Pie island and Thunder cape. The group at the latter locality, as viewed from Port Arthur, has a profile which simulates that of a recumbent man and it is known as the Sleeping Giant. The four northern mesas of the Sleeping Giant are known, respectively, as the Head, Adam's Apple, Breast, and Triangle; the most easterly mesa is Thunder mountain. On the western side of the Sleeping Giant there is a sheer cliff 800 feet high; this, so far as known, is the highest cliff in Ontario.

PLEISTOCENE LOWLANDS

Thick deposits of gravel, sand, and clay occur on lowland areas, which are presumably underlain by late Precambrian rocks, at the following localities: an area adjacent to Kaministikwia river; an area between Sawyer bay and Perry bay near Thunder cape; the eastern side of Sibley peninsula; and the eastern side of the projecting mainland east of Black bay.

These lowlands possibly mark broad valleys that had developed in the tabular uplands in pre-Pleistocene time. These valleys were probably somewhat deepened by glacial erosion in Pleistocene time, and subsequently ground moraine and lacustrine and fluviolacustrine beds were laid down, on which the surface of the lowlands has been developed.

The Pleistocene lowlands, broadly speaking, are plains which attain elevations of 850 feet above sea-level and slope gently down to lake

Superior 602 feet above the sea. On the plains there are commonly successions of low beach ridges and terraces at various elevations up to 850 feet; these are more prominently developed in the lowlands south of Fort William and near Thunder cape than elsewhere.

The Pleistocene lowlands have been trenched and gullied by streams since the level of the great lake, Algonquin and its succeeding stage, dropped to lower levels and finally to the level of lake Superior. The most prominently developed trench is that of Kaministikwia river which, in the western part of Fort William and Port Arthur map-area, is over 100 feet deep and is incised in Pleistocene deposits. Slate river has cut its channel in similar deposits to a depth of, locally, 75 feet.

DRAINAGE

Approximately half of the map-areas is occupied by lake Superior, whose elevation is 602 feet above sea-level. Soundings of 1,008 feet have been taken in lake Superior; the greatest depth recorded in the map-areas is 774 feet, at a place 5 miles south of Silver Islet landing. Soundings of 306 feet have been made in Thunder bay about 2 miles southwest of Clavet point; elsewhere the bay is shallower. Black bay is, on the whole, shallower than Thunder bay; depths as great as 222 feet are shown on the chart issued by the Hydrographic Survey of Canada.

Other lakes in the district include loch Lomond, which is 6 miles long by 1 mile wide, elevation 938 feet, and Marie Louise lake, $3\frac{1}{2}$ miles long by $1\frac{1}{2}$ miles wide, elevation 746 feet; in addition to these there are a number of small lakes and ponds scattered throughout the rocky highlands.

The Kaministikwia is the only large river in the area. It flows easterly along a meandering course and empties into lake Superior through three mouths which divide in its present delta. It is navigable for lake boats up to the turning basin at Westfort. Slate river is an important tributary joining from the south. The other rivers of the district empty directly into lake Superior. They are: Neebing river, McIntyre river, MacVicar creek, Current river which is the second largest stream in the area, Carp or Lomond river draining loch Lomond, and several creeks draining Sibley peninsula.

The streams traversing the Pleistocene lowlands have, in general, evenly graded valleys and swift currents. Above the lowlands they characteristically make their descent by irregularly spaced falls and rapids alternating with long stretches of quiet water.

In the early days the Kaministikwia was a well-known canoe route, but at present it is little used for this purpose. The other streams of the district are not navigable.

CHAPTER III

GENERAL GEOLOGY

OUTLINE

There are two striking unconformities in the geological record presented within the map-areas, and the rock groups that are separated by these are markedly different in lithological character and structure, so that for purposes of classification three major groups are recognized. The oldest of these is here called the Early Precambrian group and it consists of a complex of highly metamorphosed, intensely folded, surficially-formed rocks and great intrusive masses of granite and related rocks. This assemblage was deeply eroded, so that the plutonic rocks were exposed at the surface and the upper parts of the highly folded strata were removed before Animikie rocks, belonging to the next great group, were laid down. A consideration of the narrow zone bordering the area of Animikie sediments indicates that this erosion surface was of low relief, and, hence, it is probable that the mountainous topography implied by the highly folded rock structures and the presence of the granite, had been reduced practically to base level prior to the deposition of the Animikie sediments.

The second group, which is here embraced under the term Late Precambrian, consists of sedimentary rocks, which lie almost horizontally, and intimately associated volcanic rocks and intrusives of closely related chemical compositions.

The third group consists of a comparatively thin mantle of unconsolidated Pleistocene materials deposited during, and subsequent to, the last ice age.

This general outline of the stratigraphy accords with the interpretation of all previous workers in this region; but a variety of terms have been used at different times in referring to the consolidated rocks of the first two above-mentioned major divisions.

HISTORY OF TERMS USED IN CLASSIFICATION

Prior to 1904, when an international committee recommended the adoption of a standard classification for the rocks of Lake Superior region, the Late Precambrian rocks of the north shore were, by some, regarded as being of Palæozoic age; the rocks now called Early Precambrian were referred to as Archæan or some equivalent term having reference to a major subdivision of time antedating the so-called Palæozoic rocks. In this region no more satisfactory evidence is now available than was available to the early workers, as to whether the Late Precambrian rocks are really Precambrian or not. No fossils of value for determining this point have been found. There are, indeed, many questionable fossils and supposedly algal growths within the Late Precambrian rocks, but the study of these has not as yet contributed to the solution of the problem in hand. Fossiliferous Palæozoic rocks occur in proximity to the inferred correlatives of the Late Precambrian rocks in the vicinity of the outlet of lake Superior, on Keweenaw point, and also around the southwestern extremity of the lake in Minnesota. There is at present some diversity of opinion as to the position of the base of the Palæozoic in the Lake Superior region. The oldest known fossiliferous rocks are of Middle Cambrian age and were reported by Stauffer in 1926 as having been found in Minnesota in a boring in rocks that had previously been classified as Keweenawan.

When this region was studied by Sir William Logan in 1846 he subdivided the rocks of the Early Precambrian group into two major divisions, a supposedly older division consisting of granitic and gneissic rocks, and a supposedly younger division, consisting of schists, slates, etc. Later, these two divisions received the names of Laurentian (for the older) and Huronian (for the younger). Following the work of A. C. Lawson in Rainy Lake district in the years between 1885 and 1887, it became generally recognized that the gneissic assemblage was genetically related to the associated granitic intrusives and that the granite and gneiss assemblage which had come to be known as Laurentian, was younger than the volcanic schist assemblage. In the original Huronian area north of lake Huron it was known that certain of the typical Huronian rocks were younger than certain granites that had been mapped as Laurentian. It thus seemed desirable to revise Logan's use of the term Huronian in the area north of lake Superior, and the term Keewatin, proposed by Lawson, became generally accepted for the volcanic schist complex of this region. In Rainy Lake area Lawson had recognized a second series of pre-batholithic rocks to which he assigned the name Couchiching, and the Couchiching and Keewatin were together embraced under the major time term Ontarian. Between the years 1887 and 1904 it was found that highly deformed sediments, embracing a conglomerate with granite pebbles, occurred at various points within the volcanic schist complex between Thunder bay and Rainy lake. Certain authors referred to these rocks as Huronian and those who continued to think in terms of Logan's nomenclature regarded these sediments as Upper Huronian and the older volcanic schists, with which they are associated, as Lower Huronian. Others, adopting the modifications arising from Lawson's work, regarded the sediments which are younger than the associated volcanic schist-complex as a possible correlative of the Lower Huronian of the type locality. (The lowest Huronian is now known as the Bruce series.) There are few areas in the vast territory lying north of lake Superior where the Early Precambrian rocks have been mapped in sufficient detail to resolve the complex into all its subdivisions, and it is very questionable whether any of the rocks admit of satisfactory correlation with those of the Huronian north of lake Huron.

Though granite-pebble-bearing conglomerates are known in every extensive area in which the schist complex occurs, few places have been found where these sediments come in contact with the widely exposed batholithic intrusives. It has been inferred that at certain localities the conglomerate is older than the neighbouring granitic intrusives, whereas at certain other localities the converse relationship has been inferred. In those cases where the granite is inferred to be younger than the conglomerate it appears necessary to conclude that there are granites of two ages, and in the time scale proposed by Lawson for this general region granitic intrusives of two ages are recognized under the terms Laurentian and Algoman.

In the writer's opinion much detailed study will yet be necessary before it is possible to apply names having a precise time significance to the various Early Precambrian rocks that are represented north of lake Superior. In the small area represented by the Fort William and Port Arthur sheet the writer found it impossible to settle the outstanding problems involved in applying the various terms that have been suggested for the rocks of this region, and rather than make a commitment on matters that may be best decided from a detailed study of the adjoining area immediately to the north, it has been considered desirable to use a terminology that frankly acknowledges present uncertainty and that no significant contribution to the solution of general problems has resulted from the study of the rocks in this map-area. The divisions at one time referred to as Huronian and Laurentian are here called, respectively, Schist Complex and Batholithic Intrusives.

The Late Precambrian rocks were originally embraced under the term Upper Copper-bearing series, by Logan[1], who recognized an upper and a lower group.

In 1872 Dr. Robert Bell suggested that the term Upper Copper-bearing series might be replaced by the less cumbersome term Nipigon.[2] The same proposal was presented in a paper read before the Montreal Natural History Society, February 24, 1873. This was reported by "J.F.W." (presumably J. F. Whiteaves) in the Montreal Gazette, and this report was published afterwards in the Canadian Naturalist.[3]

The terms Animikie and Keweenaw were introduced by T. Sterry Hunt in 1873. Speaking before the American Institute of Mining Engineers on February 20, 1873, he says:

> "The silver deposits of Thunder Bay and its vicinity, including Silver Islet, are in veins traversing a series of dark-coloured argillites and sandstones, which are as yet known only in this region and are overlaid in slight discordance by red and white sandstones apparently the same as those of the Keweenaw district and the St. Maurice river. This older series of Thunder bay and its vicinity, which may be named the Animikie group, from the Indian name of the bay, is the lower division of the Upper-Copper-bearing series of Logan.
>
> The great Keweenaw group, with its cupriferous amygdaloids, is here absent, though met with a few miles to the eastward, and the almost horizontal dark-coloured sediments of the Animikie group rest directly upon the edges of the crystalline Huronian schists and are cut by great dykes of diorite.[4]"

This paper was also published in the Engineering and Mining Journal, vol. 15, No. 9, 4th series, March 4, 1873, pp. 129-32. It is not clear that

[1]Logan, W. E.: Geology of Canada, 1863.
[2]Geol. Surv., Canada, Rept. of Prog. 1872-73, p. 106.
[3]New series, vol. 7, pp. 49-51 (1875).
[4]Trans. Am. Inst. Min. Eng., vol. I, p. 339 (published in 1873 or 1874).

Hunt used the term Keweenaw group earlier than this, although it is not here spoken of as defined or proposed but is used apparently as if it were a well known term; and he later speaks of the overlying cupriferous conglomerates and trappean rocks "which we have named the Keweenian series."[1] After the publication of the term Nipigon by Bell, Hunt suggested that, as there was some question as to the age of the horizontal sandstones east of Thunder bay, lying between the Animikie and the Keweenaw, it might be used as a local name to designate these horizontal sandstones; but he distinctly states that in his opinion these sandstones are not to be confounded with those interstratified with the Keweenaw.[2]

Bell's suggesion that the term Nipigon might replace Upper-Copper-bearing series never seems to have been adopted. The terms suggested by Hunt, however, were employed by E. D. Ingall in his report on mines and mining on lake Superior.[3]

"As might be expected in so extensive a tract of country, the geological features represent a considerable diversity, although apart from the superficial deposits the rocks are all referable to the Palæozoic and Archæan. It may be said to consist of a large area of Laurentian, gneissic, and granitic rocks, etc., within which are found numerous and considerable areas of plutonic and volcanic rocks and of metamorphic slates, etc., which are considered to be of Huronian age; whilst overlying these, chiefly around Thunder bay and lake Neepigon, occur the sedimentary and volcanic rocks of the Animikie, Neepigon, and Keweenian groups, whose approximately horizontal position and low angles of dip contrast markedly with the steeply inclined or almost vertical older rocks."

Writing of the Animikie strata, Ingall[4] stated that...... "near Black bay and in Thunder Cape peninsula, they are covered up by the rocks of the Neepigon formation, and south of this, at the island in the mouth of Grand Portage bay, are seen to pass under the Keweenian series, which consists of interstratified beds of conglomerate, sandstone, and various trappean rocks." On the map accompanying Ingall's report is shown the position of the boundary between the Animikie and Neepigon rocks of Sibley peninsula, the boundary between the Neepigon and Keweenian is not shown.

Subsequently, in 1890, Dr. Robert Bell[5] used the term Nipigon as referring only to the upper group of the Upper Copper-bearing series of Logan and not, as originally proposed, to include both upper and lower groups, nor with the restricted meaning given to it by Hunt, and as used by Ingall. About this time and subsequently it became common to use the terms Keweenawan and Nipigon as synonyms which could be applied interchangeably to the composite group formed of the Nipigon and Keweenawan of Hunt.

In 1895, U.S. Grant[6] of Minneapolis, reviewed the history of the nomenclature of the copper-bearing rocks of lake Superior and after noting Bell's use of the term Nipigon in 1890 he says:

"It thus appears that the term Nipigon, especially as compared with Keweenawan (or some form of this name), has little claim as a general age designation for the

[1]Second Geological Survey of Pennsylvania, E. Azoic Rocks, pt. 1, p. 240 (1878).
[2]Trans. Am. Inst. Min. Eng., vol. I, p. 342.
[3]Geol. and Nat. Hist. Surv. of Canada, Ann. Rept., pt. H, p. 8 (1887).
[4]Op. cit., p. 23.
[5]Report of the Royal Commission on the Mineral Resources of Ontario, Toronto, 1890, pp. 2, 36-39.
[6]Am. Geol., vol. XV, pp. 192-94 (1895).

copper-bearing rocks of lake Superior. Moreover, it seems eminently fitting that a name derived from Keweenaw point, where the copper-bearing rocks occur in typical development and where they have been most carefully studied, should be perpetuated in the designation of this series of strata. But as to whether we call them Keweenian, Kewenian, Keweenawian or Keweenawan is not very important. However, the last form (Keweenawan) has been more generally used than any other, and is one adopted in the reports of the Wisconsin and United States Geological Surveys and is used by Prof. C. R. Van Hise in his correlation paper on the Archæan and Algonkian (U.S.G.S. Bull. No. 86, 1892). It thus, on the whole, seems the most appropriate and its use will engender less confusion than that of any other."

Since 1876, when T. B. Brooks[1] introduced the term Keweenawian, it has apparently been the intention of the majority of geologists employing this, or some name resembling it, that it should designate some major group of rocks and presumably a major division of geological time and not be used in the restricted sense as first applied by Hunt in 1873 to one of three divisions of the Upper Copper-bearing series. Brooks says:

"We are justified, I think, in regarding the copper-bearing rocks of lake Superior as a distinct and independent series, marking a definite geological period which separates the Silurian from the Huronian ages. Should future observations confirm this view it would be advisable to have some more convenient and geologically acceptable name for the series than is now in use. Since Keweenaw peninsula forms one of the most striking geographical features in lake Superior and is the locality where the Copper series are best exposed and were first studied, I suggest the name Keeweenawian for this period."

In 1904, in the report of an International Committee[2] the following succession and nomenclature was "recognized and adopted":

Keweenawan (Nipigon)
Unconformity
Huronian, Upper (Animikie)

Maps of an area along the north shore of Thunder bay were prepared by W. N. Smith in 1905,[3] and L. P. Silver in 1906.[4] On these, the recommendation of the International Committee was applied.

The general geological map of Lake Superior region compiled by Van Hise and Leith[5] divides the rocks that had been embraced in Logan's Upper Copper-bearing series as follows: Upper Huronian (Animikie group), Lower Keweenawan,[6] and Middle Keweenawan.

A criticism of certain features of the classification employed by Van Hise and Leith was presented by several geologists in articles or discussion at the twelfth session of the International Geological Congress. The remarks by A. C. Lawson regarding the Upper Huronian are of particular interest in connexion with certain matters discussed in this report and are here quoted in part:[7]

"There are two unfortunate circumstances which tend to obscure the discussion of the systematic place of the Huronian rocks. One is that both of the major

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[1]Am. Jour. Sci., 3rd ser., vol. II, p. 210 (March, 1876).
[2]Jour. Geol., vol. 13, pp. 89-104 (1905).
[3]Min. World, vol. 22, pp. 20-208 (1905).
[4]Rept. Ont. Bureau of Mines, vol. XV, pt. 1, pp. 156-172 (1906).
[5]U.S. Geol. Surv., Mon., vol. 52, Pl. 1 (1911).
[6]On the map the Lower Keweenawan is shown as Upper Keweenawan, but this is due to a slip in proofreading as is apparent from the general geological structure and as is clearly indicated by the text of the accompanying monograph (page 367).
[7]Lawson, A. C.: "A Standard Scale for the Pre-Cambrian Rocks of North America"; Inter. Geol. Cong., XII Session, pp. 356-357 (1913).

divisions of the Huronian should have the same name, distinguished only by the words, upper and lower. This infelicity is, at present, difficult to avoid, since both divisions were included in the original definition of the term Huronian, and geologists are loath to restrict the term to one or the other of the two modern divisions. It would, however, be a distinct simplification of our nomenclature and a great gain in the direction of clearness of ideas with regard to these ancient rocks if this restriction could be made.

The second circumstance referred to is the persistent effort which certain geologists of the U.S. Geological Survey make to include the Animikie in the Huronian under the designation Upper Huronian, although there is nothing in the original definition of the Huronian or in the type section of the Huronian, even in the comprehensive usage of the author of that term, with which it can possibly be correlated.

The history of the distension of the Huronian is interesting and illuminates the growth of our nomenclature. Prior to 1904, the geologists of the U.S. Geological Survey recognized in the Marquette region but two divisions of the Huronian, and these were known as the Upper and Lower Marquette. The Upper Marquette was correlated with the Animikie properly, and with the Upper Huronian erroneously. But an unconformity was discovered by Seaman in 1902 in the Lower Marquette, which led to the subdivision of the Marquette into the Upper, Middle, and Lower Marquette and the correlation of the two lower divisions with the Upper and Lower Huronian of lake Huron. This, of course, confirmed the objections that had been made by Willmott[1] and myself[2] to the correlation of the Upper Marquette with the Upper Huronian of lake Huron, and had the immediate effect of removing the Animikie (Upper Marquette) from the Huronian as the latter term had been understood by all geologists up to the year 1904.

But the Animikie and its equivalents on the south side of lake Superior had been so long and so positively asserted to be Upper Huronian, that the geologists responsible for the error proceeded to distend the meaning of the term Huronian for the express purpose of including the Animikie and preserving the phraseology of their old and erroneous correlation, although the latter was definitely abandoned. There are only two divisions of the Huronian in the type section, but a third was created and the Huronian was divided into Upper, Middle, and Lower Huronian. The Animikie and its equivalents, which, previous to 1904, had been correlated with what is, in this scheme, Middle Huronian, thus retained the designation of Upper Huronian, although the meaning of the term was totally changed. This curious and pathetic jugglery has been the main stumbling block to the proper understanding of the Lake Superior geology for the past nine years. That the International Committee in 1904 should have acquiesced in this remarkable procedure was a triumph of diplomacy for the geologists who proposed it; but advances in science are made along different lines. This distension of the Huronian so as to include the Animikie, and the subdivision of the term into Lower, Middle, and Upper Huronian is a most embarrassing and confusing practice, regarded merely from the point of view of necessary discussion."

In 1915 Allen and Barrett reported the discovery in Michigan that "the formations heretofore included in the Upper Huronian (Animikie) group are divisible into two groups. . . . . For the superior group we propose the name Copps" . . . . . These authors state that between the Copps and the lower of the two groups into which they divide what had been called Upper Huronian (Animikie) there is "a great structural discordance", that a granite intrudes the lower but not the upper (Copps) group. The same authors also state that "the Keweenawan is unquestionably unconformably superimposed on the Copps".

In a discussion of correlation written by Leith and Allen and appended to the article by Allen and Barrett it is stated that so far as regards the

[1] Jour. Geol., vol. X, No. 1.

[2] "The Eparchaean Interval"; Bull. Dept. Geol., Univ. Calif., vol. III, No. 3 (1892).

formations of various districts south and west of lake Superior. . . "two main possibilities present themselves: (1) that the Copps represents a fourth Huronian series between the Animikie and Keweenawan; (2) that there are three Huronian series, and that the Copps may be equivalent to certain series elsewhere in Michigan now otherwise correlated." In either case the so-called Huronian strata of Marquette district, the most easterly district and the one closest to the original Huronian area of the north shore of lake Huron, are considered to compose three groups. Under the first possibility, the uppermost group is considered to be Animikie, and the correlative of the Animikie of the Fort William-Port Arthur area; under the second possibility the uppermost group is considered to be a correlative of the Copps and both are classed as Upper Huronian, whereas the middle group is classed as Middle Huronian and is correlated with the Animikie of the Fort William-Port Arthur area. The lowermost of the three groups present in Marquette district is generally accepted as the equivalent of the Bruce series, the lower of the two groups comprising the original Huronion of the north shore of lake Huron, but the upper group of the original Huronian area, the Cobalt series, bears no close resemblance to either what has been called Middle or Upper Huronian in Marquette district.[1]

It is apparent that to many the term Huronian designates all pre-Keweenawan strata of the age of the Bruce series and younger. But some geologists would include the Keweenawan in the Huronian and others would be inclined to restrict the term to include no more than the strata of the age of the Bruce series and of succeeding series older than such a pronounced break as separates the Copps from older strata in Gogebic district.

Considering that the proper meaning to be given the term Huronian is still open to question, that the correlation of the Animikie of Fort William-Port Arthur area with formations to the south of lake Superior is still a matter of discussion, and that in Fort William-Port Arthur area the Animikie and succeeding strata form a closely related assemblage, the term Kaministikwan will be employed to designate the Animikie and younger strata of the area in Canada bordering the northwest shore of lake Superior. The name Kaministikwan, thus, designates the rocks that were formerly embraced in Logan's term Upper Copper-bearing series, for which Bell subsequently proposed the name Nipigon, and which later still came to be divided into Animikie and Keweenawan.

[1]Collins, W. H.: "North Shore of Lake Huron"; Geol. Surv., Canada, Mem. 143, p. 114.

Table of Formations

Pleistocene and Recent	Till, gravel, sand, and clay.
(Unconformity)	
Late Precambrian	
Kaministikwan	
Intrusives	Diabase and related rocks.
Osler series	Conglomerate, sandstone, mudstone, and lavas.
(Disconformity)	
Sibley series	(Sediments). F member. E member. D member. C member. B member. A member.
(Disconformity)	
Animikie series	(Sediments and lavas). Rove formation. Gunflint formation. Kakabeka formation.
(Unconformity)	
Early Precambrian.	
Batholithic Intrusives	Granite, granite-gneiss, and related rocks.
Schist Complex	Altered volcanic rocks, chlorite, hornblende, biotite and sericite schists.

EARLY PRECAMBRIAN

Schist Complex

The rocks of the Schist Complex underlie: an area of about 10 square miles in Oliver and McIntyre townships in the northwest part of Fort William and Port Arthur map-area; three areas, each less than 1 square mile, at the following localities—4 miles northwest of Jumbo Gardens, near the forks of Current river, and north of Navilus; and three, small, tongue-like areas, which project east from beneath the Animikie between 1 and 2 miles west of Jumbo Gardens. Detached masses of the schists, too small to be represented on a map scale of 1 mile to 1 inch, are scattered through the batholithic intrusives.

The Schist Complex, as exposed in that part of the relatively large area in Oliver and McIntyre townships that lies more than a mile distant from the batholithic intrusives, consists of andesitic lava, fine-grained, stratified, fragmental greenstone regarded as a pyroclastic, and a variety of schistose rocks that may be derivatives of lavas and pyroclastics. Chlorite schists predominate, and hornblende, biotite, and sericite schists occur locally. This assemblage lies close to and, so far as one can tell from a study of discontinuous outcrops, changes gradationally into another that lies adjacent to the batholithic intrusives and is characterized by the presence of glistening, black, hornblende schist and amphibolite, and minor amounts of biotite and sericite schists. These rocks occur in all of the several areas underlain by the Schist Complex in Fort William and Port Arthur map-area.

At some localities the above-mentioned rocks are in contact with the intrusive granites; at other localities the characteristic border-zone rocks of the Schist Complex and the granite and gneiss of the batholithic intrusives are separated by an assemblage merging on the one side into the schists and on the other into the intrusives. Such a series is exposed between 1 and 2 miles southwest of Intola and consists of the following types: amphibolite, porphyrite, diorite, hornblende syenite, and hornblende granite, with no sharply definable contact between any two of them. Rocks such as the foregoing, are regarded as altered equivalents of schists that have absorbed certain materials from the batholithic rocks during the time of intrusion, and as assimilation products.

The members of the Schist Complex have not been differentiated and the structure of the group, in its broader aspects, is not known. The stratified members, wherever observed, are vertical. The cleavage planes strike in different directions at different localities with a tendency toward parallelism with the trend of the contact with the batholithic intrusives.

In Fort William and Port Arthur map-area, the only members of the Schist Complex whose origin has been ascertained are of volcanic origin; probably the greater part of the complex consists of altered lavas and pyroclastics.

The rock assemblage in the northwestern part of Fort William and Port Arthur map-area is lithologically similar to the assemblage that lies adjacent and that has been mapped and described in the eastern part of the Matawin Iron range as Keewatin.[1]

The small areas north of Port Arthur are parts of areas represented as Lower Huronian on a geological map prepared by L. P. Silver and issued by the Ontario Bureau of Mines in 1906. According to Silver, the Lower Huronian rocks near Thunder bay are altered sediments and the oldest member is a schistose conglomerate which contains granite pebbles; the Keewatin rocks are older than this conglomerate. The batholithic intrusives near Thunder bay are younger than both of these groups. The present writer observed no altered sedimentary rocks in the Schist Complex areas within the map-area, and did not determine the stratigraphic relations of the rocks with reference to the schistose conglomerate that was seen beyond Fort William and Port Arthur map-area, north of Thunder bay.

Batholithic Intrusives

The Batholithic Intrusives underlie an area of several square miles in Oliver and McIntyre townships in the northern part of Fort William and Port Arthur map-area, and also a small area in the immediate vicinity of Wild Goose point. The rocks of this division consist of a number of types that cannot be separately mapped, because they either merge into

[1]Tanton, T. L.: Geol. Surv., Canada, Sum. Rept. 1924, pt. C, pp. 4-6.

one another or are intimately intermingled. All may be referred to in general as granite or granite-gneiss. A characteristic phase of the granite consists of quartz and pink feldspar, with small amounts of hornblende and chlorite. Pink and grey biotite granite occurs in small amount. The granite in the vicinity of Wild Goose point is porphyritic, with phenocrysts of pink feldspar ranging up to an inch in diameter. Granite-gneisses occur in small amounts immediately adjacent to the Schist Complex. There are also rocks similar in composition to the gneisses but which do not show the foliation characteristic of gneissic rocks and hold ghost-like, irregular-shaped inclusions, or thoroughly recrystallized xenoliths, derived from the Schist Complex. Rocks of this character have recently come to be known by Sederholm's term migmatites. In the vicinity of Intola the hornblende granite passes gradationally into a diorite which in turn appears to grade into an amphibolite. The mapping of a contact in this locality is a matter of great difficulty. In the field the writer was of the opinion that the diorite was derived essentially from the same materials as the closely associated amphibolite and it was, therefore, included with the Schist Complex but, possibly, this highly recrystallized and partly replaced phase of the Schist Complex should be classed with the Batholithic Intrusives. Deep workings at Shuniah mine encountered a complex of rocks that ranged from hornblende-chlorite schist through intermediate phases, which have been described as diorite, to hornblende syenite.

The Batholithic Intrusives are massive. They contain fragments of schistose rocks which do not appear to have been regionally sheared since the consolidation of the granitic material. Banded granite-gneisses occur locally, and the bands trend parallel to the foliation of the schist in the neighbouring Schist Complex.

The Batholithic Intrusives, as their name implies, are igneous rocks believed to have been formed at great depth, and to have intruded the covering rocks after they had been highly folded. The deeply infolded remnants of the covering rocks are the Schist Complex of this region. The manner in which the granitic rocks intruded is indicated by a study of the contacts. There are dykes extending out beyond the main mass, indicating that it advanced along fissures. There are cases where the contact shows numerous block-like inclusions of the Schist Complex within the granite, suggesting an advance by overhead stoping, and there are other localities where quartz and feldspar-bearing solutions appear to have permeated in a devious manner through either certain zones or the general mass of the older schist and to have partly replaced them. At such localities a considerable variety of rock types are present; some of these are porphyritic.

There is presumptive evidence in Matawin River and Loon districts, which lie respectively a few miles west and northeast of Fort William and Port Arthur map-area, that there are or were, in both districts, batholithic granitic intrusions of at least two different ages. For in both districts are conglomerates containing granite pebbles that must have been derived from a granite intrusive of pre-conglomerate age. The batholithic bodies in these districts have not been observed in contact with the conglomerates, but they do intrude all members of the Schist Complex with which they came in contact, and since the schistosity in the latter rocks appears to have been induced before they were intruded by the granitic rocks and since the conglomerates are schistose and steeply inclined as if they had been metamorphosed and folded along with the schists, it seems probable that the batholithic intrusives are of post-conglomerate age. They, undoubtedly, are pre-Animikie. The conglomerate and associated greywacke in Loon district were correlated by W. N. Smith with strata in Minnesota that had been designated Lower Huronian and, later on, Lower or Middle Huronian. The granitic rocks were, therefore, considered by Smith to be of Huronian age since they were younger than Lower or Middle Huronian strata and older than the Animikie which was accepted as being of Upper Huronian age.

In the report of the Special Committee for the Lake Superior region, published 1905, it was recognized that there is evidence of the existence of granites of two ages in this region and it was proposed that the term Laurentian should be applied to granites of post-Keewatin and pre-Huronian age.

In 1913, A. C. Lawson[1], after restudying Rainy Lake region, reported that there the greater part of the batholithic intrusives were younger than certain sedimentary series that he correlated with, respectively, the Lower and the Middle Huronian. Since, as redefined, the term Laurentian was to be applied to post-Keewatin but pre-Huronian granitic intrusives, Lawson proposed the name Algoman for the widespread granites of pre-Animikie but post-Middle Huronian age.[2]

Whether the granite batholiths of Fort William and Port Arthur area are to be called Laurentian or Algoman, that is whether they are considered to be post-Keewatin but pre-Huronian or post- (Lower or Middle Huronian) but pre-Animikie, depends upon the age assigned to the conglomerates and other sediments believed to be older than the granitic bodies. As already stated, Smith and Lawson considered these sediments to be of Huronian age. The special committee for the Lake Superior region also adopted this view. The schistose conglomerate and associated rocks of pre-Animikie and, presumably, post-batholithic age which have been differentiated from the Schist Complex in Matawin River and Loon districts have been classified, in recent years, under the name Windigokan. The Windigokan is regarded as being pre-Huronian because the assemblage antedates the most striking erosional unconformity in the Precambrian of this region and because the formations that antedate a similar unconformity in the Precambrian succession north of lake Huron, and in the Timiskaming subprovince generally, are now interpreted as pre-Huronian. In this report no specific time term is given to the batholithic intrusives. In Fort William and Port Arthur map-area, where Windigokan rocks are not represented, the Batholithic Intrusives are post-Schist Complex and pre-Animikie, they are probably post-Windigokan and pre-Animikie. According to the writer's interpretation, the Batholithic Intrusives are Early Precambrian, i.e., pre-Huronian.

[1]Geol. Surv., Canada, Mem. 40, pp. 103-109.

[2]It should be added that Lawson held that the Animikie was post-Huronian, and that the Huronian consisted of two divisions, a Lower and an Upper, the latter of which had been erroneously called Middle Huronian.

PRE-ANIMIKIE EROSION INTERVAL

Animikie strata, the oldest of the Late Precambrian rocks known in Thunder Bay district, lie in nearly horizontal attitude on a smooth, gently undulating erosion surface of low relief. This surface truncates the highly folded strata of the Schist Complex and the Windigokan series and has been worn down into the Batholithic Intrusives which, presumably, at one time lay under a cover of the above-mentioned strata.

The low relief of the floor of Early Precambrian rocks is indicated by the conditions existing along the northern border of the Animikie. There hummocks on the floor must be very low, for they project through the Animikie only where the preserved Animikie strata are very thin, a few inches or a very few feet in thickness. And northerly beyond the main Animikie area numerous, small patches up to a few inches thick of Animikie conglomerate are distributed over areas varying from a few hundred yards up to several acres, thus revealing the remarkable smoothness of the pre-Animikie floor.

Localities where the pre-Animikie erosion surface has been observed under Animikie conglomerate in Fort William and Port Arthur map-area, are those where "conglomerate" is indicated on Map 198A[1], the most extensive outcrops being in the vicinity of Wild Goose point. Other excellent exposures have been observed west of Fort William and Port Arthur map-area, near Kakabeka falls, in the central part of Strange township, near Little Gull lake, and near the north shore of North lake; and east of the map-area, in the vicinity of Loon lake and along the shore of lake Superior a few miles west of Schreiber. At all these localities there appears to be a lack of residual weathering products on the pre-Animikie surface. The rocks, when bared by chipping off the Animikie conglomerate, have the same general appearance as where exposed on glaciated surfaces; granite and other crystalline rocks show brilliantly reflecting feldspars.

The smoothness of the pre-Animikie erosion surface across hard granitic rocks and soft schists and the general lack of residual weathering products on it have been interpreted[2] as evidence of glacial scouring during the final epoch of the long erosion interval.

The time required for the planing down of the mountain structures, whose former existence is implied by the folded strata, and the unroofing of batholiths, must have been very long. This erosion interval is one of the most notable features in the geology of this district. It has been named by Lawson[3] the Eparchæan interval and he regarded it as the middle of three major divisions of Precambrian time.

The present writer considers that the end of Early Precambrian time occurred within the Eparchæan interval. The peneplanation of the surface on which the Animikie rests is assumed to have taken place in Early Precambrian time and the supposed glaciation of this peneplaned surface is assumed to have occurred during Late Precambrian time. These assumptions are made in accordance with a suggested correlation[4] of these events with the peneplanation and glaciation that took place in the Timiskaming subprovince which lies to the east.

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[1] Geol. Surv., Canada, Map 198A. Fort William and Port Arthur sheet, Thunder Bay district, Ont.
[2] Tanton, T. L.: Bull. Geol. Soc. Am., vol. 38, p. 738 (1927).
[3] Lawson, A. C.: Bull. Dept. of Geol. Univ. of Cal., vol. 3, No. 3, pp. 51-62 (1902).
[4] Tanton, T. L.: Bull. Geol. Soc. Am., vol. 38, p. 746 (1927).

LATE PRECAMBRIAN

The Late Precambrian rocks recognized in Fort William and Port Arthur and Thunder Cape map-areas are those of the Kaministikwan group. It is assumed that Late Precambrian time embraces a part of the pre-Animikie erosion interval, Kaministikwan time, and any time interval that may be between this and the commencement of Palæozoic time.

Kaministikwan Group

The Kaministikwan group, the Upper Copper-bearing series of Logan, is typically developed in Thunder Bay district. It unconformably overlies Early Precambrian rocks and consists of the Animikie and the succeeding strata generally known as Keweenawan. The dykes and sills that intrude Kaministikwan strata in Thunder Bay district are similar in composition to the Kaministikwan lavas, and, therefore, are regarded as forming part of the Kaministikwan group.

The Kaministikwan strata occupy a zone about 25 miles wide along the north shore of lake Superior for 180 miles from Gunflint lake to the vicinity of Schreiber, and extend north over a large area including lake Nipigon. They underlie all the land area of Thunder Cape map-area and all but a small northern part of Fort William and Port Arthur map-area. The lower part of the succession is chiefly of a great variety of sediments with an estimated thickness of between 2,500 and 3,000 feet; and the upper part is chiefly of lava flows with an estimated thickness of over 6,000 feet. Lava has been found intercalated with sediments in the lower part of the succession and stratified fragmental rocks occur between lava flows at several places in the upper part. All these rocks, broadly speaking, are only slightly metamorphosed. Locally, in the vicinity of great diabase intrusions, intensive contact metamorphism has taken place. Structurally the Kaministikwan rocks are a unit. Generally speaking, they are flat-lying or dip gently lakeward. The entire district, however, is traversed by an intersecting system of faults that have caused irregular-shaped blocks of various dimensions to move relatively to one another. Within adjacent blocks the general dip of the sediments is at different angles and locally in different directions. In the immediate vicinity of faults the strata have been in some cases slightly and other cases considerably deformed. The rocks of different degrees of competence have been differently affected, in some cases adjacent to the same fault.

The Kaministikwan are the youngest consolidated rocks in Thunder Bay district. Strata on the south shore of lake Superior that have been correlated with the younger Kaministikwan of Thunder Bay district are known to be older than fossiliferous Upper Cambrian beds, and it is common practice to classify them as Precambrian although there is a possibility that they are of early Cambrian age. In accordance with general opinion, the group is here classed as Late Precambrian.

The Kaministikwan group is divided into three series, in each of which the predominant rocks are lithologically different from those in the other two series. The successive series are separated by disconformities, indicated by basal conglomerate containing pebbles derived from several, different, older formations. The three series from the bottom upward are the Animikie, Sibley, and Osler.

This threefold subdivision, so far as one can now tell, corresponds with the subdivision of the Upper Copper-bearing series as proposed by Hunt in 1873, namely, Animikie, Nipigon, and Keweenaw, but it is now impracticable to apply the terms Nipigon and Keweenaw with the sense given them by Hunt. The Sibley and Osler series approximately correspond with, respectively, Lower and Middle Keweenawan as described in United States Geological Survey Monograph 52. The base of the Osler series is marked by a basal conglomerate which, however, lies scores of feet below the base of the Middle Keweenawan as defined in Monograph 52.

ANIMIKIE SERIES

Definition

The Animikie series embraces those rocks in the vicinity of Thunder bay that were described by W. E. Logan[1] as the lower group of the Upper Copper-bearing series. The name Animikie, the Indian word for *thunder*, was first applied by T. Sterry Hunt[2] in 1873. The Animikie was the oldest of three named subdivisions of the Upper Copper-bearing series and its upper limit was defined with reference to a white sandstone in the next overlying group of strata. In 1906, the upper limit of the Animikie was described by L. P. Silver[3] with reference to a conglomerate in the overlying series near Loon lake. Present information indicates that the sandstone referred to by Logan and the conglomerate referred to by Silver are phases of one member that is very extensive but which in the vicinity of Thunder cape is thin and, locally, for distances of hundreds of feet, is absent.

The Animikie series is as the lowest group of strata in the Kaministikwan group as developed in the vicinity of Thunder bay. Its upper limit is now redefined as being at the base of the first white quartz sandstone or conglomerate layer, whichever is the lower, occurring on Sibley peninsula above the Rove formation of the Animikie, or where this sandstone-conglomerate of the overlying Sibley is absent, is at where the thin, even lamination characteristic of upper Animikie sediments gives place to the thicker, less even layering characteristic of the overlying sediments. Plate III shows the nature of the contact between the Animikie and Sibley series where the conglomerate is absent; the rocks both above and below the contact are red and have the texture of shale; they are distinguishable only by the character of their lamination.

Distribution

The Animikie rocks underlie the greater part of Fort William and Port Arthur map-area; they extend from near the north edge of the map-area, where they rest on Early Precambrian rocks, to near the south

[1] "Geology of Canada, 1863", pp. 67-70.
[2] Trans. Am. Inst. Min. Eng., vol. 1, p. 339.
[3] Ont. Bureau of Mines, vol. XV, pt. 1, p. 168.

edge of the map-area, where they pass beneath a diabase sill. In Thunder Cape map-area they occur along the west side of Sibley peninsula. Westerly beyond Fort William and Port Arthur map-area, the Animikie has been traced to Strange township[1] and beyond to the vicinity of Gunflint lake, a total distance of about 65 miles. Farther west the Animikie occurs on the Mesabi iron range, Minnesota.

The Animikie extends north beyond Thunder Cape map-area[2] on the east and north sides of Thunder bay, to the vicinity of Loon lake. The nearest exposures of Animikie rocks east of Loon lake are 55 miles distant, where they occur on the shore of lake Superior and on islands between Pays Plat and Schreiber.

Subdivisions

The Animikie series in the two map-areas consists, in ascending order, of the Kakabeka formation, up to 4 feet thick; the Gunflint formation more than 515 feet thick; and the Rove formation, more than 1,300 feet thick. The total thickness is approximately 2,000 feet.

The Animikie rocks of the two map-areas are lithologically similar to the Animikie rocks of Loon Lake district, of the area extending west to Gunflint lake, and of Mesabi district, Minnesota.

Kakabeka Formation

The Kakabeka formation has been observed at several widely separated localities in the narrow zone along the northern margin of the area of Animikie strata.[3] Between the observed outcrops of the Kakabeka, the contact between the Animikie and the underlying rocks is, so far as known, concealed by drift. The formation has been observed east of Loon lake on the north shore of lake Superior near Schreiber, north of Fort William and Port Arthur map-area in the valley of the north branch of Current river, and at several localities west of the area embraced by the Kakabeka sheet as far as Gunflint lake.

The observed thickness of the formation throughout the region ranges from 2 inches to 4 feet. It is apparently a thin but very extensive formation, corresponding to the Pokegama quartzite formation found at the base of the Animikie in Minnesota.

The formation, as typically developed $\frac{3}{4}$ mile northwest of Kakabeka Falls station, consists of 4 feet of interstratified sandstone and conglomerate. The lowest layer, conforming to irregularities in the floor, varies in thickness from an inch to a foot within distances of a few yards and has a flat upper surface. It consists of pebbles of granite, greenstone, and quartz up to 1 inch in diameter irregularly distributed through a matrix of sandstone, between the grains of which is an earthy green material that is rusty on weathered surfaces. Above the lowest layer is a 6-inch bed of conglomerate composed of closely packed, well-rounded pebbles, up to 2 inches in diameter, of vein quartz, red jasper resembling a phase of Keewatin iron formation such as occurs on the Matawin iron range nearby,

[1] Geol. Surv., Canada, Map 213A. Kakabeka sheet, Thunder Bay district, Ont.
[2] Geol. Surv., Canada, Map 214A. Loon sheet, Thunder Bay district, Ont.
[3] On Map 198A, the Kakabeka formation is designated as "conglomerate".

and various greenstones and granites. The next overlying bed, 2 feet thick, is a sandstone in which at some places are pebble-bearing lenses; irregular masses of the bed, making up considerably less than half its volume, have been cemented by quartz and thus altered to quartzite. Above, is a bed of conglomerate about $1\frac{1}{2}$ feet thick, consisting of well-rounded pebbles of rocks like those above mentioned and discoidal pebbles with maximum diameters up to 7 inches of hornblende schist in a matrix of sandstone.

The beds of conglomerate and sandstone are horizontal. They lie unconformably on a floor of granite and are overlain conformably by iron formation of the Gunflint formation.

Gunflint Formation

General Statement. Outcrops of the Gunflint formation occur in Fort William and Port Arthur map-area within the northern half of the area underlain by the Animikie; the formation presumably underlies the younger Animikie rocks elsewhere in the two map-areas. The Gunflint formation is very extensive. It occurs near Schreiber; in Loon Lake district; in a zone extending from Thunder bay to Gunflint lake; and the equivalent formation, Biwabik, occurs throughout the Mesabi Iron range in Minnesota.

The greater part of the Gunflint formation is made up of stratified, ferruginous chert rocks commonly known as iron formation. They consist essentially of grey and red, banded and oolitic chert, or some variety of fine-grained or amorphous silica, with which one or more of the following iron-bearing minerals is intimately associated: a mineral of the chlorite group containing ferrous silicate and called greenalite; siderite; ferruginous dolomite; magnetite; and hematite. The following relatively less characteristic or accessory minerals also occur in various proportions in certain beds or parts of beds: calcite; amphibolite; epidote, chlorite, pyrite; limonite; and anthraxolite.

Much of the iron formation is characterized by a distinct texture due to the arrangement of the essential iron-bearing minerals in spherical, ellipsoidal, or irregular-shaped particles averaging slightly less than 1 mm. in diameter and lying in a cherty matrix. There are many phases showing granule texture, and all of them are known by the name taconite. Microscopic examination of the granules shows that some are homogeneous, that some consist of microgranules of iron-bearing minerals in a cherty matrix, that some have a concentric structure with layers of chert alternating with layers of iron-bearing minerals and are oolites, and that some have an oolitic structure in their outer part enveloping one or more kernels with homogeneous or microgranule internal structures. For further information regarding internal structures the reader is referred to a recent publication by J. E. Gill[1].

Interbedded with the ferruginous cherts are fine-grained, thin-bedded rocks and also beds containing layers of angular and rounded fragments of lava and fine-grained material that is interpreted as altered lava. The

[1]Gill, J. E.: "Origin of the Gunflint Iron-bearing Formations"; Econ. Geol., vol. XXII, No. 7, pp. 687-728 (1927).

origin of these rocks is not known. If they are pyroclastic, they are water-assorted tuffs; if they are clastic, they are shales, greywackes, and conglomerates. It is possible that they are mixtures of clastic and pyroclastic materials. These rocks of doubtful origin occur interlayered and forming groups of beds which are black, or grey, or greenish grey. All are soft and in the fine-grained layers exhibit a cleavage parallel to the bedding. The distinctness of the contacts between layers, beds, and groups of beds is different at different horizons, and at some places the various units are to be seen only on close examination. Each bed in whole or in part has the macroscopic properties of shale and the groups of beds, on casual inspection, resemble shales, consequently these rocks are referred to as shales, when spoken of collectively.

At two horizons in the Gunflint formation shales predominate over ferruginous cherts and form thick groups of beds, thus making possible a fourfold division of the Gunflint formation into lower cherty, lower shaly, upper cherty, and upper shaly members. The basis of the division is only the relative proportions of the two distinctive materials and these are interlayered and, consequently, the boundaries between successive members have to be arbitrarily placed within groups of beds, commonly 20 or more feet thick, which present a transition.

In the vicinity of Gravel lake a basic lava forms part of the Gunflint formation. Other occurrences of lava, probably of Animikie age, are known in Ontario west of Fort William and Port Arthur map-area.

The iron content of individual thin beds in the Gunflint formation ranges between wide limits. The core from a diamond-drill hole sunk vertically and presumably nearly at right angles to the bedding in lot D, McIntyre township, as reported by Andrew Johnson of Duluth, had an average iron content over a length of 106 feet, of 28·9 per cent; and individual 5-foot lengths had iron contents ranging between 21 per cent and 37 per cent.

Five drill holes were sunk at intervals over a distance of 1,800 feet, north of the above-mentioned drill hole, and two were sunk south of it at distances of 200 feet and 1,200 feet, respectively. These drill holes range in depth from 55 feet to 160 feet and a total depth of 572 feet is represented in the eight holes. The richest 5-foot length of core contained 40 per cent iron, the leanest recorded contained about 5 per cent. About 510 feet of the drilling was through rock in which the iron content ranged between 20 and 35 per cent, and averaged about 25 per cent.

The rocks near the surface where drilling was done are believed to be in the upper cherty member, it is not known whether lower members of the Gunflint formation were encountered at depth or not.

The average iron content of the hard taconite in the Biwabik formation, in Mesabi district, as determined by Van Hise and Leith,[1] is 25·71 per cent. This material resembles the taconite exposed in the Gunflint formation in Thunder Bay district and it is probable that the taconite of the two formations contains, on an average, approximately the same amount of iron. A section of the lower 515 feet of the Gunflint formation

[1]Van Hise, C. R., and Leith, C. K.: U.S. Geol. Surv. Mon., vol. 52, p. 181.

as revealed in the Shuniah mine (formerly known as the Duncan mine) has been given by Courtis.[1] The strata were mainly presented in the form of a vertical section in the mine shaft which was sunk in a vein lying in a fault. From the information given by Courtis and the results of an examination, made by the present writer, of the rocks in the mine dump and of a series of drill core specimens, the following appears to be the succession:

	Feet
Upper shaly	48+
Upper cherty	347
Lower shaly	78
Lower cherty	42
	515+

Lower Cherty Member.[2] The lower cherty subdivision of the iron formation at Shuniah mine, as described by Courtis[3], is composed as follows, the strata being listed in descending order:

Green, calcareous, and containing much iron. Sp. gr. 2·765; insoluble, 43·4 per cent; silica, 34·7 per cent.
Green, arenaceous band in flinty black slate. Sp. gr. 2·488; insoluble, 78·8 per cent; silica, 53·6 per cent.
Jasperized slate. Sp. gr. 2·627; insoluble, 92·6 per cent; silica, 85·7 per cent. Thickness of three bands, 22 feet.
Mostly chert with some dolomite, thickness, 20 feet.

The rock outcrops described in the immediately following paragraphs, correspond to those of the Shuniah mine section and as they are known or inferred to be low down in the iron formation, they are regarded as belonging to the lower cherty subdivision.

On lot 7, concession IV, Oliver township, a cherty limestone[4] lies on the thin basal conglomerate of the Animikie. It has a thickness of 5 feet in a well. The rock consists of dense, massive, pale bluish grey limestone with pale grey chert layers up to half an inch thick, and rows of pale grey chert nodules up to half an inch in diameter, distributed through it at intervals ranging between 1 inch and 6 inches.

In Port Arthur between the corner of John and High streets and Waverley park there is a southeasterly-facing escarpment and along the top of it for a distance of 3,000 feet there are several outcrops of the lower cherty member. On John street, at the southwestern end of this series of outcrops, flat-lying, bluish grey limestone 8 feet thick is exposed in a cliff. An indistinct bedding is observable due to textural differences between different strata and one bed, 1 foot thick, consists of small angular and rounded fragments of finely crystalline limestone in a matrix of coarsely crystalline limestone. A few layers of grey chert, each with an average thickness of half an inch, traverse the limestone parallel to the bedding.

[1]Courtis, W. M.: Am. Inst. Min. Eng., Trans., vol. 15, pp. 671-677 (1887).
[2]On Maps Nos. 198A and 203A, the lower cherty member of the Gunflint formation is designated as "cherty limestone" and lower iron formation.
[3]Courtis, W. M.: Op. cit., pp. 674-5.
[4]Analyses of some specimens of carbonate-bearing rocks of the Animikie and Sibley series published by Thomas Macfarlane in Canadian Naturalist, 2nd series, vol. IV, pp. 37-40, show that all contain both magnesium and calcium carbonate. No analyses of magnesium-free carbonate rocks in the Animikie and Sibley series have been published. The rocks referred to as limestones in this report have been identified by tests with acid in the field; they may, and probably do, include magnesian or dolomitic limestones.

In the southeastern part of the cliff near High street the beds curve downward and where last seen the dip is 25 degrees southeast. Around the corner on High street the edges of the limestone beds appear horizontal. A few layers of finely banded light and dark grey chert traverse the limestone and for distances of several feet they are parallel to the bedding, but at two places chert layers curve and cross the bedding. Each chert layer consists in part and characteristically of alternating bands of light and dark grey chert of paper thinness, disposed evenly and regularly parallel to the top and bottom of the layer; where the layer is parallel to the bedding the banding is also parallel; where a layer turns and crosses the bedding the internal banding also turns and maintains its parallelism with the walls of the layer. There is a peculiar internal structure different from that just described, which is observable for distances of several feet in some layers. In one such layer where it is horizontal and one inch thick there are zones a small fraction of an inch wide along the top and bottom of the layer composed of almost microscopically thin bands of alternately light and dark grey chert parallel to the sides of the layer. On the inner side of each zone there is a band of pale grey chert, which markedly varies in thickness, though rarely exceeding one-tenth inch. On the inner side of the upper of these two bands there are little bulges and protuberances projecting downward, and on the inner side of the lower band there are bulges and protuberances projecting upward. Along the inner side of each of these bands there are groups of alternating light and dark grey bands of chert, each band is very thin and of uniform thickness; the bands are parallel to one another and to the bulges and irregularities on the previously mentioned chert bands, and the bulges and protuberances are markedly accentuated in the wavy banded groups. Commonly the downward pointing protuberances are longer than the upward pointing bulges, otherwise the structure is symmetrical. At irregular intervals along the layer the projecting parts of the two wavy banded groups meet, thus making nearly vertical partitions. Chert bands similar to those in the previously mentioned groups occur as a continuous lining around the walls of the partitioned spaces. The remaining central part of the partitioned spaces is filled with crystalline white quartz, with the long axes of the crystals regularly oriented at right angles to the walls. The quartz grains increase in size from the walls inwards and are arranged in zonal bands.

There is a striking resemblance between the internal structure of the layer and that commonly found in amygdules filled with banded agate and quartz.

Layers with the above described internal structure have been observed in different members of the Gunflint formation north of Thunder bay. The banded chert, jasper, or other variety of fine-grained silica in these layers is of the same or nearly the same colour as the rock adjacent to the layer. In the outcrop at the corner of John and High streets the banded chert is of various shades of grey and the adjacent limestone is grey; at Deception lake, near Loon, where layers with this internal structure are prominently exposed in the upper cherty member of the Gunflint formation, the wavy banded jasper is red and the rock adjacent to the layers (*See* Plate IV) consists chiefly of red hematite.

On Summit avenue, about 100 yards northeasterly from the corner of John and High streets, there is an outcrop of grey carbonate rock in which there are cherty concretionary structures about the size and shape of cabbages; also small showings of slate and greenalite taconite.

In Mariday park, about $\frac{1}{4}$ mile northeast of the corner of John and High streets, an exposure consists of ferruginous carbonate and grey chert in about equal amounts. The carbonate rock has a structure like a breccia; there are abundant angular and rounded fragments of all sizes up to 2 inches in diameter consisting of finely crystalline iron-bearing carbonate and a few fragments consisting of green material of earthy texture, probably greenalite, in a matrix of coarsely crystalline, iron-bearing carbonate. Several chert layers are to be seen in a vertical section 4 feet high running through the carbonate rock and for distances of several feet they have the appearance of beds striking north 30 degrees east and dipping between 10 and 20 degrees southeast; the extensions of these layers, however, when traced, have been found to join and separate in an irregular manner, though preserving their platy shape and general parallelism. At one place, a chert layer which internally showed a fine colour banding cuts across another chert layer.

Several small outcrops occur between this locality in Mariday park and Waverley park. In all of them there are varieties of iron formation similar to the rocks just described, and in addition there is a development of oolitic chert which becomes progressively more abundant and more prominently exposed in the successive outcrops met in proceeding northeasterly.

At the northeast end of Banning street, close to Waverley park, Port Arthur, there is a cliff 15 feet high. Beds in the upper part of the cliff dip 25 degrees southeast and in the lower part, 60 degrees southeast, and between there is a brecciated fault zone. The rocks consist of iron carbonate, oolitic grey and green chert, and greenalite intimately associated in proportions that differ in different beds. Many small veinlets of quartz occur in the brecciated zone and a small amount of anthraxolite was observed in one.

At irregular intervals along an east-facing slope that extends for 3,000 feet north of Waverley park there are low outcrops of highly siliceous iron formation consisting of oolitic grey chert and iron carbonate. Beds exposed near the corner of Van Norman and High streets dip 10 degrees toward the east, those that outcrop 1,000 feet distant, near the corner of Peter and Hebert streets, dip 22 degrees toward the southeast. In other outcrops in this general vicinity the structure is complicated by faulting and brecciation.

It is difficult to correlate individual beds in the different outcrops of iron formation in Port Arthur and the aggregate thickness of the strata represented in the several outcrops can only be roughly estimated; it is probably scores of feet.

At the bridge over the north branch of Current river, about 1 mile beyond the northern boundary of Fort William and Port Arthur map-area, a low rock cliff, within a few feet of an exposure of basal conglomerate and presumably immediately above it, displays the following upward succession: 6-inch bed of pale grey chert; 10-inch bed of green, cherty taconite; 1-foot bed of lustre-mottled magnetite, in which coarsely crystalline magnetite is disseminated through fine-grained material in which the only identifiable mineral is magnetite; 6-inch bed of grey chert containing a small amount of disseminated pyrite; and a 2-inch layer of yellow, porous limonite at the surface. The beds dip southeast at a low angle. This 1-foot bed of magnetite was the only highly ferruginous bed observed in the map-area in the lower cherty member of the Gunflint formation.

At the localities indicated by C on Map No. 198A, other than those described above, there are small outcrops of iron-bearing carbonate and oolitic chert. The weathered surfaces of the carbonate rock are coated with limonitic material.

Lower Shaly Member.[1] The lower shaly member of the Gunflint formation at Shuniah mine is 78 feet thick. A sample from it is described[2] as "...... a soft, carbonaceous black slate, with shining particles, and apparently obliterated fossil stems. Sp. gr. 2·531; insoluble, 83·9 per cent; silica, 54·2 per cent."

On the mining dump the rocks that accord most closely with this description occur in blocks consisting of thin beds of fine-grained, soft, black, carbonaceous material interstratified with beds a few inches thick of composite texture, a layer along one side of each bed being fragmental and of relatively coarse texture, a layer along the other side being dense and fine grained like shale, with a gradational change between. The fine-grained rock in the beds and layers within beds cleaves into thin plates parallel to the bedding and on the cleavage planes tiny scales of mica are visible. The beds of composite texture are soft, and black with combustible carbonaceous material, and locally calcite is identifiable in the form of a matrix around fragments. No mineral constituents other than calcite and mica can be resolved by the naked eye. The fragments in the fragmental layers are angular and rounded; in one layer their diameters were between $\frac{1}{4}$ and $\frac{1}{2}$ inch and no layer was observed with larger fragments.

Under the microscope, fragments of different composition can be observed showing a variety of internal structures. Some consist of cloudy cryptocrystalline material, probably altered volcanic glass, in which there is an amygdaloidal structure. Others consist of tiny laths of plagioclase irregularly oriented in a fine-grained groundmass; these fragments are probably basalt. The cryptocrystalline and fine-grained material in the fragments is clouded with black, opaque, carbonaceous material, irregularly distributed through different fragments in different ways; in some fragments it is abundant around the outer part and lacking in the central part; in some it forms a multitude of tiny cloudy clusters throughout the mass of the fragment; and in some it is distributed more uniformly. Nearly all the fragments contain some calcite in the form of tiny replacement bodies and some fragments consist chiefly of calcite; the trace of the outer boundaries of these fragments and internal structures like those in basalt and amygdaloidal lava, as described above, are discernible in them due to the arrangement of impurities in the calcite. The matrix around the fragments consists of calcite.

[1]On Maps 198A and 203A, the lower shaly member is designated "shale and water-assorted tuff".
[2]Courtis, W. M.: Am. Inst. Min. Eng., Trans., vol. 15, p. 674.

The rocks representative of the lower shaly member found on the dump of Shuniah mine are lithologically similar to rocks exposed at Kakabeka falls which have been described as shale and fragmental beds.[1] It is not known whether the latter are in the upper shaly member of the Gunflint formation or the lower shaly member. Beds of fragmental material, probably of pyroclastic origin, have been described in both members of the Gunflint formation[2] in an area between Silver mountain and North lake.

The thickest exposure of the lower shaly member in Fort William and Port Arthur map-area is on lot 6, concession III, Oliver township. Here the rock has been quarried for road metal, and in a pit a thickness of 15 feet is exposed consisting of black shale with a thin platy cleavage parallel to the bedding, and one bed of cherty iron carbonate, a few inches thick, lying about 2 feet below the top of the exposure. The beds strike south 60 degrees east and dip 5 degrees toward the southwest. At the contact between the shale and the Pleistocene drift, where freshly exposed on one side of the pit, the shale is crumpled to a depth of nearly one foot, presumably as a result of glaciation.

In Current River park, Port Arthur, an extensive outcrop of shale forms a thin layer over a diabase sill; the general dip of the beds is a few degrees toward the southeast, and gentle folds occur locally. In the bed of McVicar creek, Port Arthur, shale beds are exposed dipping 2 degrees northeast.

Upper Cherty Member.[3] The succession within the upper cherty member at Shuniah mine, as recorded by Courtis[4] and arranged in descending order is as follows, the thickness being deduced from the vertical section accompanying the paper by Courtis:

	Thickness Feet
Dolomite with chert	40
Dark green slate, with masses of chert, red above and grey at the base	307

On the mine dump there are blocks consisting of layers of greenalite taconite and dark green shale and in some of the blocks the greenalite taconite is interlayered with grey chert and red chert; slate has not been observed. It is supposed by the writer that the above-mentioned blocks are from the upper cherty member.

In Baird village there is a low outcrop a few hundred square feet in area in which an excavation for road metal has been made to a depth of 6 feet, exposing a group of flat-lying beds of greenalite taconite. The unweathered rock, in the lower part of the excavation, is green and consists of alternating beds a few inches thick of massive, distinctly granular and oolitic rock and rock that is finely granular and in part shaly. In parts of beds of both textures there are discontinuous cherty seams that thicken and thin when traced along the bedding and commonly have an

[1] Tanton, T. L.: Geol. Surv., Canada, Sum. Rept. 1924, pt. C, pp. 19-21.
[2] Gill, J. E.: Geol. Surv., Canada, Sum. Rept. 1924, pt. C, pp. 43-44.
[3] On Maps Nos. 198A and 203A, the upper cherty member of the Gunflint formation is designated as "upper iron formation".
[4] Courtis, W. M.: Am. Inst. Min. Eng., Trans., vol. 15, p. 674.

average thickness of 1 inch and lengths of several feet; the seams are separated from one another by distances, measured across the beds, ranging between a few inches and a foot.

Microscopically, the massive, granular, greenalite taconite appears to consist of a multitude of rounded granules ranging between 0·5 mm. and 3 mm. in diameter and oolites of similar dimensions, rather closely packed in a matrix. The granules consist of dark green, light green, and yellow amorphous material, greenalite, through which fine-grained magnetite is disseminated in an irregular manner; the oolites show concentrically arranged, alternating layers of chert and magnetite, forming a hull around granules; the matrix consists of a carbonate, probably iron-bearing carbonate and chert.

In the exposure at Baird, the weathered rock, in a zone, averaging 3 feet thick, adjacent to the rock surface, consists of alternating beds a few inches thick of rust-coloured shaly rock, and friable, dark green, granular rock with tiny seams of limonite through it; and in beds of both types there are hard seams of cherty taconite similar to those, above described, in the unweathered rock.

Other outcrops in the vicinity of Baird village consist of greenalite taconite.

Groups of beds in which iron-bearing carbonate predominates are exposed in several small outcrops through the central part of McIntyre township west of Port Arthur, and in relatively large outcrops along the valley of Current river between the forks and a point about 700 feet south of Lyon Boulevard bridge. This group consists of beds of mottled, pale grey and bluish grey, finely crystalline, iron-bearing carbonate, each a foot or more thick, with irregularly distributed discontinuous layers of chert, rarely more than an inch thick. Groups of thin layers of dark grey shale, greenalite taconite, and oolitic chert are locally interlayered with the carbonate beds and apparently make up only a small part of the total thickness. The weathered surface of the carbonate is coated with limonite usually less than an inch in thickness. In the valley of Current river near the forks, the limonite coating locally attains a thickness of approximately 6 inches.

A variety of internal structures occur in the cherty iron carbonate beds. The following were noted in the vicinity of Lyon Boulevard bridge: (*a*) Platy and irregularly shaped replacement bodies of chert with indefinite boundaries occur through the massive carbonate, locally this material has been fractured and the fractures cemented by carbonate; later fracturing and cementation have resulted in the development of veins of fine-grained silica and pyrite which traverse this assemblage. (*b*) Spherical concretions of oolitic chert occur in the carbonate; these range up to a foot in diameter and locally two or three touch or join and form a compound structure. A rhythmic colour-banding appears as concentric circles in sections of these individuals, the alternate thin layers containing different proportions of carbonate and chert. (*c*) The thin layers of chert which commonly lie parallel to the beds of massive limestone are finely banded and individually are not of uniform thickness. Where glaciation has scoured a bulging portion of a chert layer it appears, in plan, as a more or less circular, concentrically banded mass of chert. (*d*) In the carbonate rock there are columnar structures that resemble piles of inverted bowls. The columns, locally 3 inches across and between 4 and 6 inches long, are approximately at right angles to the bedding and consist of alternate thin bands of carbonate and bands of silicified carbonate or chert, shaped like hemispheres with the dome upward or parts of hemispheres. The banding is not uniformly and regularly developed in the columns and locally the upper part of the dome is absent in parts of columns, so that in these parts there appears to be a central core of structureless carbonate rock. These structures have been attributed to algal growths by some students, and they are commonly known by the name "algal" structures. (*e*) In beds of carbonate rock there are fissure fillings, which, as viewed on surfaces parallel to the bedding, have the shape of crescents. They attain widths of $\frac{1}{4}$ inch in their wider parts, and range in size from 3 inches to 1 foot between the tips. They occur individually and in groups, the crescents in groups are concentric and are separated from one another by widths of between a quarter of an inch and an inch. In some cases the whole crescentic form consists of finely banded chert, in others finely banded chert lines the walls and the interior is white quartz showing comb structure.

Stylolites occur on the side of a cliff 10 to 20 feet high on the east side of Current river, 350 to 450 feet south of Lyon Boulevard bridge. Jagged and saw-toothed lines follow along and across the bedding of the cherty iron carbonate. Where they cross a carbonaceous cherty phase of the carbonate rock the projections that give rise to the saw-toothed appearance are roughly conical in shape, stout or slender, with lengths up to an inch, coated on the outside with a film of grooved and brilliant slickensided carbonaceous material, the cap at the apex of each cone of dull earthy carbonaceous material, and the rest of the cone of the same character as the rock at the base of the cone.

Upper Shaly Member.[1] The upper shaly member of the Gunflint formation at Shuniah mine is 48 feet thick. It is exposed on the surface south of the fault zone on which the mine workings are located, and possibly the upper part of the member has been removed by erosion.

The member consists chiefly of black shale, which cleaves readily into thin plates parallel to the bedding. Interstratified with the black shale at various horizons are beds of grey shale, beds of cherty iron carbonate, and beds of grey chert. The beds of chert and cherty iron carbonate are commonly $\frac{1}{2}$ inch thick; they are grey and in some there are tiny, dark grey, discontinuous streaks or dashes regularly oriented parallel to the bedding.

In Fort William and Port Arthur, and Thunder Cape map-areas the contact between the Gunflint formation and the overlying Rove formation is not exposed, so far as known. In the area west of the map-areas the Rove formation overlies the Gunflint formation conformably.[2] Both formations, near their contact, consist chiefly of soft, black shales; in the Gunflint formation there are intercalated thin beds of ferruginous chert

[1]On Maps Nos. 198A and 203A, the upper shaly member is designated as "upper iron formation".
[2]*See* Gill, J. E.: Geol. Surv., Canada, Sum. Rept. 1924, pt. C, p. 39.

and cherty carbonate rock and in the overlying Rove formation there are intercalated thin beds of siliceous, ferruginous, and dolomitic shales. A contact can be arbitrarily defined within a few feet as occurring between these groups of beds of different character, but it cannot be defined with reference to any one bed.[1]

Amygdaloidal Lava. Lava flows have not been observed in the Animikie in Fort William and Port Arthur, and Thunder Cape map-areas, but have been observed outside these areas.

Between 2 and 3 miles northeasterly from Gravel Lake station on the Port Arthur, Duluth, and Western branch of the Canadian National railways about 50 miles west of Port Arthur, a bed of amygdaloidal basalt is exposed in several small outcrops in an area of about one square mile. Western and northern boundaries of the lava occur within this area; the eastern and southern boundaries have not been found.

In one exposure, the lava is 30 feet thick; it lies on greenalite taconite, and the contact dips at a low angle toward the east parallel to the bedding in the taconite. The lower 20 feet of the lava bed is massive, greenish grey basalt, the upper 10 feet is ellipsoidal basalt. In the lower part of the layer of ellipsoidal lava the ellipsoids are commonly several feet in diameter, the lava for an inch around their rims is of darker colour than the lava within, and between the ellipsoids there is grey chert in tiny seamlets. A middle zone within the layer of ellipsoidal lava consists of ellipsoids smaller than those below, ranging in diameter from 1 to 3 feet, with rims of amygdaloidal lava an inch or two in width darker in colour than the inner part; there are interellipsoidal spaces filled with green and grey chert wider and more continuous than in the zone below; within the ellipsoids there are tiny fissure fillings of grey chert. The upper zone of the ellipsoidal lava layer consists of ellipsoids commonly ranging between 1 foot and 6 inches in diameter, and the lava is also divided into polyhedral masses most of which have diameters between 6 inches and 1 inch, by a system of ramifying fissures that on a surface resemble mud-crack structure; both the interellipsoidal spaces and the network of fissures are filled with chert. At some places it is difficult to distinguish ellipsoids from polyhedral masses, there being gradations in shape between them; at other places, however, the colouring and internal structure of the chert in the interellipsoidal spaces are different from that of the chert in the fissure system. In such cases the chert of the fissure system is grey and apparently homogeneous, whereas the chert of the interellipsoidal fillings, more particularly where the chert attains a width of 1 foot, exhibits different structures in layers succeeding one another regularly from the lava walls inwards towards the middle of the chert filling. The successive layers as they follow one another inwardly are the following: green banded, ferruginous chert showing straight banding in the outer part and wavy banding and "algal" structure in the inner part; red banded ferruginous chert showing wavy banding and oolitic structure; and the middle of the chert filling consisting chiefly of grey oolitic chert. Specks of green mineral, resembling malachite, occur sparsely scattered along the margins of some of the interellipsoidal chert fillings.

[1]*See* Ingall, E. D.: Geol. and Nat. Hist. Surv. of Canada, pt. H, pp. 23-24.

The lava in the upper zone of the ellipsoidal layer varies in composition and internal structure. At one locality where the lava is divided into polyhedral blocks ranging between 1 and 6 inches in diameter, the hull of the blocks consists of dense, dull reddish brown material that yields a red streak and appears to be highly ferruginous. The kernel or inner part of some blocks is pale green and of other blocks is pale brown amygdaloidal lava; the amygdules are filled with greenalite and chert. It was observed locally that the lava adjacent to the interellipsoidal chert-fillings consists of highly vesicular, green, amygdaloidal lava, the amygdules filled with grey chert and the lava for a half inch adjacent to the chert-filling being highly siliceous.

Northeast of Gravel Lake station, in several outcrops separated by hundreds of feet from one another iron formation overlies amygdaloidal lava. The character of the contact is different in different outcrops. In one outcrop a chert layer, in places oolitic and in places showing wavy banding and "algal" structure, immediately overlies ellipsoidal lava in which the interellipsoidal spaces are filled with chert showing the same internal structures as the overlying layer. In another outcrop the rock consists of angular fragments of lava and of chert of all sizes up to 6 inches in diameter in a matrix of fine-grained green rock; the rocks immediately above and below this are not exposed, but lava occurs nearby at a lower altitude and greenalite taconite nearby at a higher altitude.

In the southern part of lot 12, concession III, Oliver township, there is an isolated outcrop about 70 feet in diameter and 4 feet high, of copper-bearing amygdaloidal basalt. An outcrop of flat-lying Animikie black shale occurs 100 yards southwest of the lava and at the same elevation. The lava is believed to be of Animikie age.[1]

Outcrops of copper-bearing amygdaloidal basalt occur in section 8, concession VI, Blake township, and also in section 4, concession II, Crooks township. The only other consolidated surficially-formed rocks reported in the vicinity of these occurrences are Animikie sediments. It has been inferred that the lavas are either Animikie or younger than Animikie.[2]

Rove Formation[3]

The Rove formation is very extensive; it occurs in a zone extending from Thunder bay to Gunflint lake, and the equivalent formation, Virginia slate, underlies a large area in Minnesota adjacent to the Mesabi iron range. Near Fort William the Rove formation rises in mount McKay to a height of 800 feet above lake Superior and at Squaw bay, about 3 miles southeast, a bore-hole was sunk 1,280 feet below lake-level in the Rove formation. The total thickness is presumably more than 1,280 feet and may be more than 2,000 feet, but as faults may occur in the area between mount McKay and Squaw bay, it is not certain that the strata represented in mount McKay are not duplicated in the bore-hole at Squaw bay. At Thunder cape the part of the formation exposed above lake-level

[1]Tanton, T. L.: Geol. Surv., Canada, Sum. Rept. 1924, pt. C, p. 21.

[2]Lawson, A. C.: Am. Geol., vol. V, pp. 174-178 (1890). Coleman, A.P.: Rept. Ont. Bureau of Mines, vol. IX, pp. 146-147 (1900).

[3]On Maps Nos. 198A and 203A the Rove formation is designated as "shale and greywacke, in part tuffaceous".

is approximately 800 feet thick. Northeastward of Thunder cape, along the eastern shore of Thunder bay, the base of the formation is not exposed until the head of the bay is reached. At Pass lake, some 21 miles northeast of Thunder cape, the Rove formation is 130 feet thick. Near Silver lake, 4 miles north of Pass lake, at the most northerly exposure of the formation in the cliffs extending northerly from the east side of Thunder bay, the formation is about 20 feet thick. The change of thickness between Pass lake and Silver lake appears on the whole to take place gradually, but apparently with, at certain places, sudden changes of many feet.

The Rove formation is a succession of sediments of questionable origin, but which for purposes of general description are called shales and greywackes. The shales and greywackes are interlayered and the shales make up somewhat more than half of the succession.

The shales are fine-grained sediments. The most abundantly developed variety is a soft, dark grey, bedded rock possessing a thin, platy cleavage parallel to the bedding. At various horizons there are black, brown, and green shales, and, near Thunder cape, red shale 20 feet thick occurs at the top of the formation. The mineralogical and chemical composition of the shales is not fully known, but, differing from the prevailing type, there are some layers and groups of layers that are cherty and others that contain notable amounts of calcium carbonate, and again others that contain ferruginous carbonate and pyrite. The carbonate minerals and the pyrite are commonly concentrated in concretions (subsequently described). In some of the grey and black shales, small amounts of mica occur as tiny flakes irregularly disseminated through the rock and most prominently visible on cleavage planes parallel to the bedding. The black shales contain carbonaceous material which is combustible.

The greywackes are not thin-bedded like the shales, they are commonly thick-bedded; they do not possess a platy cleavage parallel to the bedding, and the texture of each bed, either in whole or in part, is coarser than that of shale. There is one variety of fragmental rock in the group here referred to as greywackes that is much more prominently developed in Fort William and Port Arthur map-area than other varieties in the same group. It is a soft, grey rock with the texture of silt or a fine-grained sandstone made of grey rock fragments, whose mineral constituents cannot be identified with a hand lens, and sparsely scattered tiny flakes of biotite. Under the microscope the fragments can be seen to consist of tiny flakes of green mica and chlorite in a cloudy, finely crystalline mass, which is probably feldspathic material; the material resembles altered basic lava.

Other varieties of greywacke are black, brown, and green, and otherwise identical, so far as one can tell in the field, with the above-described grey rock. There are, also, beds and parts of beds that are hard and cherty and others that contain carbonate minerals and pyrite in concretions. Some beds contain clastic quartz grains, recognizable with a hand lens, distributed through a fragmental matrix made up chiefly of soft, grey, rock particles; this variety of greywacke was observed in Fort William and Port Arthur map-area in a few beds on mount McKay; farther south in the vicinity of Pigeon river this variety of greywacke was observed more frequently than elsewhere in the region.

Some beds of greywacke are homogeneous in texture; others show textural differences and most of these have the texture of fine-grained sandstone in their lower part and there is a textural gradation upward into that of a mudstone. One bed on mount McKay, in addition to showing the above-mentioned features, had at its base a conglomeratic layer with pebbles up to half an inch in diameter, of soft, grey, fine-grained rock in a matrix of almost identical appearance. This rock resembles fragmental rocks with textural gradations which occur in the Gunflint formation.

The greywackes are interlayered with the shales. The former occur in beds varying in thickness from a few inches up to 20 feet. There appears to be an intimate relationship between the various different kinds of shale and the various different greywackes. The grey, black, brown, and green greywackes are each, respectively, interlayered with shales of the same colour. The cherty and carbonate-bearing greywackes are interlayered with shales which are also, respectively, cherty and carbonate-bearing. The contacts between shales and greywackes are, at some places, distinct along well-defined bedding planes; at other places there are indistinct, merging contacts. At some places, blocks of shale are enclosed in greywacke.

Throughout the greater part of the Rove formation the differences between successive beds are so slight that specially favourable conditions of observation would be required in order to describe the succession of detail. Considerable parts of the best exposures, on high cliffs near Thunder bay, are not accessible for close examination; and in the case of mine workings and bore-hole records it has been customary to refer to all members of the Rove formation as shale, or argillite, or by some other single, all-embracing term.

The log of a bore-hole, drilled in 1923, on a drift-covered surface 10 feet above the level of lake Superior on the shore of Squaw bay,[1] based on records in the Borings Division, Geological Survey, is as follows:

	Depth in feet
Calcareous clay (Pleistocene)	0— 30
Dark grey shale	30— 110
Grey shale	110— 230
Slightly calcareous, grey shale	230— 240
Grey shale	240— 280
Slightly calcareous, grey shale	280— 290
Grey shale	290— 370
Slightly calcareous, grey shale	370— 390
Grey shale	390— 490
Slightly calcareous, grey shale	490— 500
Dark grey shale	500— 570
Slightly calcareous, black shale	570— 580
Dark grey shale	580— 640
Shale and quartz-calcite vein material	640— 650
Dark grey shale	650— 700
Quartz and shale	700— 710
Dark grey shale	710—1,040
Black shale	1,040—1,060
Diabase	1,060—1,080
Quartz and black shale	1,080—1,100
Greenish grey shale	1,100—1,110
Magnetite-bearing, black shale	1,110—1,160
Black shale	1,160—1,190
Slightly calcareous, black shale	1,190—1,200
Black shale	1,200—1,290

[1]The position in indicated by B. H. on Map 198A.

A salient feature of the sediments of the Rove formation is the evenness and regularity of the stratification. The exposures, including those on cliffs hundreds of feet high, when viewed from a distance, appear to be composed of thinly and evenly laminated sediments, interlayered with thick, massive beds that apparently maintain a constant thickness for distances of at least hundreds of yards, or as far as they have been traced.

The apparently thinly laminated sediments when closely inspected are found to consist in part of groups of thin beds that cleave readily along bedding planes and in part of sediments, which make up scores of feet in the succession, and are like those just mentioned except that no bedding can be seen, their thinly laminated appearance being due entirely to a fissile cleavage parallel to the general bedding. Wrinklings, similar to those that form on a surface of cooling scalded milk, occur on some of the thinly laminated sediments. The relatively thick, massive beds possess a variety of internal structures. Some are homogeneous; some faintly show groups of thin beds usually contorted and exhibiting the structure known as slip bedding; and some consist of blocks of contorted strata in a homogeneous paste of material similar to the substance of the folded strata. Flowage wrinkles occur on some massive layers. Excellent, well preserved, examples of this structure have been observed in place at the following localities: on the east side of mount McKay, at an elevation of 775 feet above sea-level, on the breast of the Sleeping Giant near Thunder cape, at an elevation of 1,350 feet above sea-level, and on a mesa, known as the Pie, on Pie island, a mile south of Fort William and Port Arthur map-area, at an elevation of 1,160 feet above sea-level. A cast of the flowage structure at the latter locality as it appears on the under surface of a detached, thin bed of shale is illustrated on Plate IV B. At the above-mentioned localities the form and disposition of the wrinkles indicate that flowage was in a northwesterly direction. Flow wrinkles have been frequently observed in the map-areas on blocks of sediments of the Rove formation in talus at the foot of cliffs.

Near Thunder cape, at a locality 2,000 feet south of Shale lake, a pond in a depression between Sawyer bay and Perry bay, at an elevation of 900 feet, and also at a place 600 feet north of the head of Perry bay, at an elevation of 640 feet, there is a layer of sediment about 10 feet thick which shows upon close inspection blocks, ranging in diameter from a few inches up to a yard, of thin-bedded grey sediments in a homogeneous paste of material similar to that in the blocks. Each block is like a segment of folded strata. At each locality the layer as a whole is of apparently uniform thickness for a length of scores of feet and as viewed from a distance of a few yards it appears to lie in nearly horizontal attitude, precisely parallel to the thinly bedded, shaly, grey sediments that occur above and below. At both localities it was observed that within the layer there are blocks in which the bedding and the general form of the block was shaped like the letter C. The concave side of these particular blocks faced northerly, the direction varying from northwest to northeast. At the locality near Perry bay one such C-shaped block is a yard long, a few inches thick, and it appears to be a fragment dislodged from the underlying beds of shale and curled up into the paler grey paste of the thick layer. The various internal structures in the 10-foot layer indicate that material in it acted as a viscous mass moving northerly. The evenly laminated, nearly horizontal attitude of the shales above and below the 10-foot layer indicate that there has been no disturbance since the rock consolidated such as to cause the fracturing of blocks and the folding of beds within the 10-foot layer.

In the shales at Alsip quarry, north of Sawyer bay, and elsewhere, sparsely and irregularly scattered depressions occur on the upper surfaces of exposed layers. At Alsip quarry a block of shale was detached from an outcrop, and split along a cleavage plane parallel to the bedding, thereby exposing circular and elliptical depressions on the lower layer with corresponding prominences on the upper layer. The pits range from $\frac{1}{4}$ to $\frac{3}{4}$ inch in diameter and are about $\frac{1}{16}$ inch deep. The rock in which the pits occur seems to be homogeneous shale and sections across the pits do not show any foreign matter. The origin of this internal structure is not fully understood; it was probably caused by some inorganic agency before the rock was consolidated.

Concretions occur in some beds of the Rove formation. They are exposed, in Fort William and Port Arthur map-area in Slate River gorge, in the valley of Kaministikwia river near the mouth of Slate river, and at Hewitson quarry, Port Arthur; specimens from the latter place are on exhibit at the Pagoda, Port Arthur. In Thunder Cape map-area, they occur along the east side of Thunder bay north of Sawyer bay. In Loon sheet map-area, concretions occur in a railway rock-cut near Pass lake, and on Keshkabuon island. Concretions have been observed in the Rove formation at numerous localities west of the above-mentioned map-areas. At every locality the concretions are within groups of beds 30 feet or less in thickness and no more than one such group of concretion-bearing beds has been observed in any one section of the Rove formation. At some localities the concretion-bearing beds are on the shore of lake Superior, at other localities they are hundreds of feet higher. East of Thunder bay, the concretion-bearing beds are much nearer the top of the Rove formation at Pass lake than those exposed farther south. The succession of beds that show the concretions is different at different localities. Presumably the concretion-bearing beds are in different stratigraphic horizons at different localities.

The concretions have the general shape of oblate spheroids, some are almost spherical, some are shaped like curling-stones, and some are like disks somewhat thicker in the middle than at the edges. They are usually bounded by evenly curved surfaces, but occasionally, as at Hewitson quarry, the surface has the appearance of two opened umbrellas with many ribs, joined along their rims with the convex sides outward. The concretions are commonly symmetrical with reference to a plane passing through their longer axes, but in some cases they are not; for instance, one side may be more convex than the other. The concretions that have been observed in any one outcrop, or within a restricted area, are very similar to one another in shape.

The concretions are irregularly disseminated through groups of beds. In some exposures they are separated from one another by several yards, in other cases they are closely crowded together; occasionally twins and composite forms occur where two or more concretions of the simple type have grown together. The concretions of the simple type range in maximum diameter from a few inches up to 8 feet. The largest observed is on the south shore of Keshkabuon island (Loon sheet map-area); the smallest observed are near the east shore of Thunder bay north of Sawyer bay (Thunder Cape map-area); the prevailing maximum diameters elsewhere are between 1 and 3 feet.

The concretions consist chiefly of the same material as the enclosing rock, commonly a grey or black mudstone with the addition of finely crystalline calcite which can be detected by chemical test and, in some cases, optically. Some concretions also contain pyrite either finely disseminated or in platy layers or as concretionary nodules up to 1 inch in diameter. The concretions are somewhat harder and more massive than the enclosing rock, and they have no internal cleavage.

The concretions from the east shore of Thunder bay, near Hoorigan bay, when broken open show a remarkably well-developed septaria structure, consisting of concentric fissure fillings intersected by irregularly radial fissure fillings of white, coarsely crystalline calcite, and in one occurrence also sphalerite. The largest of the concretions showing the septaria structure has a maximum diameter of 2 feet.

The maximum diameters of the individual concretions are parallel to the bedding of the enclosing rocks. Where thin-bedded shales lie adjacent, the bedding planes can be traced through the concretions; those passing through the middle follow an even course and those above and below are slightly bulged away from the middle. The strata a few inches above and below the concretions are distinctly bulged. There is commonly no indication of physical movement between the concretions and the surrounding rocks; at Hewitson quarry, however, surfaces at the sides of some of the large concretions are slickensided, the striations being disposed in the directions of lines of longitude.

Faulted concretions have been observed at Hewitson quarry and elsewhere west of Thunder bay. At these localities the dislocated parts of concretions occur in pairs that are obviously the complementary parts of the normal spheroidal type of concretions, and there is no indication that concretionary growth continued after the time of faulting. The fissures along the faults are cemented by veins of the silver-bearing type; those that occur within concretions can be traced beyond for several yards in the surrounding rock.

The continuity of stratification planes through the concretions indicates that the concretions originated through a local cementation of the enclosing rock. The curvature of the laminations around the concretions and the occurrence of slickensided surfaces suggest that the process of cementation was accompanied by or caused an increase of volume, or, more probably, the cementing materials may have become concentrated while the enclosing rocks were in the condition of loosely compacted mudstones under water, and during the process of consolidation the sediments around the concretions were compacted, each layer being reduced in volume relative to its original thickness and to the width as maintained in its locally cemented part within a concretion.

The cracks in the interior of septaria are commonly believed to be due to shrinkage accompanying the loss of water while the material within the concretion had the consistency of mud. Presumably septaria would not form until the sediments in which they occur had been elevated above the water body in which they were deposited.

Cone-in-cone structure is well developed in curved zones, with thickness varying up to a few inches, in the peripheral upper and lower parts of spheroidal calcareous concretions in shale, at Pass lake, on Welcome islands, and elsewhere. The apices of the conical structures point toward the centre of the concretion; so that the cones developed in the upper part of concretions point in the reverse direction to those in the opposite, lower part of concretions. High on the west side of the Triangle, Sleeping Giant, near Thunder cape, cone-in-cone structure was observed in a fragment of a bed $\frac{1}{2}$ inch thick of shaly limestone. The axes of the conical structures are at right angles to the bed, all the bases face to one side of the bed, and many of the conical structures extend completely through the bed. A unit of the cone-in-cone structure consists of a series of cupping cones, smaller ones within larger ones, and each composed mainly of calcite with thin layers of shaly material between them. The shaly material and the cones show a series of crinkles or tiny folds whose axes are parallel to the rims at the base of the cones; and the shaly material is slickensided, the striations running from the rim to the apex of the conical structure. Longitudinal sections through the cones near Thunder cape show the walls meeting at the apex at an angle of 30 degrees. Cone-in-cone structure is caused by inorganic agencies; in the opinion of some students, it is caused by locally developed pressure accompanying crystallization.

On the Head of the Sleeping Giant, Thunder cape, fluted and striated surfaces occur in little depressions visible on cleavage surfaces in some carbonaceous black shales and also in grey shales, at different stratigraphic horizons. The depressions are of irregular shape, in some cases roughly triangular; they have maximum dimensions of 1 inch or less and vary in depth up to $\frac{1}{16}$ inch. The floor of the pit appears to have been slickensided, there being numerous, parallel, delicate striations in one direction and crossing these striations at angles varying from 70 to 90 degrees are tiny ridges or flutings almost parallel to one another and occurring in groups spaced at intervals varying from $\frac{1}{20}$ inch to $\frac{1}{50}$ inch. The orientation of the striations in the depressions on each individual shale layer is in the same direction; the direction of striation is different at different stratigraphic horizons. The beds in the vicinity of the markings appear to be homogeneous shale; they are not calcareous. The origin of the structures is not known.

Metamorphism

The rocks of the Animikie series have not been greatly metamorphosed. The basal conglomerate has not been sufficiently indurated to fracture across its pebbles. The cherty and carbonate phases of the iron formation exhibit evidence of chemical replacement, but these changes do not appear to have obliterated either the original bedding or various small and even microscopic structures that are regarded as original. The internal structures of different layers as revealed by oolites and granules are continuous in layers as far as they can be traced. It is inferred that the chemical alterations within these rocks occurred almost contemporaneously with their deposition. In certain layers of the iron formation, fragments of laminated carbonate lie with various attitudes in a matrix of cherty iron carbonate, whereas adjacent beds are not disturbed; the fragmental layers are regarded as autoclastics that formed before the overlying beds were deposited. Only one small outcrop of coarsely crystalline limestone is known to occur in the map-area; it occurs in locally disturbed beds at the corner of John and High streets in Port Arthur; the crystalline limestone is a product of metamorphism perhaps resulting from high pressure applied locally. Slaty cleavage does not occur in any of the Animikie sediments.

The Animikie rocks at their contacts with dykes and sills of diabase commonly show a slight baking and increased induration of the sediments in a zone from 1 to 4 inches thick. At some places shaly layers abut against diabase with no distortion and no visible lithological change. At a few localities Animikie sediments have suffered extreme contact metamorphism. At such places the adjacent rock in the intrusive body is granophyre. The phenomena observed in the vicinity of granophyre occurrences are described in a subsequent section of this report.

Structure

The Animikie strata have a gentle regional dip toward the southeast. Dips in various directions of 5 degrees and less are to be observed by a general inspection of the huge exposures on cliffs in the vicinity of Thunder bay. Close examination reveals the presence of broad, gentle folds in certain parts of the succession and in some members of the iron formation there is a wavy layering with minor undulations within the major ones. Steeply inclined beds occur locally in the vicinity of certain faults. There is a well-developed system of joints in the sediments.

Faulting has occurred extensively and where the rocks are well exposed it has been noted that the known faults are either occupied by diabase dykes or cemented by vein material and that they occur commonly in linear topographic depressions. In some localities a study of intersecting dykes and veins indicates that faulting has occurred at different times.

Origin

The Kakabeka formation consists of normal clastic sediments. The pebbles of the conglomerate are of materials such as are known to occur in the area underlain by Early Precambrian rocks adjacent and north of the Animikie area, and the sandstone of the Kakabeka formation is presumably finer debris derived by erosion from the Early Precambrian rocks. The Kakabeka formation is thin and extensive, as is also its correlative the Pokegama quartzite of Mesabi district, Minnesota, and these characteristics of the formation have led to the inference that the rocks were laid down as a littoral marine deposit[1] in consequence of the advance of the Animikie sea over a gently sloping land surface.

[1]Van Hise, C. R., and Leith, C. K.: Mon. U.S. Geol. Surv., vol. 52, p. 613.

It is generally agreed that the ferruginous cherts of the Gunflint formation are chemical precipitates. The results of a study by Gill of the origin of these rocks, and references to previously published works by other students, are given in "Origin of the Gunflint Iron-bearing Formation."[1] Interlayered with the chemical precipitates are fragmental rocks and at one locality, Gravel lake, there is an extrusive igneous rock. The fragmental rocks are made up in part of lava fragments that appear to be of the same general nature as Kaministikwan basic volcanic rocks, and different from any rocks known in the Early Precambrian assemblage. In large part the fragmental rocks are made up of other material too fine grained to admit of identification. There are gradations within individual beds from rocks consisting of volcanic debris and rocks that have the texture of mudstone, and it is probable that the mudstone in such beds consists of finely divided volcanic debris. All the mudstone or shale-like rocks in the Gunflint formation resemble one another to such an extent that it is possible that they are all of the same origin.

The Rove formation consists chiefly of the same sort of fragmental rocks as occur in the Gunflint formation. Those groups of beds that are siliceous, ferruginous, and calcareous probably originated as mudstones and chemical precipitates deposited contemporaneously. The materials in these groups of beds are the same as, or correspond closely to, those in groups of beds in the Gunflint formation, but instead of being arranged in separate alternating layers as in the latter formation they are mingled.

The layers in the Rove formation that show mud flow structure occur commonly, between beds of evenly stratified sediments. The mud flows hence appear to have occurred on surfaces sloping at no greater angle than the depositional dip and probably nearly flat. There is no evidence of structural disturbances either of the nature of tilting or subsidence of floors that would cause mud flowage and, consequently, it is inferred that mud flowage was caused by excessive local accumulation of fragmental material. The direction of flowage as indicated by flow wrinkles shows that in the case of a layer on mount McKay, and in the case of layers near Thunder cape, the sites of accumulation were toward the southeast. The several local accumulations of fragmental material, which presumably took place during the time of Rove formation deposition, may have been caused by volcanic agencies.

The beds in the Rove and Gunflint formations that show gradations in the sizes of the composing grains, appear to have formed by the differential settling of mixtures of fine and coarse fragmental material simultaneously contributed to the water body in which they were deposited; and these materials were not subjected to the sorting action of currents. In the case of the Animikie graded sediments where volcanic fragments only have been identified, it seems probable that the fragmental material was contributed by explosive volcanic action.

It is not known with certainty that any of the fragmental beds in the Gunflint and Rove formations are normal clastic sediments, nor, on the other hand, that any particular bed is of pyroclastic origin. It is

[1]Gill, J. E.: Econ. Geol., vol. XXII, No. 7, pp. 687-728 (1927).

desirable, therefore, to call attention to the fact that in cases where the term tuff has been applied to Animikie sediments there is, so far as known, no available means of proving that the fragmental material was produced by volcanic action; and, conversely, in cases where names such as shale and greywacke are applied to beds in the Gunflint and Rove formations, the rocks so named are not demonstrably normal clastic sediments.

The rocks in the Gunflint and Rove formations are very similar to those in the respectively equivalent formations, the Biwabik and Virginia Slate, in Minnesota. Fragmental rocks in the latter formations have been described as tuffs[1] and, by other authors,[2] the same rocks are described as shales and greywackes. The contrasting inferences by these authors as to conditions under which these rocks were formed are, however, not greatly dissimilar. The above-mentioned authors[3] say, "The Taconic (Animikie) in northeastern Minnesota, therefore, with some periods of quiet was deposited in the midst of violent volcanic disturbance and oceanic transportation." Van Hise and Leith, in their discussion of the origin of these fragmental rocks, say,[4] "Contemporaneous basic igneous extrusions so abundant in the Upper Huronian (Animikie) doubtless furnished an unusual source for mud by their decomposition when hot, through the agency of acid solutions, through the agency of the atmosphere acting upon sulphides and thereby freeing sulphuric acid for attack on the adjacent rock, and finally perhaps by reaction of the hot lavas with sea water," and in another part of the report[5] these authors list the following possible ways in which the Upper Huronian shale may have been derived from basic rocks: "It may be due partly to weathering of the greenstones, to direct contribution of volcanic ash and muds, and possibly even to direct reaction with sea water."

There is no generally accepted evidence that any material or structure in the Animikie series is of organic origin. The carbonaceous material in the fragmental rocks of the Gunflint and Rove formations has been considered to be of organic origin by some authors, but similar material elsewhere is believed by some students to be of igneous origin. The carbonaceous matter shows no structure that can be identified as of organic origin and it is not present in supposed fossils (subsequently mentioned). At some localities, for example Kakabeka falls and Shuniah mine, it occurs as cloudy black dust in, or merely in the hull of, lava fragments, and it does not occur in the cementing material between fragments.

The first supposed fossils to be described in the Animikie were *Taonichnites* and *Ctenichnites*. These were regarded by G. F. Matthew[6] as the tracks of radiate animals and a kind of squid. The specimens that he examined were collected by E. D. Ingall.

In 1923, the writer observed mud flow structures on mount McKay that exhibited the characteristics of the supposed fossils as described by Matthew. Mr. Ingall subsequently informed the writer that in his opinion

[1]Winchell, N. H., and Winchell, H. V.: Geol. Nat. Hist. Surv., Minn., Bull. 6, p. 114 (1891).
[2]Van Hise, C. R., and Leith, C. K.: U.S. Geol. Surv., Mon., vol. 52, pp. 173 and 611 (1911).
[3]Winchell, N. H., and Winchell, H. V.: Op. cit., p. 114.
[4]Op. cit., p. 614.
[5]Op. cit., p. 513.
[6]Selwyn, A. R. C.: "Tracks of Organic Origin in the Rocks of the Animikie Group"; Am. Jour. Sci., vol. XXXIX, p. 145 (1890).

the specimens he had collected were examples of mud flow structures and not fossils.

In 1919 Grout and Broderick[1] noted the similarity between peculiar structures in the Animikie iron formation in Minnesota that had previously been described[2] as contorted beds and structures, which in rocks elsewhere had been attributed by C. D. Walcott, E. S. Moore, and Charles Schuchert to algal growths. Walcott was quoted as having reported that he was at a loss to explain the peculiar structures in the Animikie iron formation without the influence of some organic agency acting in conjunction with diffusion and concretionary action. Grout and Broderick suggested that the structure be named *Collenia* (?) *biwabikensis ferrata*.

In 1921, Holtedahl[3] compared forms in Algonkian rocks in America, which had been described as fossil algæ by Walcott, to similar structures in the Permian of England which latter, as a result of long study, were generally believed to be of inorganic origin.

In 1922, Capt. H. E. Knobel examined the internal structures in the Gunflint formation at Loon in company with the writer. Specimens that the writer identified as equivalent to the algal structures described by Grout and Broderick were submitted by Knobel to F. A. Bather of the British Museum, who reported[4] that W. N. Edwards, palæobotanist, Geological Department, British Museum, expressed the opinion that the specimens were probably of inorganic origin and that there was no definite evidence of the presence of an alga. Bather stated that he held the same opinion as Edwards.

A well-illustrated description of the macroscopic features of the above-mentioned structures in the iron formation at Loon was published by E. S. Moore in 1925.[5] The structures are termed algal concretions. Moore reports that microscopic examination by R. B. Thomson, botanist, revealed no trace of actual plant material, but the grouping and outlines and other features of the materials in the slides strongly suggests plant deposits of algal type.

Previous to the publication of the above-mentioned article Gruner[6] had described some microscopic structures in the Biwabik iron formation of Minnesota as fossil bacteria, bacilli, and algæ. Subsequently, Hawley[7] demonstrated by laboratory experiments that similar forms may be reproduced by inorganic agencies.

Age

The Animikie series lies unconformably on the Early Precambrian rocks of Thunder Bay district and it is overlain by the Sibley series with a disconformity at the contact. Sheets of diabase and related rocks of Kaministikwan age meet the Animikie strata with irruptive contacts; some, and possibly all, of these intrusives are of post-Sibley age.

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[1]Grout, F. F., and Broderick, T. M.: Am. Jour. Sci., vol. XLVIII, p. 199 (1919).
[2]Leith, C. K.: U.S. Geol. Surv., Mon., vol. XLIII, Pl. XII, p. 126 (1903).
[3]Holtedahl, O.: Am. Jour. Sci., 5th ser., vol. I, pp. 195-206 (1921).
[4]In a letter to H. E. Knobel, dated London, March 18, 1925.
[5]Moore, E. S.: Trans. Roy. Soc., Canada, vol. 19, sec. IV, pp. 21-26 (1925).
[6]Gruner, J. W.: Econ. Geol., vol. XVII, pp. 407-460 (1922).
[7]Hawley, J. E.: Jour. of Geol., vol. XXXIV, pp. 441-461 (1926).

Some authors[1] have inferred that the Animikie is of Lower Cambrian age because of the discovery of the supposed fossil tracks of *Taonichnites* and *Ctenichnites* in it. And for many years prior to the discovery of these supposed fossils the Animikie was regarded as early Palæozoic because of its relatively flat attitude and lack of metamorphism. According to current usage the supposed fossils are regarded as probably of inorganic origin or, in the case of microscopic forms, of doubtful origin of no value for purposes of correlation. The Animikie is older than strata in Minnesota containing Middle Cambrian fossils[2] and, hence, it is tentatively regarded as Precambrian.

SIBLEY SERIES

Definition

The Sibley series consists of the strata on Sibley peninsula and Edward island that overlie the Animikie series and underlie the Osler series; and equivalent rocks elsewhere. The contact between the Animikie and overlying Sibley series is typically exposed on cliffs east of Thunder bay extending for 15 miles from Sawyer bay northerly to Pass lake. Throughout this distance, there is a disconformity marked by a basal conglomerate reposing accordantly on the nearly flat-lying uppermost shale of the Animikie formation. In all of the exposures the contact is an even plane and there are no irregularities such as might be attributed to erosion of the floor on which the conglomerate was laid down. The basal formation of the Sibley series, which includes layers of white and red sandstone in addition to layers of conglomerate, is about 15 feet thick in the vicinity of Pass lake and 5 feet thick near Sawyer bay. Between these two localities the thickness varies between 15 feet and 5 feet. The pebbles in the conglomerate consist of Animikie iron formation, granite, greenstones such as occur in the Schist Complex, and vein quartz. They range in diameter up to 6 inches, the majority being between 1 and 2 inches in diameter. The pebbles are rounded, but those of iron formation are less perfectly rounded than those of other materials, and they are commonly subangular.

On the cliffs that extend southeasterly from Sawyer bay for about 4 miles to the vicinity of Silver Islet landing there are many excellent exposures of the contact between the Animikie and Sibley series, showing a variety of relations such as is particularly well exposed southeast of Surprise lake.

On the southeast side of Surprise lake, about 3 miles southeast of Sawyer bay, the contact between the Animikie and Sibley series is almost continuously exposed for 1,000 feet. At places there appears to be a conformable sequence across the contact, at other places the strata above and below the contact have different attitudes; at some such places exhibiting either relation, there is a basal conglomerate and at others the conglomerate is absent. The upper part of the Animikie consists of grey shaly rock that grades upward into red shaly rock above which and along a well-defined, even plane there are at places lenses of conglomerate with some

[1] Winchell, N. H., and Winchell, H. V.: Geol. and Nat. Hist. Surv., Minn., Bull. No. 6, p. 113 (1891).
[2] Stauffer, C. R.: Bull. Geol. Soc. Am., vol. 38, pp. 470 and 475 (1927).

rounded pebbles and some angular fragments. The largest lens has a maximum thickness of 6 feet and the part exposed has a length of 250 feet. Another lens has a maximum thickness of 2 feet and a length of 200 feet. Between the lenses and resting directly on the Animikie shale, there is white sandstone that along the strike grades into red sandstone and this in turn into a red, fine-grained sediment of apparently the same composition as the red shaly rock in the underlying Animikie, but distinguished from it by the lack of thin laminations. On the whole, both the Animikie and Sibley are nearly horizontal and there is no discordance. Both series of strata have been affected by faults and local folds; in these disturbed zones, which are commonly less than 20 feet wide, the shaly strata have been crumpled and the more competent layers of sandstone and conglomerate of the Sibley series have been gently arched or disjointed into blocks and moved through various small angles out of their normal attitude. The difference in the dip and strike of the strata above and below the Animikie-Sibley contact at such localities is not interpreted as recording an original discordance. In some of the disturbed zones there are sandstone dykes that extend across the contact. They are between 1 and 2 feet long and 1 and 2 inches wide in their upper part, tapering to nothing downward. They have the appearance of cracks filled with sandstone of the same character as the rock layer that lies above them. Their upper parts appear as crack fillings in conglomerate and they continue downward across the bedding into the Animikie shale, where they pinch out.

Northward from Pass lake for 4 miles to the vicinity of Silver lake the contact between the Animikie and Sibley series is exposed at several localities and at all of them a nearly horizontal basal conglomerate rests accordantly on the upper shaly member of the Animikie. At Deception lake between $3\frac{3}{4}$ and 4 miles north of Pass lake, a zone of highly deformed, brecciated Animikie iron formation outcrops to the west of and within 100 feet of the foot of the cliff on which the contact is exposed. The area between the cliff and the outcrop of iron formation is covered by drift and talus. At several places in this general vicinity the talus along the cliff of Sibley sediments obscures the contact with the Animikie. At such places the flat-lying Sibley sediments in the cliff, and the Animikie iron formation dipping up to 30 degrees toward the cliff, would admit of the inference that there is here a discordance between the Animikie and Sibley sediments.

The materials and angularity of the pebbles in the basal conglomerate of the Sibley differ considerably from place to place in the outcrops exposed north of Pass lake. In some outcrops the conglomerate consists chiefly of rounded pebbles of granite, whereas in other outcrops the conglomerate consists chiefly of angular fragments of Animikie iron formation. A few, well-rounded or subangular pebbles of rocks such as occur in the Schist Complex, accompany the pebbles of the other rocks. The thickness of the conglomerate is at some localities 5 feet and at others 25 feet, and in some cases there are differences in thickness of several feet between adjacent outcrops a few hundred feet apart. The matrix is at some places sandstone, at others red, shale-like material, and at others white limestone. At some localities all these various materials occur in the matrix in more or less well-defined layers. The contact between the conglomerate and the underlying Animikie sediment is usually along an even, sharply defined plane, but locally, as at a locality 2 miles north of Pass lake, the lowest conglomerate pebbles (which here consist of subangular fragments of Animikie iron formation) are embedded for a depth of an inch in the Animikie sediment as if they had been emplaced while the Animikie sediment was still in the condition of a plastic mud.

On the east side of a pond called Iron lake, between a quarter and a half mile northeast of Deception lake, the contact between the Animikie and Sibley series is exposed on the side of a cliff. There flat-lying iron formation is overlain by flat-lying Sibley conglomerate-breccia, consisting largely of angular fragments of Animikie iron formation. The disconformity at this locality has been figured and referred to as an unconformity, by Silver.[1]

North and east of Loon lake the Sibley sediments overlap the Animikie and rest on Early Precambrian rocks. The floor on which the Sibley sediments were laid down, as observed at a few localities between Loon and Granite point, is a smoothed, hummocky erosion surface of low relief, with a very thin covering of residual weathering products usually less than an inch thick. At a locality near Granite point residual weathering products extend to depths of about 6 inches along joints in granite under a scale of Sibley sediments.

The foregoing descriptions of the contact between the Animikie and Sibley series on the whole indicate the existence of a disconformity. Structurally the two formations are conformable, but the Animikie and older strata were, at some place or places, exposed to erosion before or during the time of deposition of the Sibley. The foregoing description also indicates how, by an inspection of only a few localities, former observers were induced to conclude that the relations indicate: (1) a conformable sequence,[2] (2) a slight discordance,[3] and (3) an unconformity.[4] These differing interpretations of the contact relations have influenced the various changes in the classification of the rocks.

Logan[5] considered the strata now known as the Animikie and all the younger strata as forming one " series " of Palæozoic age. He divided this series into two " groups ", a " Lower Group " and an " Upper Group " and placed the division between the two groups at what is now recognized as the base of the Sibley. Ingall[6] likewise treated the whole assemblage as a natural unit of Palæozoic age but considered it as being divisible into the Animikie, Neepigon, and Keweenian groups; the Animikie, in places termed a " series " by Ingall, corresponded with Logan's Lower Group.

The Special Committee for the Lake Superior region, after visiting Thunder Bay region, reported[7] the existence of an important structural break between the Animikie and the overlying strata. According to the

[1]Silver, L. P.: Rept. Ont. Bureau of Mines, vol. XV, pt. 1, p. 169.
[2]Logan, W. E.: "Geology of Canada, 1863," p. 70.
Ingall, E. D.: Geol. Surv., Canada, Ann. Rept., N.S., vol. III, pt. H, p. 8 (1887).
[3]Hunt, T. S.: Trans. Am. Inst. Min. Eng., vol. 1, p. 339 (1873).
[4]Van Hise, C. R., and Leith, C. K.: U.S. Geol. Surv., Mon., vol. LII, p. 369.
Silver, L. P.: Rept. Ont. Bureau of Mines, vol. XV, pt. 1, p. 168 (1906).
Tanton, T. L.: Geol. Surv., Canada, Sum. Rept. 1919, pt. E, p. 3.
[5]"Geology of Canada, 1863," pp. 67 *et seq.*
[6]Geol. Surv., Canada, Ann. Rept., N.S., vol. III, pt. H, p. 8 (1887).
[7]Jour. Geol., vol. 13, 1905, pp. 89-104.

table of formations and other information given in this report, the Sibley and later Kaministikwan rocks occurring in Loon Lake area were assigned to a Keweenawan system and the Animikie to the Upper Huronian of the "Huronian system". The majority of the Special Committee assigned both the Huronian and the Keweenawan to the Precambrian; a minority objected to classifying the Keweenawan as older than Cambrian but did not record a similar objection with respect to the Animikie, thus by implication stressing the importance of the Animikie-Sibley contact, which would then become the dividing place between the Precambrian and the Palæozoic.

The present writer is of the opinion that though the full significance of the break between the Animikie and Sibley is not apparent yet it cannot be such as would warrant treating the two assemblages as anything but parts of one group, namely, the Kaministikwan group.

Distribution

The Sibley series occurs on Sibley peninsula, east of Thunder bay, where it overlies the Animikie series, and on Edward island and several other islands in the southern part of Black bay where it lies beneath and is largely concealed by the next overlying series of strata, the Osler. The Sibley series also occurs on the east shore of Black bay, at a few localities in the lower part of cliffs overlain by Osler strata. Northerly and north-easterly from Sibley peninsula, there is an extensive area, around lake Nipigon and Nipigon bay, underlain by the Sibley series.

Subdivisions

The Sibley series in Thunder Cape map-area consists of a succession of sediments that for purposes of description are divided into six members, designated in their order of superposition from the bottom upward: A, B, C, D, E, F. The rocks characteristic of the subdivisions and their thicknesses are as follows:

	Feet
(F) Grey grit and quartz sandstone interbedded and intermixed with red mudstone	40+
(E) Red and purple mudstone	50—350
(D) Thinly interbedded grey chert and limestone	2
(C) White quartz sandstone	40
(B) Pink limestone, red mudstone, and white quartz sandstone	60
(A) Basal conglomerate	0—8

A Member. The A subdivision or member in Thunder Cape map-area is absent from a few localities near Surprise lake, but elsewhere it has been observed wherever the base of the Sibley series is exposed, and it has been traced for many miles. The base of the member at all observed outcrops is along a plane that coincides with the attitude of the bedding in the underlying Animikie sediments. Near Surprise lake the member thins from 6 feet to nothing in a distance of 250 feet, but on the whole the thickness is rather uniform for long distances, and the example cited is the most extreme case of variation known in the map-area. The member attains a maximum thickness of 8 feet near the northern boundary of the map-area.

The member consists of conglomerate with, at some localities, interbedded layers of quartz sandstone. An extensively developed phase of the conglomerate consists of closely packed, subangular pebbles of red and varicoloured cherty taconite, such as occurs in the Gunflint formation, and less numerous, well-rounded pebbles of vein quartz, granite, and mica and chlorite schists such as occur in the assemblage of Early Precambrian rocks of the region. The pebbles are less than 6 inches in maximum diameter and the majority range between 1 and 2 inches. There is no regular change in the size of the pebbles between the top and bottom of the conglomerate. At a few localities between Sawyer bay and Silver Islet landing, the conglomerate also holds thin, angular slabs of greywacke such as occurs in the Rove formation. In the majority of the outcrops where they have been observed the slabs are not more than 6 inches long and occur singly, scattered sparsely among the pebbles; on the southeast side of Surprise lake, however, grey greywacke slabs locally make up a considerable part of the formation and attain dimensions up to 2 feet in length and $\frac{1}{4}$ inch thick. At this locality the majority of the slabs are inclined with a dip toward the west, whereas the underlying Animikie shale and the stratified material in the matrix of the conglomerate-breccia are horizontal.

The matrix of the conglomerate everywhere consists of quartz sandstone and red mudstone, and at some localities, as for example in the conglomerate-breccia occurrence southeast of Surprise lake, there is also limestone. These several materials commonly occur in more or less sharply defined layers interrupted by the pebbles or slabs that they surround. In some outcrops of conglomerate there are only two layers, one of quartz sandstone and the other of red mudstone, and the relative proportions of these vary widely at different places. In some outcrops of conglomerate there are several alternating layers of different matrix materials.

Irregular growths, a few inches in maximum diameter, of crystalline barite, occur in the red mudstone of the matrix of the conglomerate, exposed 500 feet east of Mud lake and at other localities near Silver Islet landing. The barite growths are not veins.

B Member. The B member overlies the A member where present; in the vicinity of Surprise lake it rests directly on the Rove formation of the Animikie series. It is well exposed in cliffs extending northerly from Silver Islet landing and on mesas of the Sleeping Giant. It is inferred to extend throughout the area mapped as Sibley series on Thunder Cape sheet. Between Silver Islet landing and Sawyer bay the formation is 60 feet thick, and no considerable variation in the thickness occurs in the rest of the map-area so far as known.

The member consists of quartz sandstone, red, fine-grained, fragmental rocks, and pink limestone. These several rocks occur in layers, some of which are a few inches thick and some several feet thick, interstratified with one another. At some places the layers of different rock have sharply defined boundaries, at other places they grade into one another. Layers of red fragmental rock traced along their strike have been found to grade into quartz sandstone. Thin layers of limestone have been observed at some localities to merge into fine-grained, red, fragmental rock. At some localities, as for example at the east ends of Red Sandstone and Sawbill lakes, there are layers of autobreccia consisting of irregularly oriented fragments of beds of limestone in a matrix of red fragmental rock. The proportions of the various constituents in the formation vary from place to place. In the northern part of the map-area quartz sandstone makes up considerably more than half of the formation and there is only a small amount of limestone. Farther south the quartz sandstone is relatively less abundant, and near Silver Islet landing the red fragmental rock and limestone make up approximately 40 per cent and 10 per cent, respectively, of the total volume.

The sandstone is an even-bedded, white or pale grey rock composed almost entirely of rounded quartz grains with diameters of 0·5 mm. to 5 mm. Between the grains there is commonly calcite cement and pore space. A system of intersecting joints occurs at right angles to the bedding. Ripple-marks, a phenomenon rare in the Sibley sediments on Sibley peninsula, have been observed near Fork bay on layers of sandstone of this member. The ripple-marks are of the symmetrical type such as are produced by wave action in shallow bodies of standing water.

Red, fine-grained, fragmental rock occurs in a variety of phases. The commonest occurs as layers, some of which are a few inches and some several feet in thickness, showing no internal stratification and consisting of homogeneous, soft, brick-red material of earthy texture and sparsely scattered, tiny scales of mica; buff-coloured spots, streaks, and flame-shaped areas occur through various parts of the rock unrelated in orientation, though occasionally parallel to, the top and bottom of the layer; and a similar buff coloration occurs along the margins of irregularly spaced, prominent joint-planes. Flow wrinkles have been observed on the surfaces of layers of this phase of red fragmental rock exposed in the cliff southeast of Surprise lake. The form of the curved wrinkles, here, indicates that the flowage was toward the northwest. Other phases of the red fragmental rock are more or less distinctly stratified. In some of these there are alternating beds of different textures, the coarser materials have the texture of silt; in some, calcareous red beds alternate with non-calcareous red beds; and in some there are beds resembling red, green, and purple shales. Some layers of red fragmental rocks consist of curved flakes and irregularly oriented large slabs of stratified red beds in a matrix of structureless, homogeneous, red, fine-grained, fragmental rock. Buff colours in spots, streaks, and flame shapes occur more or less prominently in all phases.

Irregular growths, a few inches in maximum diameter, of crystalline barite, occur in a layer of unstratified, red, fragmental rock near the top of the cliff south of the outlet of Sawbill lake.

The mineralogical composition of the red fragmental rocks cannot be ascertained by optical methods. The chemical composition of a sample selected as representative of the commonest phase of red fragmental, is as follows:[1]

SiO_2	53·99	CaO	3·03
TiO_2	1·14	MgO	3·87
Al_2O_3	14·46	K_2O	4·53
Fe_2O_3	9·73	Na_2O	3·53
FeO	0·85	H_2O+CO_2	4·37
MnO	0·10		

The chemical composition of the rock resembles that of a basic igneous rock, and it is probable that the rock consists of material derived from lava.

This rock resembles red rock in E member of the Sibley series that consists of fragments of lava, and it also resembles red fragmental rock that probably consists of lava debris found on the tops of amygdaloidal basic lava flows in the Osler series.

The limestone is dense, massive, and consists chiefly of calcite. It occurs in layers ranging from an inch to more than a foot in thickness. The thicker layers are pink or pale red, the thin layers are commonly bright red, probably due to admixture with red, fine-grained, fragmental rock which occurs in adjacent layers.

C Member. The C member overlies the B member. It is exposed in cliffs extending northerly from Silver Islet landing and elsewhere through the central part of Sibley peninsula. It probably underlies almost all of the area mapped as Sibley series on Thunder Cape sheet.

In the area between Silver Islet landing and Sawbill lake where, due to the prominent development of red sediments in the B member, a boundary between the B and C members can be most readily identified, the C member is 40 feet thick. It consists of evenly stratified, rectangularly jointed, white and pale grey quartz sandstone. The greater part of the rock is imperfectly cemented with calcite. Irregular-shaped masses with diameters ranging from a few inches to a few feet, irregularly distributed through the rest of the rock, are well cemented with quartz and calcite. Weathered surfaces commonly show nodular prominences and relatively large ovoid and irregular-shaped shallow pits.

D Member. The D member overlies the C member. It is exposed on the shore of lake Superior near Fork and Middlebrun bays; at several localities on hills between Fork bay and Sawyer bay; and elsewhere, farther north, in the central part of Sibley peninsula. Its average thickness in the outcrops at these several localities is 2 feet, and in Thunder Cape map-area it nowhere exceeds 3 feet. It has been observed north of Thunder Cape map-area at Silver lake; and near each of the following stations on the Canadian National railways, Pass Lake, Pearl, Ancliff, and Nipigon. Presumably the formation is very extensive.

[1]Analysis by M. F. Connor, Geol. Surv., Canada.

The lithological character of the member is unique in the Sibley series and is of value as a horizon marker. The member consists of grey chert and grey limestone in thin alternating layers that range in thickness from $\frac{1}{40}$ inch or less to $\frac{1}{4}$ inch. The layers in parts of the member maintain uniform thicknesses and are evenly and regularly interlaminated over considerable distances. In other parts of the member the thin layers vary in thickness from place to place, and an individual layer may pinch out or divide into two or more layers, and in addition, groups of layers show a wavy structure with, at intervals, an upward bulging through which the minor wavy structure persists (*See* Plate V A). Intricately contorted and brecciated groups of layers occur locally. At some localities weathering has removed the limestone to a depth of $\frac{1}{4}$ inch and has left chert laminæ protruding.

E Member. The E member overlies the D member. It is prominently exposed on the hills north of Silver Islet landing and at all outcrops observed in the eastern half of Sibley peninsula; it probably underlies the greater part of the area mapped as Sibley series on Thunder Cape sheet.[1] The total thickness of the member is not known but is inferred to be approximately 350 feet. Continuous exposures have not been found between outcrops in which the top and the bottom, respectively, is exposed. Partial thicknesses of 50 feet have been measured in single exposures.

The member consists of several phases of red fragmental rock interlayered in beds that range in thickness from a fraction of an inch to 30 feet or more.

Some fine-grained phases are thinly bedded like shales and some of these are highly calcareous, others are not. One fine-grained phase occurs in layers ranging up to 30 feet in thickness and, on the whole, is devoid of internal stratification, but beds of this type at some localities pass, along the strike, into an indistinctly stratified phase in which there are contorted groups of beds or an autobreccia consisting of fragments of contorted groups of red beds in a matrix of red, unstratified, earthy textured material. Various shades of red are exhibited by different layers, bright brick red being most prominently developed; some layers are mottled in different shades of red. All phases show more or less prominently buff colorations in spots, discontinuation layers along the bedding, or irregular shaped streaks. In the shaly phases exposed on the west shore of Black bay the buff discolorations are spherical, have an average diameter of one inch, with a faint, concentric, colour banding and a black central mass less than $\frac{1}{10}$ inch in diameter containing manganese.

A red phase, in part somewhat coarser than those just described, occurs in layers several feet thick near Red Sandstone lake and at several places east of Marie Louise lake. This rock in parts of the exposures is indistinctly stratified, due presumably to slight differences in texture. In single outcrops the rock varies from brick red to purplish red in a large-scaled, mottled pattern which shows no relation to the bedding, and irregularly distributed are pale greenish grey and buff masses of irregular shape commonly less than an inch in diameter. Crystalline masses of red carbonate

[1] Geol. Surv., Canada, Map 203A. Thunder Cape sheet, Thunder Bay district, Ont.

about $\frac{1}{10}$ inch in diameter are disseminated through the rock, and small masses of rock immediately adjacent to, and in some cases remote from, the crystalline carbonate growths are calcareous. The greater part of the rock is not calcareous. Tiny mica scales are sparsely disseminated and they can be identified by the naked eye. At widely separated places are occasional developments of grey jasper in tuberous masses about the size of peas. A thin section of a calcareous part of the rock (Plate V B) consists of angular fragments up to 0·1 mm. in diameter of volcanic glass, for the most part devitrified and clouded red with hematite, and grains of augite, magnetite, biotite, feldspar, and quartz set in a matrix, making up about half of the total volume, and consisting of minutely granular red material through which there are irregular-shaped, indefinitely bounded, pale grey areas in which a carbonate can be identified. Under the microscope the rock has the appearance of a crystal-vitric tuff.

F Member. The F member overlies the E member. Its lower part, about 40 feet thick, is exposed on a hill between Sawyer bay and Sawbill lake. It there consists of grey, impure quartz sandstone, grit, and red, fine-grained, fragmental rock interlayered. There is only one bed of grit in the succession at this locality. It is between 4 and 6 feet thick and consists chiefly of large grains of quartz with some of red jasper and greenstone. The impure quartz sandstone occurs in layers ranging from a few inches to several feet in thickness and is evenly bedded. The interbedded layers of quartz sandstone and red fragmental rock in part of the succession are sharply differentiated; in other parts one type grades upwards into the other.

Metamorphism

The Sibley sediments have not been altered to any considerable degree. The conglomerate and quartz sandstone fracture around and not across the pebbles and grains. Buff discolorations in streaks and blotches through the red fragmental rocks seem to have been caused by some widely disseminated reducing agent indigenous to the rock which, within its zone of influence, reduced ferric iron to ferrous iron. Buff discoloured zones a few inches wide border diabase dykes which, presumably, at the time of intrusion caused a reduction of the ferric iron in the adjacent red country rock. The red fragmental rock of the B member is discoloured grey in the contact zone beneath the diabase sill on Thunder mountain.

Structure

The Sibley strata in Thunder Cape map-area have a very gentle regional dip toward the southeast. In exposures, some masses of strata are horizontal, and others dip in various directions at various angles up to 5 degrees.

Vertical fault planes have been observed at several localities and are occupied either by diabase dykes or veins. Commonly a linear depression extends back from wherever a prominent fault is revealed in the cliffs of the highland area north of Silver Islet landing; presumably these depressions have been developed on the trace of faults.

Origin

Sibley sediments as regards origin, consist of three types. One of these, embracing conglomerate, grit, and quartz sandstone, consists of stratified layers of fragments of rocks or minerals presumably derived from pre-existing rocks; they are normal, clastic, waterlain sediments. Another type is represented by limestone and thinly interlaminated limestone and chert; these rocks are non-fragmental and so far as known are devoid of organic remains; they are regarded as chemical precipitates. A third type, which makes up the greater part of the Sibley series, is represented by the red fragmental rocks. Their origin, as in the case of the fragmental rocks in the underlying Rove and Gunflint formations, is problematical. A microscopic examination of some of the rock shows that it is made up of lava fragments and seems to be a tuff; the chemical composition of a sample from the B member is very similar to that of a basic igneous rock; the general appearance of the red fragmental rocks is strikingly similar to red fragmental rocks that occur interlayered with basic lava flows in the Osler series east of Sibley peninsula and which are inferred to consist of volcanic debris; hence it seems probable that the red fragmental rocks of the Sibley series consist of volcanic debris. There are no pre-Sibley formations exposed in the region that would likely yield by erosion red fragmental rocks such as occur in the Sibley. There are no known Sibley lavas. The resemblance between the red fragmental rocks of the Osler and Sibley series suggests that the rocks of both series originated in a similar way. Those in the Osler series are inferred to have formed by volcanic agencies from the red-topped, basic lava flows with which they are intimately associated. It is, therefore, inferred that there were pre-Osler lavas similar to those of the Osler series somewhere in the region, and that the red fragmental rocks of the Sibley series were derived from them either by volcanic agencies or by erosion.

The layers of red fragmental rock that show autobrecciation and flow wrinkles, occur commonly between evenly stratified beds. Presumably the material in the layers flowed as viscous mud on nearly flat surfaces. Flowage may have been caused by excessive local accumulation of fragmental material. The direction of flowage as indicated by flow wrinkles on layers on the southeast side of Surprise lake shows that the site of the inferred local accumulation was southeast of this locality.

Age

The Sibley series lies above the Animikie and below the Osler, and there is a disconformity at the lower and upper contacts. Sheets of diabase and related rocks meet the Sibley strata with irruptive contacts; some, possibly all, of these intrusives are younger than some of the Osler strata.

The Sibley is tentatively classified as Precambrian. Forms that have been identified as algal growths occur in limestone of the Sibley series north of Thunder Cape map-area, but these forms are of no value for purposes of age correlation.

OSLER SERIES

Definition

The Osler series is the succession of lavas and sediments of closely related age, known or inferred to be younger than the Sibley series, which occur on Edward island and the neighbouring mainland in and northeast of the eastern part of Thunder Cape map-area, including St. Ignace island and other islands south of Nipigon bay. The upper limit of the Osler series cannot be defined because, so far as known, the Osler strata in the above-mentioned area are the youngest consolidated strata.

The contact between the Osler and the underlying Sibley series is exposed on cliffs that extend for several miles along the north side of St. Ignace island and near the north headland of Osler bay on the west side of Edward island. At these localities nearly horizontal sediments of the Sibley series are overlain by the basal conglomerate of the Osler series. The conglomerate has the same attitude as the underlying sediments, but is made up of pebbles derived from the Sibley series and from various other older rocks of the region.

On St. Ignace island and Edward island the basal conglomerate is overlain by beds of sandstone and red mudstone with a total thickness of about 200 feet on St. Ignace island and 40 feet on Edward island. The sandstones are prominently crossbedded and in this respect contrast markedly with the evenly bedded but otherwise similar nearby Sibley sediments. The Osler sediments are overlain by lavas and the contact relations between the lavas and sediments are well exposed on the north side of St. Ignace island and the west side of Edward island. A considerable thickness of the immediately overlying lavas is made up of several thin flows between which there are locally developed, thin deposits of red fragmental rocks. The phenomena exhibited at the contact of the lowest lava and the underlying sediments are interpreted as indicating that the sediments were plastic when the lava flowed over them and that, therefore, no considerable time elapsed between the deposition of the sediments and the overlying lava.

The term Osler is derived from Osler bay on the west side of Edward island. The first published reference to the Osler series as such, appeared in an article presented by the writer[1] in 1926. Previously Van Hise and Leith[2] classified the basic igneous rocks and subordinate amounts of interstratified clastic material near Black and Nipigon bays as Middle Keweenawan, and by implication the sediments immediately beneath the lavas, that is, the Osler beds, were classed with those now termed the Sibley series as Lower Keweenawan. No mention was made of the conglomerate now regarded as the basal conglomerate of the Osler series, and no evidence was presented of a break in the geological record between the Lower and Middle Keweenawan.

In 1873, Hunt[3] gave the name Keweenaw group to one of three divisions of Logan's Upper Copper-bearing series. From the brief descripiton of the character and distribution of the rocks of this group as given

[1]Tanton, T. L.: Bull. Geol. Soc. Am., vol. 38, pp. 731-743 (1927).
[2]Van Hise, C. R., and Leith, C. K.: U.S. Geol. Surv., Mon., vol. LII, p. 368 (1911).
[3]Hunt, T. S.: Trans. Am. Inst. Min. Eng., vol. 1, pp. 339, 342 (1873).

by Hunt it is evident that his Keweenaw group corresponds approximately with the Osler series, but the limits of the group were not defined and Hunt was in doubt as to whether this group was older or younger than the strata on Sibley peninsula which he assigned to the Nipigon group (Sibley series). The latter of these alternatives had been expressed by Logan,[1] in 1863; and the former by Macfarlane,[2] in 1869.

Distribution and General Character

In Thunder Cape map-area the Osler series occurs on Edward island, on the islands south and east of it, and on the mainland east of Black bay.

The series consists of a basal conglomerate 12 feet thick, overlain by about 40 feet of crossbedded, quartz sandstones and interstratified red mudstones, and these are overspread by lavas and red fragmental rocks with a known thickness of 150 feet in the map-area. The eruptive members in the adjoining area to the east attain a thickness that has been estimated at between 6,000 and 10,000 feet.[3]

Basal Conglomerate

The basal conglomerate is exposed near lake level on the north headland of Osler bay and at intervals through a distance of 800 feet north of this point, on the west side of Edward island. It is 12 feet thick and dips south 80 degrees east at an angle of 3 degrees. It consists, from the bottom upward, of coarse conglomerate, 1 foot; lenticularly interbedded conglomerate and sandstone, 3 feet; coarse-textured conglomerate, 2 feet; sandstone with a few small pebbles, 2 feet; and fine-textured conglomerate, 4 feet. In all the conglomerate layers the pebbles, cobbles, and boulders are rounded, closely packed, and lie in a matrix of impure red and grey sandstone. The coarse-textured layers of the lower part of the member contain some boulders with diameters exceeding 1 foot, though the average diameter is approximately 6 inches. In the upper part of the member, the pebbles range in size between narrow limits and average one inch in diameter.

The fragments in the conglomerate consist of the following materials: red, light grey, and dark grey quartz sandstones; red, cherty taconite; white vein quartz; granite; greenstone; and red, quartz porphyry. The largest boulders consist of grey quartz sandstone, and fragments of sandstone are more numerous than those of all other materials combined. The quartz sandstones are rocks such as occur in the Sibley series, and, with the exception of the red quartz porphyry, the other fragmental materials are such as occur, as pebbles, in the basal conglomerate of the Sibley series. Red, quartz porphyry occurs at Agate point 16 miles east of Thunder Cape map-area and elsewhere farther east, in lava inferred to be younger than the basal conglomerate of the Osler series. No other red quartz porphyry which might be regarded as a possible source of the pebbles has been

[1]Logan, W. E.: "Geology of Canada, 1863," p. 70.
[2]Macfarlane, Thomas: Canadian Naturalist, new ser., vol. 3, 1869, p. 252; vol. 4, 1869, p. 38.
[3]Logan, W. E.: "Geology of Canada, 1863," p. 71.

identified in the region. It is possible that these pebbles were derived from a pre-Osler lava, of the Kaministikwan group, which either is not exposed, or has not been identified, in the region.

The matrix of the conglomerate is an impure quartz sandstone the greater part of which is grey but with red layers and lenses interrupted by the large fragments and pebbles. Grey and red fine-grained materials occur as a filling around the quartz grains in the sandstone.

Sandstone and Mudstone

Two feet of interbedded red sandstone and mudstone, in beds $\frac{1}{4}$ to $\frac{1}{2}$ inch thick, conformably overlies the conglomerate on Edward island. It is succeeded by strikingly crossbedded, white, impure, quartz sandstone from 20 to 25 feet thick. Above this lies 15 feet of evenly stratified quartz sandstone intermixed with red mudstone. The mudstone displays irregularly disposed, buff and pale grey, flame-shaped streaks and blotches; probably due to a local reduction of the ferric iron in the rock. The distribution of the bleached material does not appear to be related to the present surface of the rock nor to any particular horizon within the rock. Overlying the mixed member there is locally a bed of red mudstone with a maximum observed thickness of 6 inches.

Lavas

A thick succession of lavas with minor amounts of interbedded red fragmental rocks overlie the above-mentioned sediments of the Osler series. The contact between lava and the underlying sediments is well exposed in several cliffs occurring in a space of 3 miles along the west shore of Edward island. In general the contact appears to be horizontal, and accordant with the bedding planes in the subjacent rocks. The uppermost sediments have been indurated for depths of a few inches and small druses and gash veins have developed in them, filled with the same material as that in the amygdules of the lava above; calcite predominates where this mineral characterizes the nearby amygdule fillings, and agate is well developed where the equivalent relationship is found. In a vertical cliff south of Osler bay the contact at the base of the lava shows a series of gentle, apparently symmetrical, undulations, the distance from crest to crest being 4 feet, and the height of the crests above the troughs 3 inches. The bedding for a few inches beneath the contact shows undulations parallel to it; the strata below do not. If the undulations in the sediments were induced by movements in the fluid lava above, and no other interpretation occurs to the writer, it is to be inferred that these sediments were plastic when the lava poured over them.

Lava cuts across layers of sediments on the south headland of Osler bay, on the north and east shores of Edward harbour, on the southwest side of the island in Edward harbour, and in Horseshoe cove. The bedding in the sediments commonly shows a gentle downward curving as it approaches the lava contact. At two localities in Edward harbour, layers of agglomerate, 15 feet and 5 feet thick, respectively, occur along one side of the lava sheets. The agglomerate consists of subangular and very irregular fragments of amygdaloidal lava up to 8 inches in diameter and a few small fragments of sandstone, in a groundmass of bright red, earthy-textured, fragmental material. A considerable amount of calcite is present as amygdule filling. On the east shore of Edward island lava dykelets penetrate the indurated sandstone in an irregular manner for a foot or more from the vertical contact and a few blocks of quartzite are enclosed by lava. On the whole, little disturbance, and very little shattering and penetration of the sediments, attended the emplacement of the lavas.

The lava sheets that truncate sedimentary beds are interpreted as extrusives which poured over fault scarps or into fissures developed just prior to the coming of the lava, possibly at the same time as the disturbance that actuated or accompanied the volcanic effusion. Only one side of any lava sheet is in contact with sediments and the other side is the more vesicular and, as observed in several instances, corresponds to the upper surface of the flat-lying continuations of the sheets. At the few localities where topographical irregularities are inferred to have existed on the pre-lava surface, there is no field evidence that these declivities were produced by erosion. The curving of the bedding planes in the sediments tends to conform to the attitude of the base of the lava sheets and is regarded as evidence that the sediments were still plastic when overspread by the lava. The rarity of tongues of lava penetrating the sediments suggests that jointing had not developed in the sediments at the time of the eruption.

The lavas of the Osler series extend over Edward island, the smaller islands south and east of Edward island, and at least that part of the large peninsula east of Black bay that lies within the map-area. Regularly superposed layers of lava with minor amounts of red fragmental material are well exposed on numerous westerly-facing cliffs, which, along the shore, rise to heights varying up to 50 feet. The succession consists of sheets of basaltic lava ranging in thickness from 5 to 40 feet, the majority appear to be less than 20 feet thick. The thickest observed flow is on Edward island, in a cliff a few hundred feet east of the bottom of Horseshoe cove. East of Miles bay, hills composed of lavas rise 150 feet above lake Superior. The succession probably attains a thickness of more than 200 feet within the map-area. The continuation of this assemblage in the region to the northeast is to be measured in thousands of feet.

The lavas are rather uniform in lithological character and the differences between individual members is less striking than the differences within single flows. All the flows are basic and are generally of fine texture. They have an earthy or porcellanic lustre which markedly contrasts with the more glassy lustre of the fine-grained dykes of related composition that intrude them. Some of the flows are amygdaloidal throughout. Usually the upper part of a flow is more vesicular than the lower part, and this arrangement, together with differences in colour, which appears to be related to the abundance of the amygdules, permits the demarcation of flows where interlayered fragmental material is absent. The highly vesicular parts of the rock do not form regular, even layers along the tops of the flows. At some localities the irregularity of the lower boundary of the highly amygdaloidal zone gives an appearance of downward projecting tongues or of a series of detached masses of various sizes and irregular shapes. The disposition of these vesicular tongues and masses occasionally suggests a flowage structure.

Some of the basalt flows are characteristically dense, and massive; they are dark geenish grey, break with an uneven or imperfect conchoidal fracture, have a dull lustre, can be scratched with a knife, but are tough under the hammer. In the majority of the flows a finely crystalline texture can be observed with the naked eye, even within the vesicular part. Under the microscope the rock is seen to consist essentially of tiny laths of plagioclase (probable labradorite), chloritic minerals of different shades of green, magnetite, and clouded, devitrified glass commonly red or reddish brown. It is probable that the chlorite is, in whole or in part, an alteration product of pyroxene, small remnants of which may be observed associated with chlorite.

Though the predominant colour of the lava is dark greenish grey, some flows show, upon close inspection, tiny green mottlings through a base of greyish purple or dull reddish brown.

In some flows there is no readily observable difference between the rock of the amygdaloidal part and that of the non-amygdaloidal part; but in some cases with the increase in the vesicular character, the colour of the rock tends to change to a reddish hue. The highly vesicular upper parts of the flows, usually less than 2 feet thick, show a great variety of colours ranging from reddish brown and chocolate, to pale brick red; in individual beds the reddish upper parts when traced laterally through hundreds of feet commonly alternate with greenish grey, somewhat harder and less highly vesicular material.

Most of the amygdules are approximately spherical and less than ½ inch in diameter. Locally, various other shapes and sizes are to be observed, such as: simple and compound tubular forms up to a few inches in length with their longer axes normal to the layering; and potato-shaped amygdules attaining maximum diameters of approximately 1½ feet. Examples of the latter are well exposed on the north headland of Pringle bay; they are partly filled with coarsely crystalline, white calcite in which some chalcocite was observed, and an inner development of beautifully terminated quartz crystals, colourless, amethystine, and red, which project into the central cavity. The following minerals commonly occur in the amygdules: calcite, agate, delessite and other minerals of the chlorite group, laumontite and other unidentified zeolites, and, in certain large amygdules, quartz in crystalline aggregates of prismatic habit projecting toward the centre.

In amygdules filled with several minerals it was noted that chlorite usually forms the rim and calcite the central part. The amygdule fillings are commonly of very different composition in different parts of individual flows, yet, on the whole, the amygdaloidal part of any flow has certain distinctive characters expressed either by a preponderance of one or more minerals or by the presence of certain minerals. Calcite is the most abundant filling material and some amygdaloidal layers contain comparatively small amounts of other minerals. The agate fillings are neither as large nor as beautiful as those developed at several localities to the northeast and they offer no attraction to collectors of semi-precious stones. Native copper occurs in small amounts in some amygdules in the lava on the eastern shore of Miles bay, on Edward island, and along the western side of Porphyry island; numerous other similar occurrences are known beyond the map-area, but so far as known are not of economic importance. An unsuccessful attempt was once made to mine the copper-bearing lava at a point on the east shore of Black bay, 3 miles north of Thunder Cape map boundary. Narrow veins of banded agate and calcite cutting the lava, and such as are known to carry native copper elsewhere in the region, have been observed in the map-area.

Monk island is underlain by medium to coarse-grained diabase or ophite consisting of reddish laths of plagioclase, surrounded by augite and magnetite. A phase of the rock is dense, hard, and massive, differing in general appearance from the diabase dykes of the region only in its reddish colour; another phase is amygdaloidal but otherwise similar. The majority of the amygdules are less than $\frac{1}{8}$ inch in diameter, lie on an average 1 inch apart, and are partly filled with chlorite and laumontite with a cavity in the centre. A few sparsely scattered amygdules attain diameters of more than half an inch and are filled with calcite. The structure of the rock mass exposed on Monk island cannot be determined, it may be an intrusive with any amygdaloidal phase, or it may be a lava.

The red fragmental rocks lying between some lava flows occur as layers or broad lenses. Some are a few inches thick, some have a maximum thickness of a few feet. Individual layers have been traced for scores, and in some cases hundreds, of feet and in no case were both ends of any one layer seen.

Some layers and parts of layers consist of irregularly arranged sub-angular fragments, ranging in diameter from a few feet to a fraction of an inch. The fragments are of amygdaloidal red lava and lie in a matrix of unstratified, red, fine-grained material which appears to be a fine-grained phase of the identifiable volcanic debris. Some layers consist of stratified, soft, red, fine-grained material which closely resembles the matrix of the previously described rock. Other layers consist of large and small angular and rounded fragments of amygdaloidal lava irregularly distributed through stratified, fine-grained, red material.

Metamorphism

The sediments in the lower part of the Osler series present metamorphic phenomena of two different types along zones bordering irruptive contacts. The more prominently developed type is represented in zones a few inches wide where the sediments have been indurated and impregnated with silica and calcite. The second type is represented in a zone about 100 feet wide at the south end of Edward island where all gradations exist between indurated sediments and granophyre.

The lavas in a zone, averaging 100 feet wide, adjacent to a dyke at the south end of Edward island, have been highly metamorphosed, and all gradations are present between lava and red granophyre. This zone has been traced discontinuously across an island east of Edward island and across Porphyry island.

Blocks of red granophyre, a few inches in diameter, occur in a dyke of greenish grey diabase 4,000 feet northeast of Miles bay. These blocks may be partly assimilated inclusions of lava.

At many localities the lavas in contact with diabase dykes show no contact metamorphism.

A prominently developed type of metamorphism in the lavas is represented by soft, greenish and red, altered basalt in flows and parts of flows. The degree of metamorphism varies in single flows and between individual flows. The more intensely altered phases are in the highly vesicular parts of the flows, and in thin flows the alteration has pervaded the whole sheet. The distribution of the altered basalt does not show any relationship to stratigraphic position, nor to joint-planes, nor to layers of even thickness along the tops of the flows. The alteration is of a catamorphic nature; and as it has occasionally affected whole flows, it probably took place during the relatively brief cooling period after extrusion, and probably was due to mineralogical rearrangements, particularly in those parts rich in volatile constituents, tending toward the development of minerals characteristically developed under lower temperatures and pressures than those producing primary minerals in igneous rocks.

Structure

The structure of the Osler series, in its broad features, is similar to that of the Sibley and Animikie series. On the whole, the strata are nearly flat-lying; it is common, however, to find at different localities gentle dips at angles up to 5 degrees in various directions. The prevailing dip of the strata on Edward island is toward the east; in an area of nearly one square mile west of Miles bay it is toward the southeast; elsewhere the strata are either flatter or do not show a uniform direction of dip over a considerable area. The strata have been dislocated by vertical or steeply dipping faults at many localities; the majority of the faults are occupied by diabase dykes, and at a few localities dykes as well as the Osler strata which they cut have been faulted. One such fault occurs at Edward Island mine and there fissures along the fault have been cemented with silver-bearing vein material.

Origin

The basal conglomerate of the Osler series lies on sandstone of the Sibley series and its pebbles and boulders consist of debris from the Sibley series and older rocks of the region; these facts indicate that at the beginning of Osler time rocks of the Sibley series were exposed to erosion, presumably by uplift of some part of the basin in which they had been deposited, and that sedimentation was either resumed or was continued in that part of the Sibley basin where the Osler conglomerate was laid down. No pebbles of diabase have been found in the basal conglomerate;

this indicates that diabase if it occurred in this region in pre-Osler time, was not exposed to erosion in the areas from which the pebbles of the conglomerate were derived.

The red quartz porphyry pebbles in the conglomerate are assumed to have come from an intrusive body or lava which is not exposed in the region, and which is older than the quartz porphyry masses exposed northeast of the map-area.

The sandstones and red mudstones that occur interlayered with and above the basal conglomerate are similar in composition and other characters to strata of the Sibley series except that the Osler sandstones commonly show crossbedding and the nearby sandstones of the Sibley series do not. It is inferred that the Osler sediments were laid down in a water body of the same character as that in which the Sibley sediments were deposited, namely, a lake or sea.

The materials of the Osler sandstones and red mudstones may have been derived from the Sibley series or from sources similar to those that supplied the Sibley sediments. In the latter case, the materials of the quartz sandstone may be inferred to have come from eroded Early Precambrian rocks and the red mudstone may be tuff or clastic volcanic debris, a product of Kaministikwan volcanism.

The basic lavas that overlie the Osler sediments were emplaced in a highly fluid condition, as may be inferred from the rather uniform thickness of individual flows over considerable distances. At several places east of Thunder Cape map-area, flowage wrinkles on the tops of lava flows have been observed and indicate the direction in which the lava was flowing prior to consolidation. At places between Roche Debout and Agate points, between 20 and 21 miles northeast of Edward island, the lava flowed toward the north; on the eastern side of St. Ignace island, a lava flowed toward the north and another sheet flowed toward the northeast; on Simpson island, about 45 miles northeast of Edward island, a lava flowed toward the north; and on Wilson island, about 55 miles northeast of Edward island, a lava flowed toward the northeast. All observations indicate that the lava came from a southerly source and it seems probable that the lava was poured out along fissures in the site of lake Superior.

The red fragmental rocks which occur as layers or broad lenses between some lava flows, include a breccia type, stratified beds, and a third type that has the appearance of breccia distributed through, or filled around by, stratified beds.

The breccia fragments consist of amygdaloidal lava similar to rock in the underlying lava flow top, this suggests that they may have been derived from the subjacent lava flow; the size, angularity, and arrangement of the fragments and their occurrence on a surface that was originally nearly flat, that remained so after a succeeded flow overspread it, and still is nearly flat, indicates that they probably formed by the brecciation and piling up of the vesicular consolidated crust on the surface of the lava, while yet fluid in its lower part, and while it still was flowing. It is possible that some of the coarse fragmental material was a result of volcanic explosions. The fine-grained matrix probably consists of material resulting from the abrasion of blocks of lava crust moved by flowage and possibly volcanic ash.

The stratified beds are waterlain deposits. The material in the beds resembles the matrix substance of the breccias, and probably was derived from lava either by explosive agencies or by abrasion or erosion.

The third type of deposit, consisting of large and small, angular and rounded fragments of amygdaloidal lava irregularly distributed through stratified, fine-grained material, could be satisfactorily explained in some cases as volcanic breccia similar in origin to the first-mentioned type, reworked by water; in some cases, however, where rather large fragments occur scattered through the upper part of a deposit whose lower part is fine grained, it is more probable these represent bombs and lapilli dropped along with ash, or into a clastic sediment, accumulating under water.

It is questionable whether the lava assemblage of the Osler series accumulated under water or not. It is known that the lowest lavas exposed in Thunder Cape map-area and throughout the adjoining region to the northeast lie on sediments inferred to have been laid down in an extensive water body, a lake or sea; and it is evident that these lavas accumulated on the site of an extensive basin. Some of the fragmental rocks interlayered with the lavas show stratification and some do not, the former indicate the existence of water over the lava at the time of their formation, the latter may or may not have been deposited in water. Quartz sandstones occur below the Osler lavas, but none occurs interstratified with the lavas. The cessation of this type of sedimentation suggests that the lavas accumulated on a land area.

The water bodies whose former existence is recorded in the stratified deposits found between lava flows, may have been ponds and rivers that formed from time to time on successive lava flows.

Age

The Osler series disconformably overlies the Sibley series. In Thunder Cape map-area, and, so far as known, elsewhere in Thunder Bay district, the Osler are the youngest consolidated strata. The lava assemblage in the Osler series is generally regarded as correlative with a lithologically similar assemblage of rocks on the south shore of lake Superior mapped as Middle Keweenawan. In St. Croix valley, Minnesota, and on the southeast side of Keweenaw point, Michigan, the Middle Keweenawan is overlain unconformably by Upper Cambrain strata.[1] Van Hise and Leith state[2] that it is difficult to prove decisively that the Keweenawan is Precambrian rather than Middle or Lower Cambrian. Some geologists are of the opinion that the Keweenawan is probably Cambrian and some are of the opinion that it is Precambrian.

Dykes of diabase and related rocks meet the Osler strata with irruptive contacts; they may be the irruptive phase of lavas of the Osler series and it is assumed that they are of Osler age.

[1]Van Hise, C. R., and Leith, C. K.: U.S. Geol. Surv., Mon., vol. 52, p. 415.
[2]Idem., p. 415.

KAMINISTIKWAN INTRUSIVES

Distribution

The Kaministikwan intrusives include dykes and sills of diabase and related rocks. Throughout the part of the region underlain by Kaministikwan strata there are numerous dykes ranging in width from a few inches up to 650 feet, the majority are between 10 and 50 feet wide.

Many dykes have been traced for hundreds of feet; some are probably many miles in length. Most of the dykes maintain a constant width for considerable distances. Some divide and the branches in some cases reunite, but in other cases do not appear to do so.

Many dykes strike northeasterly, some approximately east and west, and a few southeasterly. A majority dip steeply toward the south or are nearly vertical. The dip and strike of some dykes vary slightly from place to place; and at the following localities considerable variations in dip occur, the upper part of the intrusive at each locality dipping less steeply than its lower part: on Tee point; on Burnt island; and at a place about 1,000 feet southwest of Shuniah lake. From information obtained in Silver Islet mine it has been inferred that a similar variation in dip occurs in Silver Islet dyke.

The sills are lateral extensions of dykes, intruded parallel or nearly parallel, to the bedding of the enclosing strata. The erosion remnants of a sill averaging 200 feet in thickness, caps the high mesas on mount McKay and southward, on Pie island, and on Thunder cape. On mount McKay a second sill 15 feet thick lies 200 feet below the other. Sills also occur in the lowland west and north of mount McKay as follows: in Neebing township between the Fort William Industrial farm and Kaministikwia river; on lots I, K, L, McIntyre township; in the city of Port Arthur; between Thunder Bay mine and Wild Goose point; on Mary island; and on Clavet point and a hill northeast of Clavet point. A sill about 2 feet thick is exposed in Port Arthur; the others are between 8 and 60 feet thick.

Where sills and dykes are intimately associated areally the dykes commonly intrude the sills, but at the following localities sills may be seen to form extensions of dykes: Clavet point, Hare island, Tee point, and the north shore of Burnt island.

On the northeast part of Thunder mountain the great capping sheet divides into two sills, the upper about 175 feet thick, and the lower about 50 feet thick. On the north side of the mountain the lower sill at its ends can be seen curving upward and assuming the form of dykes which cut across a block of flat-lying sediments about 70 feet thick and 1,200 feet long.

Jointing

The majority of the dykes, and particularly those less than 50 feet wide, show columnar jointing. In cross-section the columns are polygonal, occasionally hexagonal. In dykes less than 10 feet wide there is commonly one set of columns at right angles to the walls, each column extending across the entire width of the dyke. In some dykes there are two sets of columns, each set extends at right angles from one wall toward the middle of the dyke where a well-developed joint or system of closely spaced joints is developed parallel with the walls of the dyke.

In the sills there are three intersecting sets of joints and the rock naturally cleaves into roughly cubical blocks. Columnar jointing is not developed in the sills, though the falling away of loose blocks from cliff faces produces a columnar effect when viewed from a distance.

Lithological Character

Sills and dykes are chiefly of dense, hard, massive, greenish grey, medium-grained diabase, showing an ophitic texture and consisting essentially of plagioclase and augite. There are, however, a variety of petrographical differences between various intrusive masses and also between different parts of single large sills and dykes.

The sills on Thunder cape are typical of all the thick sills in the map-area. At the base of the sill is a chilled edge. This is a black, hard, dense rock about 1 inch thick. It merges upward into a very fine-grained, dark grey porphyrite in which slender, needle-shaped phenocrysts of feldspar are visible. Proceeding upward the porphyrite gradually becomes coarser, and at a distance of about 3 inches from the base of the sill, the groundmass appears crystalline. In the succeeding 3 inches the progressive increase in coarseness of the matrix results in a fine-grained, dark grey diabase, in which the average maximum diameter of the essential constituents is 0·75 mm. In the overlying foot or 3 feet a change from fine to medium-grained diabase takes place. Above this for the succeeding 100 or 200 feet, or as far as the sill permits of examination, there is no progressive change in texture. Whatever variations occur are within irregular patches and, in general, the whole sheet above the contact zone very closely approaches textural dimensions of 4 mm. On the basis of texture a considerable proportion of the rock in the sills might be called gabbro. There is a progressive change upwards in the proportions of the various constituents. In the lower portions, the constituents are present in the following proportions: plagioclase, 45; augite, etc., 50; ilmenite, 5. This gives a rather dark, greenish grey rock whose weathered surface is only slightly rusty. In the upper part of the sill pale grey rock predominates in which the constituents have the following proportions: plagioclase, 60; augite, etc., 30; ilmenite, 10. The weathered surface of this rock is very rusty.

Under the microscope a thin section of what may be considered an average specimen was found to consist of laths of plagioclase, principally labradorite. These form a meshwork, the interstices of which are nearly filled with augite and hypersthene in the proportion of 3 to 1. Occasional sections show augite with numerous cloudy inclusions, such as characterize the titaniferous variety. Small amounts of olivine occur in the rock in the upper part of the sill. Ilmenite or magnetite occur in grains and crystalline aggregates and occasionally as rods. Slender needles of apatite are present. In some slides small, irregular-shaped aggregates lie in the interstices of the feldspar meshwork and are micrographic intergrowths of quartz and cloudy feldspar. These irregular aggregates have the appearance of foreign inclusions in the otherwise fresh, unaltered rock. The appearance under the microscope is identical with that of the quartz diabase of Cobalt and Gowganda areas.

A general study of all dykes shows that there is a prevailing type of diabase very like the lower 50 feet of the capping sills. This is a dense, hard, greenish grey rock of medium-grained ophitic texture. In the hand specimen one can see the slender laths of white plagioclase surrounded by dark green augite. Except for surface layers the rock is characteristically fresh-looking and the minerals give brilliant reflections from their cleavage surfaces.

Under the microscope thin sections are seen to consist of a network of laths of plagioclase (commonly oligoclase), the spaces between which are occupied by augite, a small amount of apatite in slender needles, and ilmenite or magnetite in tiny, stout rods or disseminated grains; these constituents are fresh and unaltered. In every slide there is a very small amount of brown biotite and microcrystalline segregations of obscure, cloudy, feldspathic material lying between the essential constituents in such a way as to indicate that they are not derived from them by alteration. A few of these cloudy segregations contain a little quartz. Every diabase dyke shows chilled edges, usually 1 inch wide, consisting of dense, hard, black material. There is commonly a gradational change to a medium-grained rock within a few inches of the chilled edge, and the median parts of dykes are usually homogeneous in texture whether they be a few feet or hundreds of feet wide. In some large dykes there are irregular masses, several feet across, composed of very coarse-grained diabase; within these masses there are commonly one or more druses, a few inches in diameter, filled, around the walls, with prehnite and, in the central part, with calcite. On the east end of Hardscrabble island, Monk island, and Marvin island where this material was observed, the plagioclase laths attain 1 inch in length and the associated augite and magnetite are also very coarse grained.

Several of the wide dykes are composed of lustre-mottled diabase. It is best exposed on Shangoina island and is a dense, hard, massive, fine or medium-grained, commonly grey rock which on freshly fractured surfaces shows lustrous reflections from nearly circular areas about $\frac{1}{4}$ inch in diameter. Microscopic examination shows that the rock is made up of a felt of tiny feldspar laths and that within each of the closely packed, sub-circular areas $\frac{1}{4}$ inch in diameter the augite that fills the interstices is oriented in the form of a crystallographic unit, which occasionally shows twinning. The accessory minerals magnetite and apatite, fine-grained augite, and cryptocrystalline material occur between the feldspar laths in what might be termed the interstices between the large augite units. On the weathered surface the more coarsely crystalline parts of the rock stand up as nodules.

A peculiar dyke occurs near the south shore of Skinaway island and can be traced for 200 feet. The country rock is red, fine-grained, fragmental rock which is bleached buff for 2 inches at the contact. The dyke is 8 inches wide with straight walls, but divides near the west shore of the island into two nearly parallel tongues each about 4 inches wide. It strikes north 60 degrees east and dips vertically. The rock is dense, greyish violet, has a hardness of 3, and in it are a few scattered phenocrysts which now consist of bright green serpentine. These occasionally are in groups. Under the microscope the base cannot be resolved and the phenocrysts, which show sharp, rectangular, crystallographic outlines, are found to consist of a number of independently oriented areas with the obscure optical character common to the secondary minerals, epidote and serpentine. The character and field relations of this peculiar rock and of similar occurrences 1½ miles west of Pass lake and in lots 3 and 5, McTavish township, indicate that it is altered, red, fragmental rock, which has been sufficiently impregnated with magmatic juices from a concealed intrusive below to develop an igneous-looking structure. The further history indicated by the alteration of the phenocrysts is not understood.

There are a few dykes of amygdaloidal basalt in the area. Outcrops were seen at the following places: on the cliff 600 feet west of Shale lake; 3,000 feet south of the east end of Sawyer bay; 1,500 feet south of Mountain lake; and 2,000 feet east of the east end of Sawyer bay. The largest is 4 feet wide and consists of a dense black matrix through which are scattered a considerable number of white calcite amygdules about the size of peas. There are occasionally narrow red rims of laumontite around certain amygdules. The dykes are vertical and cut sedimentary rocks. The apparent lithological identity with Osler amygdaloidal basalts warrants their designation by the same name. Amygdaloidal dykes of this character are decidedly rare. They presumably were intruded under very low pressure, probably near the surface.

An amygdaloidal diabase dyke of unusual character occurs 800 feet south of Shuniah lake and strikes south 70 degrees east. It is a fine-grained rock which when examined closely appears to be made up of a finely mottled green and white matrix with a number of bright red spots scattered through it. A thin section shows that the greater part is of fresh-looking, fine-grained, normal diabase constituents and that the red spots are amygdules. They are about 1 millimetre in diameter and the surrounding plagioclase laths occur in tangential positions. They are composed of an outer hull of chlorite and a central mass of radio-fibrous calcite. The outer portions of these fibres are stained a bright red as if by finely divided hematite. Occasionally the fibrous growth is not symmetrical about the centre and instead the radiating structure starts from one side of the amygdule, producing a hemisphere with a fan-like cross-section.

On Hardscrabble island, 500 feet east of its western extremity, there is a dyke of red, biotite syenite, 1 foot wide, cutting a wide diabase dyke at right angles to its trend. Rounded and angular xenoliths of diabase occur locally in the red rock.

Several peculiar rock types and various phases of diabase occur on Silver islet, Trowbridge island, and the alined islands between. On each of these islands there is a wide dyke which may be the same one throughout.

The dominant rock on Ship island has some of the appearances of a medium-grained diabase, but is a mottled assemblage of pale grey feldspar and dark greenish minerals, among which magnetite can be recognized but not augite. Through certain areas there is considerable disseminated pyrrhotite which appears as a primary accessory constituent. On the weathered surface of this rock, on the north shore, a number of fantastic forms have been produced by the development of pits and ridges. Evidently there is an irregular distribution of the more resistant constituent minerals through the rock. On the south shore there is a seam of pale grey, finely crystalline rock, 4 inches wide. This "dykelet", though sharp walled, shows no chilled edge, nor variation in texture across its width. None of the rock has been sheared. Under the microscope, a specimen of the dominant rock is seen to consist of a very irregular network of microperthite, obscure feldspars with irregularly segregated cloudy patches, and a little quartz, together with localized, irregularly intergrown, green hornblende, brown biotite, chlorite, and magnetite. Slender needles of apatite, and irregular grains of pyrrhotite and pyrite are minor accessory constituents. The pale grey rock of the "dykelet" consists of quartz, cloudy feldspar, and contorted biotite interleaved with penninite, with small amounts of magnetite and pyrite. The irregularity of the boundaries between the constituent minerals and the way they are intermixed resembles the condition found in the dominant rock. Several of the quartz individuals in this pale rock have the shape of clastic quartz grains. The petrographic examination of the rocks from Ship island indicates that the study specimens were taken from parts of the dyke that contained variable amounts of assimilated country rock. In the field one cannot see the walls of the main dyke at this locality.

Narrow selvages of pink diabase occur along both sides of some quartz and calcite veins that cut diabase dykes. Examples may be seen on the north shore of Shangoina island, on the south shore of Burnt island, and in the Perry dyke on the east side of the mouth of Sawbill creek. Under the microscope the pink rock shows a felt of cloudy feldspars with jagged and irregular individual boundaries, together with a small amount of interstitial material composed of calcite and little patches of obscure green and yellow minerals which may be chlorite and uralite. In the hand specimen, the rock has the appearance of the normal diabase except that the feldspar is pink instead of white or pale grey. It differs from pink granophyric interaction product in that it appears to be entirely composed of minerals that can be distinguished by the naked eye; in the granophyric phase which most closely resembles it the recognizable crystals make up only a part of the rock.

On the shore of lake Superior, about 1,000 feet east of Silver Islet landing, a block of porphyritic diabase was found, in which the feldspar phenocrysts have a pale, bright blue colour. In thin section the feldspars are found to be made up of several cloudy plagioclase individuals oriented in different ways. The blue colour is a schiller phenomenon. The ferromagnesian minerals in this rock have been largely altered to yellowish brown uralite.

Metamorphism

By far the greater part of the intrusive rocks is fresh looking and shows no sign of alteration since it solidified.

The inconsiderable volume of intrusive rock which has been metamorphosed, occurs locally in shear zones, near hot solution channels, along fracture planes, and on surfaces that have been exposed for a considerable time to weathering agencies. Minerals such as chlorite, which are usually regarded as products of metamorphism, occur in the intrusive rocks in connexion with the granophyric phases previously mentioned; the process that resulted in their presence is regarded as coming under the head of assimilation and not metamorphism of the intrusives.

In shear zones the intrusive rock is altered to an earthy, dark grey gouge or a chloritic schist.

Adjacent to certain veinlets the feldspars in the normal diabase are altered from grey to pink. On Ship and Pyritic islands the diabase along both sides of quartz veinlets has been silicified. In intrusives adjacent to pyrite-bearing veins such as occur on the Breast south of the east side of the Adam's Apple sill (at the rusty slide) and the north shore of Shangoina island, pyrite has been developed.

A veinlet of cross-fibre asbestos (picrolite variety) has been developed by the alteration of diabase on Middlebrun island, and a subsequently developed fissure, parallel to this veinlet, has been filled with calcite. This is the only known occurrence of cross-fibre asbestos in the map-areas. Veinlets of calcite showing a similar cross-fibre structure were observed on Middlebrun island and in other localities; on dusty surfaces they superficially resemble asbestos. The origin of the cross-fibre asbestos is not fully understood; it may have developed along a solution channel which while gradually tending to open on account of tensional stresses, permitted the ingress of those hot aqueous solutions that cause the alteration of augite to serpentine with an increase in volume. The orientation of the fibre appears to be parallel to tensional stresses acting in the rock and the alteration was possibly controlled by a nicely co-ordinated inter-relationship between the ingress of an altering agency and the decrease in pressure occasioned by tensional stresses.

The intrusive rocks, for the most part, have been only slightly affected by weathering. The surfaces exposed in cliffs show no weathering products; on flat or gently sloping surfaces, the surface commonly shows a brown or reddish brown stain which contrasts with the grey or greenish grey colour of the freshly fractured rock. At a few localities on the tops of mesas, in areas of a few hundred square feet, the upper part of diabase masses to a depth of as much as 2 inches has been disintegrated to a loose granular mass of rust-stained material in which kaolinized feldspar and magnetite grains can be identified.

The country rocks adjacent to the intrusives are, at some places, not altered, at some places, slightly altered, and at other places profoundly altered. Slight alteration has been observed in the red fragmental rocks of the Sibley and Osler series, these being discoloured buff and pale grey over a width of a few inches adjacent to the walls of the intrusive. Blocks of shaly Animikie sediment engulfed by an intrusive, as near Clavet point, have been slightly indurated and a spotted structure developed. Profoundly altered country rocks are presumably represented in zones, of variable width but commonly a few feet wide, of granophyre complex adjacent to the upper sides of some sills and the hanging-walls of some inclined dykes. In these zones there are usually several different varieties of granophyre, all of which consist of irregular intergrowths of quartz, feldspar, and occasionally other minerals. The different varieties of granophyric rock in some zones are so arranged that on one side there is a transition through quartz diabase into diabase and on the other side a transition through rocks, which are commonly mottled, nodular, and spotted, into unaltered country rock. Excellent exposures of zones of granophyre complex occur on Tee point and Pyritic island.

On Tee point a diabase dyke, about 250 feet wide, dips southeast. Nearly flat-lying, Animikie, shaly sediments are exposed on both sides; those on the northwest or foot-wall side show no alteration, but those on the hanging-wall side have been altered to or replaced by a granophyric complex in a zone averaging 3 feet in width immediately adjacent to the dyke, and exposed for a length of 500 feet. The rocks in the outer part of the zone are recrystallized Animikie sediments in which bedding planes are continuous with those in unaltered sediments adjacent. The recrystallized sediment is a grey rock more resistant to weathering than the unaltered sediments and the greater part is so fine grained that mineral constituents cannot be identified even under the microscope. Irregularly scattered through the dense, outer zone are nodular developments varying in diameter from a fraction of an inch to 2 inches, of pinkish grey granophyre, which, under the microscope, show coarse and fine intergrowths of quartz and feldspar. The stratification in the rock bulges around these nodules, thus indicating that the development of the nodules was accompanied by an increase in the volume of the rock.

The middle and main part of the granophyric complex zone viewed from a distance resembles an indurated conglomerate. It consists of nodules, ranging from a fraction of an inch to 6 inches in diameter, of different kinds of granophyre, in a fine-grained, grey matrix consisting of cloudy feldspar, little plates of chlorite, and numerous, tiny, amœboid-shaped masses of microscopical intergrowths of quartz and red feldspar, rimmed with chlorite. The granophyre nodules are pink, grey, or green. They are complicated intergrowths of minerals that meet each other along curving or accrenulated planes. The minerals are quartz, microcline, plagioclase, chlorite, epidote, and biotite; these occur in varying proportions in different nodules. Some nodules are fine grained, others are coarse grained, and some contain both fine and coarse-grained intergrowths. In some nodules, individual plagioclase crystals, like phenocrysts, attain diameters of more than 1 inch, and enclose a swarm of tiny chlorite scales and other material which cannot be identified under the microscope. Roughly spherical groups of large crystals of feldspar occur in some nodules. Some of the nodules are drusy, there being one or more small cavities within single nodules; in a few cases crystalline growths of quartz, calcite, and chalcopyrite were observed projecting into, and forming a lining around the walls of, druses.

The part of the zone immediately adjacent to the diabase intrusive is more homogeneous in appearance than the adjoining nodule-bearing part, though in it there are masses of rock that show the various characteristics of the nodules and matrix of the middle part. The various described phases of granophyre occur in the inner part of the zone in small, irregular-shaped masses which merge into a predominant phase that is fine to medium grained, reddish grey, of igneous aspect, and consists of interlocking grains of cloudy red plagioclase and quartz, irregular-shaped grains of microscopically intergrown feldspar and quartz, and tiny, platy masses with irregular-shaped, tattered boundaries and consisting chiefly of chlorite enclosing biotite and magnetite. The granophyre appears to merge into fine to medium-grained quartz diabase at the wall of the wide dyke. The transition takes place in a zone a few inches wide with no identifiable plane of contact between the rock of the transition zone and the medium-grained normal diabase of the wide dyke.

The greater part of Pyritic island is underlain by diabase, part of a dyke over 200 feet wide and presumably the same dyke as occurs on Silver islet. The dyke dips southeast and the southeastern wall is exposed at a few places and there graphite-bearing granophyre and altered grey stratified rocks occur adjacent to the wall. Within the dyke there is a large included mass of Animikie shale bordered by a zone of granophyre complex. A horizontal section from northeast to southwest, across these rocks as exposed on the easterly end of the island, is as follows:

	Feet	Inches
Grey, medium-grained diabase traversed by irregular seams rich in feldspar which stand out on the weathered surface; several tiny quartz calcite veinlets trend north 40 degrees west	25	0
Sharp contact, no chilled edge on either side, trend north 50 degrees east.		
Fine and medium-grained, pink granophyre with nodules of graphite, and fine-grained pyrite and pyrrhotite	3	0
Medium-grained granophyre with dark grey constituents predominating, pink feldspar, disseminated graphite, small aggregates of pyrite, nickeliferous pyrrhotite, and chalcopyrite with occasional inclusion-like masses of dark grey hornfels with tiny parallel "dykelets" of the pink granophyre through it	2	0
Gradational contact.		
Medium to coarse-grained granophyre with dark constituents (chiefly chlorite) predominating, grey and pink feldspars, finely disseminated graphite; sparsely scattered "druses" as large as one inch in diameter lined with dark green quartz crystals	3	0
Gradational contact.		
Dense, dark, fine-grained rock in part replaced by sulphides; one locality shows a distinct bed, as of Animikie shale, and this when broken shows a central discontinuous layer of dark, dense, aphanitic material, a rim of pyrite, and around this a pale pinkish grey rock	0	6
Gradational contact.		
Fine-grained, pink and greenish grey, recrystallized sediment resembling a fine-grained igneous rock; within this zone are some small patches having the appearance of Animikie sediment with no bedding, other patches of a fine-grained, olive-green rock with segregations of pyrite and pyrrhotite, also a medium-grained pink and green granophyre with abundant disseminated magnetite and with scattered druses half an inch in diameter filled with quartz and calcite	3	0
Gradational contact.		

	Feet	Inches
Grey shale, mottled and streaked with pinkish grey, finely crystallline rock similar to that in the adjacent, above-described zone. The beds strike north 10 degrees east and dip 8 degrees east............	4	0
Continuing across the section the same series of metamorphic rocks is encountered in reverse order....................................	12	0
The contact between the fine-grained, pink, graphite-bearing granophyre and the medium-grained diabase strikes north 75 degrees east.		
Diabase	45	0

Thin sections of a suite of specimens taken across the zone of granophyre complex on Pyritic island show a transition from a fine-grained sediment through an intermediate zone, to a granophyre. In the sediment, shadow-like outlines of a felt of cloudy anisotropic minerals can be resolved. In the intermediate zone tiny, irregular-shaped, nodular intergrowths of quartz and feldspar rimmed with chlorite lie in a groundmass of fine-grained, cloudy, unidentifiable, crystalline material. The granophyre consists of closely packed, club-shaped, vermicular, and branching groups of minerals showing micrographic or irregular intergrowths. Some groups consist of quartz and feldspar, others of plagioclase and microcline, or of chlorite, biotite, hornblende, apatite, and magnetite, and some consist of feldspar and crystalline material of low birefringence, possibly nepheline, clouded with red, dust-like material, probably hematite. Nodules of graphite occur through this phase of granophyre, and in some of the nodules there is pyrite and pyrrhotite.

Samples from Pyritic island representing, respectively, the diabase, the graphite-bearing granophyre, and the shale from the enclosed block were analysed by M. F. Connor of the Geological Survey, with the following result:

—	Diabase	Graphitic granophyre	Shale
SiO_2	54·60	52·31	60·79
Al_2O_3	16·31	16·22	16·79
Fe_2O_3	2·36	0·67	1·05
FeO	6·88	8·36	5·67
MgO	4·23	3·66	2·76
CaO	3·54	1·28	0·96
Na_2O	2·20	3·47	2·80
K_2O	2·25	3·77	3·77
H_2O+	4·30	3·89	4·06
H_2O-	0·55	0·31	0·24
CO_2	....	0·20	....
TiO_2	2·00	1·50	0·80
P_2O_5	0·18	0·03	0·12
FeS_2	0·30	2·26	....
Fe_7S_8	0·08	0·81	0·31
NiO	....	0·04	0·04
MnO	0·07	0·06	0·04
Carbon	....	1·74	....
	99·85	100·58	100·20

"The above were tested for silver, but the traces were so small that very much larger quantities are required to be taken for determination by fire assay to settle the question as to the presence of silver in these rocks."

Macfarlane reported 0·02 per cent silver in the graphite-bearing granophyre on Pyritic island.[1]

Non-graphitic granophyre complexes occur at the following localities, in addition to that of Tee point: (1) between diabase and grey shaly rocks of the Rove formation; the broad peninsula southwest of Perry bay; Catholic point, east of Perry bay; the water supply tunnel northeast of loch Lomond; south of Fort William and Port Arthur map-area, on Spar, Jarvis, and Victoria islands; and Pigeon point, Minnesota; (2) between diabase and Gunflint iron formation; Shuniah mine; Thunder Bay mine; and Sugarloaf hill near Navilus; (3) between diabase and basic lava of the Osler series; Porphyry island; an unnamed island west of Porphyry island; and the southern extremity of Edward island.

Graphite-bearing granophyre complexes occur at the following localities, in addition to that of Pyritic island; Silver islet; Keshkabuon island; and Edward island. On Edward island the graphite-bearing granophyre grades into an impure quartz sandstone in which are nodules cemented with calcite. On Keshkabuon island the graphite-bearing granophyre occurs adjacent to calcareous shale. Neither graphite nor black carbonaceous material was observed in the unaltered rocks adjacent to the graphite-bearing granophyre of any of these localities.

The feldspathic composition and crystalline structures of the granophyre complexes, their situations adjacent to intrusive sheets, and the gradation between granophyre and intrusive on one side and between granophyre and country rock on the other side, indicate that the granophyre probably was formed by interaction between the country rock and an agent from the adjacent intrusive. The lack of granophyre along the walls of some diabase dykes and its presence along the upper side of inclined sheets not so bordered along their lower side, suggest that the altering agent tended to rise and to escape from the intrusive. The probability that magmatic water or other volatile material was given off by the intrusive and received in the granophyre is indicated by the presence of druses in granophyre complexes. A comparison of the analyses of the diabase, granophyre, and shale of Pyritic island shows that soda, sulphur, and carbon dioxide are each more abundant in the granophyre than in the shale or the diabase. Presumably these constituents were contributed to the granophyre and came from the magma of the intrusive.

Faulting

At many places intrusives occur in faults and it is probable that most of the intrusives occupy faults. The apparent displacement, where determinable, of strata on either side of dykes is usually between 5 and 50 feet, but the amount of dislocation along many of the faults could not be determined.

Faulting has also occurred after the consolidation of some of the intrusives. A number of nearly vertical faults, with displacements of commonly tens of feet, have been observed in all of the thick sills in the map-

[1]Macfarlane, Thos.: Canadian Naturalist, 2nd ser., vol. 4, 1869, p. 461.

areas and, as in the case of the capping sill on the Sleeping Giant, diabase dykes occupy some of these faults. At a few localities, as at Silver islet and on the adjacent mainland, faulting has been observed in dykes.

Age

Intrusives of diabase and related rocks occur over a very extensive area, including all that part of Lake Superior region that is underlain by Precambrian rocks. All these intrusives presumably were emplaced during the same geological period and probably came from a parent body of enormous dimensions. The intrusives cut the Kaministikwan as well as older strata and are either of Kaministikwan or post-Kaministikwan age. The close resemblance in composition of the intrusives and the lavas of the Kaministikwan group suggests genetic affinities and an intimate age relationship.

The intrusives were not all injected at the same time. Some dykes east of Thunder cape do not appear to have been dislocated at places where they intersect the inferred courses of faults that nearby have affected other dykes, and it is possible, therefore, that the first-mentioned dykes were intruded subsequent to the latter and after faulting had occurred. At many places one intrusive cuts another and shows chilled edges, indicating that at least sufficient time had elapsed to permit the earlier intrusive to become relatively cold. Dykes cutting capping sills may be seen on the Sleeping Giant, Thunder cape. Examples of dykes cutting other dykes, occur at the following localities: a few hundred feet north of the east extremity of Sawyer bay; 1,200 feet south of Shuniah lake; and near the middle of the south shore of Shangoina island. Field studies failed to discover any general, noteworthy difference in composition between earlier and later intrusives.

In 1893, Lawson[1] interpreted the intrusives as being post-Keweenawan, and proposed the name Logan sills for the nearly flat-lying sheets. A common usage, in recent years, has been to regard the intrusives as being Keweenawan, and thereby to imply that the sills and dykes are probably intrusive phases of the vulcanism evidenced by the so-called Keweenawan lavas. But since it is known that basic lava was also extruded in Animikie time, it is not improbable that there were Animikie intrusives, probably of diabase or related rock. This being the general situation it seems preferable to class the intrusives as being of Kaministikwan rather than Keweenawan age, for the use of the latter term implies that all are post-Animikie.

PLEISTOCENE AND RECENT

General Statement

The following statement regarding the Pleistocene history of an extensive area of which Fort William and Port Arthur, and Thunder Cape map-areas form a small part, is drawn from a publication by Frank Leverett.[2]

[1]Lawson, A. C.: Geol. and Nat. Hist. Surv., Minn., Bull. No. 8, pp. 24-48.
[2]Leverett, Frank: "Moraines and Shore Lines of the Lake Superior Region"; U.S. Geol. Surv., Prof. Paper 154A (1929).

The Pleistocene glacial formations in America include a complex series of deposits, there being four distinct sheets of boulder clay separated by soils and non-glacial deposits formed during stages of deglaciation. Aside from the four distinctly recognized drifts, there is, in Iowa and part of bordering states, a glacial deposit of debatable rank and age which has been termed Iowan drift. In order, from oldest to youngest, the drift sheets of the Great Lakes and Mississippi Valley region are as follows:

(1) Nebraskan drift
(2) Kansan drift
(3) Illinoian drift
(4) Iowan drift (a deposit of debatable rank and age)
(5) Wisconsin drift, separable into early, middle, and late Wisconsin

The first and second drift sheets are best displayed on the west side of Mississippi valley, but one of them, probably the Kansan, has been recognized as far north as the north side of Lake Superior basin, in the Kaministikwia drainage basin back of Fort William, Ontario. These drift sheets have been covered by the Illinoian drift to a large degree in Illinois, Michigan, Indiana, and Ohio. The latest or Wisconsin is the uppermost deposit over fully 90 per cent of the glaciated area of North America, and is thus more widely open to inspection than the earlier drifts. A study of the distribution of its moraines and of the materials embodied in it has served to show that the outline or shape of the ice field and the direction of ice movement were subject to wide variation. In the early part of this glacial stage (substages 1 and 2) the ice appears to have moved southwestward from Labrador across the Great Lakes into central Illinois. At that time it may not have extended into the region north and west of the Driftless area in Wisconsin, Minnesota, Iowa, and the Dakotas. But later the ice-sheet appears to have extended westward so that in the midst of this stage of glaciation (substage 3) its highest part, or centre of radiation, was in the district of Kenora, Patricia portion, in Ontario, north of the Great Lakes. The ice then moved southward across the eastern part of the Lake Superior basin and through the basin of lake Michigan into Indiana and Illinois. At the same time it moved slightly west of south across the west end of Lake Superior basin into western Wisconsin and eastern Minnesota. It deposited the sheet of young red drift of that region called the Patrician drift.

After the Patrician drift was deposited there appears to have been less snowfall in the region north of the Great Lakes and a corresponding shrinking of the ice in the Lake Superior region, and, presumably due to an increase of snowfall in central Canada, ice moved from what is known as the Keewatin Centre of glaciation southward across Manitoba and beyond to the site of Des Moines, Iowa. There were two minor lobes in eastern Minnesota branching off from the main lobe.

It was at this time (substage 4) that the lobe in Lake Superior basin reached its fullest extent. The ice at this time moved much farther southwest through the deep basin of lake Superior than it did over the relatively high land lying northwest of the lake in Minnesota. The ice there appears to have had a movement west of south and to have reached a little beyond Vermilion lake and Lake of the Woods. This ice coalesced with that in Lake Superior basin from eastern Lake county, Minn., northeastward into Canada. It probably also coalesced with that moving south from central Canada in the district west of Lake of the Woods. Later (substage 5) the ice from central Canada extended past this line of coalescence in Manitoba and northern Minnesota.

Toward the close of the Glacial epoch there was a recession of the great ice-sheet; and the melting of the Superior lobe within the area that now drains to lake Superior supplied water which became ponded along the ice border in several independent lakes, to which names have been applied that correspond usually to the names of the present drainage districts on the same site.

As melting continued, the independent lakes spread over wider areas and some of them coalesced, and at one time the western part of the Lake Superior basin was occupied by a large water body known as Lake Duluth.

On the north side of Lake Superior basin, Lake Duluth extended eastward step by step with the recession of the ice border. During the recession the outlet became deepened. The highest beach of the eastern part of the north shore does not correspond with the highest beach of the western part, but is the continuation of one of the lower beaches. The same thing is true of the beaches on the south shore, the highest beach of Lake Duluth in Michigan is lower and is believed to be younger than the highest beach west of Bayfield peninsula. Lake Duluth was lowered step by step as lower and lower lines of border drainage were opened by continued recession of the ice border. Eventually the waters were lowered to the level of Lake Algonquin, and that body of water occupied the western part of Lake Superior basin as well as the basins of lakes Michigan and Huron, and finally the eastern part of Lake Superior basin.

An extensive area including Lake Superior basin was subject to warping in late Pleistocene time, the northern part of the area being uplifted relatively more than the southern part. Ice recession continued and the level of Lake Algonquin was lowered step by step. The position of several outlets from Lake Algonquin have been recognized and a history of a changing discharge has been worked out.

At a stage when the discharge was eastward past North Bay through Ottawa valley, Lake Algonquin passed transitionally into Lake Nipissing. This great water body occupied the basins of lakes Superior, Michigan, and Huron. Differential uplift raised the outlet at North Bay so high that the lake waters were brought up to the St. Clair outlet at Port Huron and for a while the discharge was divided between the two outlets.

The Nipissing Great Lakes came to an end when continued warping so raised the North Bay outlet that the whole discharge went through the St. Clair outlet, as at present.

A fragmentary record of the events reviewed in the foregoing statement is presented in Fort William and Port Arthur, and Thunder Cape map-areas in the form of glacial striations and other erosion features, and in a widespread mantle of irregular thickness of till, stratified gravel, sand, silt, and clay.

Glacial Deposits and Erosion Features

Evidence of the erosive action of glaciation is to be seen throughout the map-areas; the products of weathering were scoured from the surface of the consolidated rocks; talus along the base of cliffs was selectively removed so that there is now no uniform relation between the heights of cliffs and the amount of talus along their base; the uplands were sculptured in a manner peculiar to glacial action, smoothed hummocks and jagged crags occurring respectively on the stoss and lee sides of hills; and parallel systems of grooves and glacial striæ were engraved on surfaces of hard rocks such as granite, sandstone, and diabase. Glaciation considerably modified the minor details of the pre-existing topography.

The directions of glacial striæ as observed at several localities are shown on the accompanying map (197A) and on Map 203A. Two groups of striæ occur trending in markedly different directions. One group, found in the northwest part of Fort William and Port Arthur map-area, has a general trend south-southeast. The other group, found in various parts of the map-areas other than the northwest part of Fort William and Port Arthur map-area, has a general trend southwest. On the summit of mount McKay an outcrop reveals two sets of grooves and striæ, one set trending south 20 degrees east and an intersecting set, of later development, trending south 68 degrees west. In Current River park, Port Arthur, striæ trending south 80 degrees east appear to be intersected by striæ of later development trending west.

It is considered probable that the glacial striæ observed in the map-areas were all formed during the latest (Wisconsin) stage of glaciation and that the ice advanced from a north-northwest direction and subsequently, as indicated by intersecting striæ, the direction changed, the general direction of movement being from the northeast. It is possible that these ice movements from different directions occurred during substages 3 and 4 of the Wisconsin stage, as recognized by Leverett and mentioned in foregoing statements.

Till sheets of different ages were not identified in Fort William and Port Arthur map-area. Presumably all till there observed was formed during the Wisconsin stage of glaciation. A few miles west of Fort William and Port Arthur map-area, in the vicinity of Kakabeka Falls and Hymers, two sheets of till are exposed, separated, at each locality, by stratified sand and gravel deposits scores of feet thick. Leverett states[1] that an early drift, probably the Kansan, has been recognized in the Kaministikwia drainage basin back of Fort William. According to this statement the lower till sheet of the two localities west of the map-area was probably formed during the Kansan stage.

Glacial till occurs as a mantle of irregular thickness throughout the map-areas. Its distribution in Fort William and Port Arthur map-area is shown on Map 197 A.

The till consists of unstratified clay or other fine-grained material in which large and small, angular, subangular, and rounded fragments of rocks are irregularly distributed. The large fragments include boulders

[1]Leverett, Frank: U.S. Geol. Surv., Prof. Paper 154A, p. 18 (1929).

commonly several feet, and occasionally a few yards, in diameter. Some of the boulders show striations and polished facets. The composition of the boulders and of the matrix varies from place to place, though at all localities numerous varieties of rocks are present. Boulders of sandstone and red fragmental rocks, such as occur in the Sibley series, have been observed along with other boulders in glacial till at localities distributed throughout the extent of Fort William and Port Arthur map-area.

The colour of the matrix of the till varies. At some localities it is grey and at others it is greyish or reddish brown. In parts of Oliver and McIntyre townships the matrix of the till is strikingly rust coloured, presumably due to ferruginous material scoured from the Animikie iron formation. At a locality 2¼ miles north of Murillo, Oliver township, the matrix of the till, exposed for a depth of a few feet and lying on Animikie iron formation, is reddish brown; half a mile southeast of this locality the till, exposed for a depth of a few feet and lying on Animikie dark grey shale, is dark grey. At the latter locality the upper layers of the shale for a depth of a few inches beneath the till are crumpled and, locally, the disturbed layers extend up into the till, and disjointed blocks of these layers have been incorporated therein. Apparently the colour of the till matrix for at least a short distance above soft Animikie rocks may be that resulting from the pulverizing of the underlying rock.

Glacial outwash deposits occur over a considerable part of Fort William and Port Arthur map-area. South of Kaministikwia river, they occur in the depressions on the highlands and consist of gravelly sand and silt. North of Kaministikwia river, glacial outwash deposits of two types are differentiated on the accompanying map (197A). One type occurs as plains and fans at various elevations, and consists of gravelly sand and silt, showing stratification. Boulders, up to several feet in diameter, are sparsely scattered in an irregular manner through these deposits. The second type occurs in elongated areas less than a quarter mile wide and commonly appears as ridges rising a few feet, locally as much as 30 feet, above the surrounding country. The ridges consist of well-stratified gravel and sand which commonly show crossbedding; a few boulders up to several feet in diameter occur at intervals in an irregular manner. In a gravel pit about 1½ miles northeast of Baird village, a 25-foot section through crossbedded fine gravels and sands shows groups of beds dislocated along faults which have a throw of a few inches. It is inferred that the faults were caused by the melting of ice that had been buried by the sand and gravel.

Delta, Terrace, and Lake-Bed Deposits of Glacial Lakes

Leverett says[1] " The eastern limits of Lake Duluth on the north coast of lake Superior have not been determined. It is known, however, that the lake extended at least to the Kaministikwia River basin, back of Fort William, Ontario." And further,[2] " Observations were made with aneroid barometer on McKay mountain, south of Fort William, Ontario, which

[1]Op. cit., p. 58.
[2]Op. cit., p. 59.

indicate lake action up to 1,350 feet above sea-level, or about 200 feet below the top of the mountain."

The present writer did not identify, in Fort William and Port Arthur map-area, beach deposits higher than 850 feet above sea-level. Differential erosion features occur at several different elevations up to 1,350 feet on the steep sides of the mesas in the area south of Kaministikwia river and on Pie island, where diabase sills occur in and over a succession of nearly flat-lying Animikie sediments.

Rock benches occur at the elevations where diabase sills and strata resistant to erosion occur, and there are receding parts of cliffs at various elevations where soft, shaly rocks occur with, locally, shelves of relatively resistant strata or diabase sheets projecting above them. Till has been observed on broad benches higher than 850 feet above sea-level. Recent talus accumulations commonly cover a part of all benches.

The distribution of the raised lake beaches is shown on Map 197A. They occur at various elevations up to 850 feet above the sea. The highest on record is about 1½ miles northwest of Alba station. A prominently developed succession of beaches and terraces occurs in the area west of Whiskeyjack and Grand points and rises inland on the flank of mount McKay and the adjacent upland extending southerly to Squaw bay. The highest lake beach observed on mount McKay is 835 feet above sea-level. The beaches on the flank of the upland in the vicinity of mount McKay consist of water-worn, large and small fragments of Animikie sediments and diabase, materials the same as those in the talus deposits of this locality. Beaches at a considerable distance from cliffs consist of sand and gravel.

A succession of beaches and terraces is well exposed in the city of Port Arthur. Terraces at the following elevations[1] above sea-level, 772·1, 750·8, 720·4, 697·7, and 691·8 feet, are regarded as terraces formed during successive stages in Lake Algonquin. A lower, prominently developed terrace at, according to Lawson, an elevation of 663·4 feet above the sea, and on which the principal business portion of the city is built, is generally regarded as a terrace formed during an early stage of Nipissing Great Lakes, following the identification of this feature by Taylor.[2] Other terraces, presumably formed during stages of Nipissing Great Lakes, occur at elevations of 645 and 628 feet, respectively, above sea-level.

In Thunder Cape map-area, successions of raised beaches and terraces are well developed in the depressions that extend inland from Perry and Sawyer bays, respectively. Details regarding the elevations of these beaches have been published by Lawson.[3] The highest beach observed in this map-area by the present writer is south of Sawyer bay at an elevation of 835 feet above sea-level. A succession of rock benches and cliffs showing differential erosion occurs on the sides of mesas between Thunder cape and Sawyer bay, which rise to about 1,700 feet above sea-level; the writer was unable to identify as due to post-Glacial lake action erosion features above an elevation of 835 feet.

[1]Lawson, A. C.: 20th Ann. Rept. Geol. and Nat. Hist. Surv., Minn., p. 262 (1891).
[2]Taylor, Frank B.: Am. Geol., vol. XX, p. 114 (1897).
[3]Lawson, A. C.: pp. 266-268.

Wave-cut caves are prominently developed on cliffs in Thunder Cape map-area. In the southern part of Sibley peninsula they are more numerous at an elevation of about 670 feet above the sea than at other elevations; and some of them are deeper than any found along the present lake shore. It is possible that the water level remained at this elevation, nearly 70 feet above the level of lake Superior, longer than at any stage of the receding lake and that it stood there longer than lake Superior has stood at its present level.

Lacustrine deposits of clay, silt, and fine sand occur in areas where lowlands extend back from the shore of lake Superior.

A thick deposit of fluviolacustrine origin underlies the easterly sloping plain in the lowlands drained by Kaministikwia river. This, as stated by Lawson,[1] is the largest and most impressive delta on the north side of lake Superior. The deposit consists of boulder-bearing, poorly stratified sand and clay, and of well-stratified clay, silt, fine sand, and gravel and stony sand. The distribution of these several materials on the present surface is shown on Map 197 A.

Vertical sections through parts of the deposits are exposed at many places along the entrenched channel of the present Kaministikwia river. Due to engineering work at Westfort information is available regarding the vertical distribution of materials in the entire deposit there. It is reported[2] that solid Animikie rock lies about 100 feet beneath the surface of the plain on which the town of Westfort is built; that on the rock lies a layer of conglomerate 4 to 6 feet thick, and above this a deposit of stratified blue clay between 60 and 90 feet thick, the surface of which has been eroded in channels, and that on this uneven surface there are crossbedded sands varying from 4 to 40 feet in thickness filling up the inequalities on the clay surface and forming the plain at the present surface. The elevation of the plain at the west end of Westfort is 638 feet above sea-level.

In the partial sections through the deposit exposed west of Westfort, evenly stratified deposits of clay and silt are overlain by deposits of gravel and sand which commonly show crossbedding. Some of the gravel deposits such as are exposed near Twin City junction and a few miles farther west near Stanley, are coarse and consist in part of boulders more than 6 inches in diameter; they were evidently transported in a swiftly flowing river.

The distribution of the various materials in the deposit is interpreted as due to the building up of an easterly advancing delta in lake Algonquin and the later stages of this great lake. Presumably a large river flowed easterly in Kaministikwia River valley into Lake Algonquin transporting sediments; the finer clayey material was deposited over a very considerable area in the bottom of the lake, and the relatively coarser material was deposited over a less extensive area near the mouth of the river, as a delta. During all stages of the great lake the delta deposit was being built up outward into the lake and as the level of the lake dropped step by step

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[1] Op. cit., p. 210.
[2] McKellar, P.: Communication to Director, Geol. Surv., Canada, dated Sept. 5, 1918.

the accompanying changes in the base level of erosion caused a more rapid lakeward extension of the delta than if the level had remained constant. When the surface of the lake dropped below the level of delta deposits formed during an earlier stage, these deposits were channelled, re-worked by river currents, and contributed to new delta deposits extending lakeward.

The process of delta formation was probably continuous during all stages of Lake Algonquin, of which there is record in this area, and during the Nipissing Great Lakes stage down to the present time. Kaministikwia river is continuing the work of the ancestral river; it is deepening its trench in the delta and lake bed deposits formed during the higher stages of the great lake and it is contributing to the delta deposit now forming. In Recent time the course of the meandering river below the junction of Slate river has changed from time to time, and oxbow lakes, former river channels, occur in the low land adjacent to the present stream.

Within 2 miles of the present lake shore, Kaministikwia river bifurcates twice and flows into the lake through three distributaries known as Fort William river, McKellar river, and Mission river. Subaqueous channels continue into the lake beyond the mouths of these rivers through the delta deposit. The subaqueous channels continuing beyond Fort William river and Mission river have been modified and deepened by dredging.

The dredging operations that have been conducted in the bed of Kaministikwia river at and below Westfort, effectively retard the normal geological changes in the lower part of the river. The turning basin, 5 miles upstream, acts as a settling basin for sediments other than the finest mud, and the channel for lake-going steamers below this point has been excavated in tough clay which does not readily erode under the action of the slow-moving current.

Relics of Prehistoric Man

Relics of prehistoric man have been found, according to Mr. Peter McKellar,[1] at a number of places in Kaministikwia River valley, in addition to the four regarding which he has supplied the following information.

Relics were discovered July, 1918, in an excavation made by the Canada Car and Foundry Company "about eighty (80) feet north from the turning basin," Westfort. "About twelve (12) bones of a mammal and a finely made copper spear-head were found together, about forty (40) feet below the surface of the ground."

A discovery of relics was made, in 1913, about 680 feet north of the turning basin, Westfort, "in the Stanley Street sewer, at a depth of about forty (40) feet. They appeared to rest on clay, same geological horizon as that of No. 1" (the previously described site). "Many copper tools were found." . . . .

In 1914, relics were discovered on Mountain avenue, Westfort, about 3,400 feet north of the first described site. "Here the skeleton of a man

[1]Communication to the Director, Geol. Surv., Canada, dated Sept. 5, 1918.

was found four (4) feet below the surface of the ground, in a sitting position, height five (5) feet, four (4) inches. Near him were a number of copper tools, three square copper chisels each a foot long, and one flat and one half round chisel." Also a copper adze.

"A discovery of relics was made in 1872 in the McKellar garden on island No. 1, Fort William, about one hundred and fifty (150) feet back from the junction of Kaministikwia and McKellar rivers. The plough turned up seven (7) or eight (8) copper tools in a bed of ashes. The tools were much eroded and covered with green carbonate of copper."

Relics found at the first-mentioned site were submitted to the Geological Survey and Mr. Harlan I. Smith, archæologist, reported[1] the results of examination as follows:

"According to Mr. Lawrence M. Lambe, vertebrate palæontologist of the Geological Survey and Mr. Sternberg, preparator of palæontological specimens, the bone marked B11...... is of a cloven footed animal, possibly a buffalo or a specimen of domestic cattle...... Bones marked B1 to B10 and B12 to B13 inclusive, Mr. Lambe and Mr. Sternberg both pronounce to be those of the horse and not petrified. Mr. Sternberg is convinced that most of them belong to one individual, and probably all of them belong to the same individual.

The point with flanged tang made of copper marked C1......, is characteristic and typical of prehistoric Indian handiwork. Many like it have been found. They belong to a rather highly developed and comparatively recent culture."

The deposits in Westfort, above the clay referred to by McKellar, consist of sand and gravelly sand in which there is evidence of current action. They were presumably laid down in the delta of the ancestral Kaministikwia river and at a time when the level of the great lake, either a stage of Nipissing Great Lakes or Superior, was lower, possibly only a few feet lower, than 638 feet above sea-level (which is the elevation of a place on the higher, western part of the plain at Westfort). Since that time the level of the lake has dropped and Kaministikwia river has entrenched its valley at Westfort, so that its high water surface is about 30 feet below the top of the old flood-plain. The time involved in bringing about these changes might be of the order of a few thousand years.

If the relics found near the Turning basin, Westfort, were overspread by sandy deposits about 40 feet deep, as one would gather from Mr. McKellar's statement, the relics might reasonably be inferred to be of great antiquity, possibly thousands of years old. The horse bones, identified by competent authorities, however, could not, in this region, be older than about 400 years; because, as is commonly known, the horse was introduced on this continent by Europeans. It seems probable that the arrival of the horse in this region would be much more recent than 400 years ago, and at present it is difficult to understand how these bones could have been overlain by deposits about 40 feet thick near Westfort.

Salt Water Springs

Saline springs occur at several localities near the shore of lake Superior between Port Arthur and Schreiber, and in Nipigon River basin. The positions of those that have been observed on Sibley peninsula are shown on the accompanying map, No. 1902. The waters of Silver Islet mine are saline.

[1]In a communication to Mr. Peter McKellar, dated Nov. 21, 1918, on file Geol. Surv., Canada.

A sample of water from the spring west of the northern end of Marie Louise lake was analysed by E. A. Thompson, of the Mines Branch, and he has recalculated for purposes of comparison a published analysis by Adams[1] of a sample of Silver Islet mine water, with the following results:

Analyses of Filtered Water

(Parts per million)

—	Adams, 1885 Recalculated	Thompson, 1919
Sodium (Na)	6,613·5	226·2
Potassium (K)	240·3	32·0
Calcium (Ca)	6,302·2	127·8
Magnesium (Mg)	328·8	48·4
Iron (Fe)	....	3·5
Aluminium (Al)	....	10·6
Sulphuric acid (SO_4)	47·4	....
Carbonic acid (CO_3)	not detd.	120·0
Nitric acid (NO_3)	....	trace
Chlorine (Cl)	22,305·7	603·5
Silica (SiO_2)	54·0	5·0
	35,891·9	1,177·0
Total solids by direct experiments dried at 180° C	35,956·6	1,196·0
Specific gravity at 15·5° C	1·028	1·001
Reaction	Neutral	Neutral
Taste	Strongly saline (salty) with bitter after taste	Very mildly saline (salty)

The salt springs may be recognized in Thunder Cape map-area by the evidences of much wild-animal traffic in their vicinity. The springs are rather small ebullitions coming up through sand and clay and every spring that has been found lies only a few feet from a freshwater stream.

At localities northeast of Thunder Cape map-area where saline water has been observed issuing from fissures in consolidated rock, the saline water in every case came from crevices in faults that had been partly cemented by veins of the silver-bearing type. In Silver Islet mine the saline water rises along fissures in a fault zone partly cemented with silver-bearing vein material. At some of these localities the saline water emerges from crevices in Kaministikwan strata; at Silver Islet mine, from crevices in diabase; and on lot 9, concession IV, Nipigon township, from crevices in Early Precambrian granite.

Solutions of similar character to the saline waters of this district have been reported[2] as occurring in the deep workings of iron mines in Michigan, in deep copper mines of Lake Superior region, in deep wells in the Palæozoic of the upper Mississippi valley, and elsewhere.

Van Hise and Leith state[3] "that these peculiar salt waters seem to be characteristic not only of marine sediments but of sediments of sub-

[1]Geol. Surv., Canada, Rept. of Prog., vol. I, N.S., pt. M, p. 17 (1886).
[2]Van Hise, C. R., and Leith, C. K.: U.S. Geol. Surv., Mon., vol. 52, p. 544.
[3]Op. cit., p. 544.

aerial origin, of surface eruptives, and of plutonic igneous rocks. They are related to depth and stagnancy rather than to kind of rock or geologic horizon." And these authors infer that the salt waters are meteoric waters which have leached various salts, including chlorides, from wall-rocks during circulation and that during slow circulation at depth the less soluble salts have been precipitated, and that there has been a progressive accumulation of the more soluble chlorine salts. A large factor in the accumulation of salt in water bodies at the earth's surface is the lack of sufficient circulation to carry off and dilute the salt waters that are developed by evaporation. "In deep underground waters there is essentially the same condition of stagnancy". . . . . . "In the shallower mine waters the rapid circulation and accession of fresh waters from the surface prevent such accumulation of salt."

SUMMARY STATEMENT OF GEOLOGIC HISTORY

The sequence of events which have taken place in the map-areas may be summarized as follows:

(1) Period of volcanic activity during which lavas and sediments of the Schist Complex were deposited.

(2) Batholithic intrusion of granite during an early, or early stage of a, period of mountain building.

(3) Period of erosion during which granite intrusives were unroofed and debris from Schist Complex and granitic intrusives formed Windigokan sediments.

(4) Batholithic intrusion of granite during a late, or a late stage of a, period of mountain building; Windigokan sediments as well as rocks of the Schist Complex were folded and metamorphosed.

(5) Extremely long period of erosion during which extensive peneplanation took place.

(6) Period during which large portions of the soil cover of the peneplain surface were removed, crystalline rocks were scoured down to a fresh surface, and a hummocky or mammillated topography was developed.

(7) Period of submergence during which Animikie sediments and lava accumulated.

(8) Period of disturbance during which Animikie strata were locally uplifted and eroded.

(9) Period during which Sibley sediments accumulated.

(10) Period of disturbance during which Sibley strata were locally uplifted and subjected to erosion.

(11) Period during which Osler sediments and lavas accumulated.

The events (7) to (11) inclusive are inferred to have taken place contemporaneously with the rise of a hypothetical batholith in the site of lake Superior. This batholith presumably sustained volcanic activity intermittently during the combined periods (7) to (11), and during the effusion and release of its molten rock and gases, the rocks about its chamber collapsed, from time to time and at various places, in such a way as to cause changes in the limits and depth of the basin of deposition which occupied the site of the north shore of lake Superior in Thunder Bay district. Differential collapse in different areas accounts for local uplifts above the basin of deposition. At various times during the period of volcanic activity, dykes of diabase and related rocks were intruded into the rocks overlying the hypothetical batholith and during a late part of the period (11) faulting, presumably due to differential collapse of rocks above the batholith, and diabase intrusion occurred in the map-areas on a more extensive scale than previously. Some faults, which developed later than some of the diabase intrusives, were cemented with mineralized vein material.

(12) Period of extensive erosion.

(13) Period of ice invasion, during which rock scouring and deposition of morainic materials occurred.

(14) Period of ice retreat, during which glacial lakes formed and land warping occurred.

(15) Period following ice retreat when present drainage system was established.

CHAPTER IV

ECONOMIC GEOLOGY

On the following pages are given details of the mineral deposits of the two map-areas and of the silver-lead-zinc-bearing veins in a larger area, which with a width of about 25 miles extends for about 150 miles from Nipigon bay to the International Boundary. Much of the information here given has been drawn from the report, by E. D. Ingall[1], made at a time when mining was more active in this district than it has been in any subsequent period. Notes are given regarding the occurrence of copper, iron, and molybdenite deposits in the above-mentioned larger area.

Silver ore deposits have been the principal source of mineral production in the district. No metalliferous deposits are being mined at present.

Soils of agricultural value are of very limited extent in Thunder Cape map-area. A description is given of the soils in Fort William and Port Arthur map-area.

SILVER, LEAD, AND ZINC

GENERAL STATEMENT

The silver-lead-zinc region in Thunder Bay district embraces an area on the north shore of lake Superior 150 miles long and 25 miles wide and extending from the International Boundary northeasterly to Nipigon bay.

The history of mining in this region commenced in 1846 when the first mining locations were taken up. Several parcels of land, each embracing 10 square miles, were located in that year. A period of intensive prospecting followed the discovery of rich silver ore at Thunder Bay mine in 1866 and before the end of 1868 numerous veins of the silver-bearing type were found close to the north shore of lake Superior east of Fort William including Silver Islet vein, the richest of all the known deposits. The Silver Islet vein was found in the course of a geological examination of a mining location that had been taken up 22 years previously. Between 1882 and 1891 the silver-bearing area was explored and developed west of Fort William to the vicinity of the International Boundary. The more important mines in this part of the region are in two groups, one of which is at Silver mountain, the other in the vicinity of Rabbit mountain. Beaver mine, one of the latter group, was the greatest individual producer west of Fort William. Since 1892, nearly all the numerous mines in the region have lain idle, but from time to time a re-examination or further development of known veins has resulted in additional production from certain mines. The largest production since 1892 has come from West End Silver Mountain mine. The most recent production of silver ore was from Silver Islet mine in 1922.

[1]Ann. Rept. Geol. and Nat. Hist. Surv., Canada, N.S., vol. III, pt. H, pp. 1-131 (1887).

Ever since the commencement of mining activity in this region it has been known that local concentrations of lead, zinc, and copper minerals occur in the veins of the silver-bearing type and that these minerals are more widely distributed and more evenly disseminated through individual veins than the silver minerals. Lead ore was produced from Enterprise mine, McTavish township, in 1872. More recently, and particularly since 1926, several veins in the region northeast of Thunder bay have been developed in the hope of proving the existence of lead and zinc ore-bodies of commercial value.

The veins on Jarvis and McKellar islands in lake Superior have been mined for barite.

Three mines were in operation in the region in 1927, Neepatyre and West End Silver Mountain mines and a property on Whitefish river west of Strange township. At each of these, pebble dash for stucco work was produced from vein material consisting chiefly of coarsely crystalline calcite.

Development work has been done on at least one hundred and seventy-five veins distributed throughout the region. All these carry metallic minerals locally. The production from the silver mines up to 1913 has been recorded[1] as follows:

Mine	Value of ore produced
Silver Islet	$3,250,000
Silver Mountain	500,000
Beaver	550,000
Badger and Porcupine	300,000
Rabbit Mountain	50,000
Thunder Bay	20,000
Shuniah	50,000
3A and Beck	10,000
Jarvis Mining Co	40,000
	$ 4,770,000

Subsequent to 1913, $10,000 worth of ore was produced from Silver Islet mine, in 1922. Since 1922 there has been no production of silver ore.

Veins were being developed in 1927 as lead-zinc prospects at the following localities: Silver lake, near Loon; Pike lake, near Pearl station, Canadian Pacific railway; mining lots A, B, and C, McTavish township; a group of claims held by E. Nurmela, east of Ancliff station, in lots 3, 4, 5, and 7, McTavish township; properties in Dorion township, locally known as Ogema, Dorion, and Malotte mines, and on recently discovered veins on lots adjoining or lying between these properties; an unsubdivided area west of Wolf lake and less than 3 miles north of Dorion township; Nipigon township southwest of Nipigon village; and the vicinity of Ozone station on the Canadian Pacific railway.

The region in which the veins occur is underlain by a complex of ancient, schistose volcanic and sedimentary rocks and intrusive granite and granite-gneiss, classified as Early Precambrian. Lying unconformably above is a group of nearly flat-lying strata in which three series are recognized: Animikie, Sibley, and Osler. All of the above-mentioned rocks have been intruded by diabase dykes; and, in the flat-lying strata, there

[1]Ont. Bureau of Mines, vol. XIX, pt. 2, p. 208 (1913).

are also extensive diabase sills up to 250 feet thick. These intrusives and the strata younger than the Early Precambrian are now classified as Late Precambrian.

Subsequent to the intrusion of the diabase a great number of nearly vertical faults and fissures were developed whose positions and trends bear a relation to those of the dykes and inclined sills, there being a considerable number parallel and a smaller number at right angles to the strikes of these intrusive masses. The majority of the faults that have been examined occur in two nearly parallel zones separated, on an average, by a distance of 15 miles; the northerly zone passes along the north shore of Thunder bay and the southerly embraces the chain of islands, locally known as the Macfarlane belt, which extends for many miles east-northeasterly from near the mouth of Pigeon river.

Fissures in the faults were cemented by vein-forming minerals. The fissure fillings are of the following types: simple veins, composite veins, and vein material occurring as cement around brecciated fragments of country rock along shatter zones. Variations between simple veins and breccia cement may occur in a single vein system within short distances, these changes being due largely to the physical properties of the enclosing rock, and, to some extent, to the amount of deformation that took place when the fissuring occurred. Simple veins range in width from a fraction of an inch up to 70 feet. In the majority of the vein systems the greater part of the fissure filling is within zones less than 20 feet wide either in a tangle of veins of various widths and which, individually, pinch and swell when traced through distances of a few yards; or disposed in the more irregular form of a fault-breccia cement. Some vein systems are more than 100 feet wide.

Throughout the region the veins characteristically consist of calcite, barite, fluorite, white and amethystine quartz, and, when mineralized, carry galena, zinc blende, chalcopyrite, and pyrite in varying proportions, and, in certain localities, silver-bearing minerals, small amounts of gold, and of minerals containing cobalt, nickel, arsenic, antimony, bismuth, and mercury. Platinum is said to have been found by assaying vein material rich in chalcopyrite from the Detroit-Algoma mine at Pearl.

The parts of mineralized veins that carry galena, zinc blende, and chalcopyrite are commonly found to have been deposited early in the process of cementation, for where veins show zonal banding these three minerals are commonly concentrated near the walls and where veins cut one another the same three minerals are notably more abundant in earlier-formed material. Amethyst and barite are commonly found to have been deposited somewhat later than the other minerals with which they are associated. The rich concentrations of silver ore at all mines other than Silver Islet were deposited later than the gangue; native silver and argentite occur in wire and leaf form in vugs and in the cleavage cracks of primary minerals and the wall-rock; the concentrations are irregularly distributed through the veins and vein systems in pockets, with maximum dimensions seldom exceeding 20 feet, spaced at intervals varying from a few feet to hundreds of feet, and localized vertically within 200 feet of the present surface.

Silver Islet vein system occurs in a fault zone which passes through Animikie sediments and several diabase dykes. The composition and general character of the vein material where the walls are sediments is the same as that of the fissure fillings commonly found throughout the region, but where the walls are of diabase of either of three dykes, the vein material is different from that found elsewhere, a distinguishing feature being that it consists in part of a fine-grained mixture of quartz and pink and buff dolomite, which commonly lacks banding, and this is rather homogeneous from wall to wall. Vein material of this nature between the walls of Silver Islet dyke is mineralized in an irregular manner with microscopically intergrown aggregates of silver, argentite, galena, zinc blende, niccolite, cobaltite, smaltite, domeykite, chalcopyrite, and other minerals. This is the only primary silver deposit known to occur in the region.

Vein material of a later generation than that above described occurs in the Silver Islet vein system in the forms of veins and replacement bodies. It is a secondary deposit consisting of materials such as might have been derived from the primary deposit: quartz, calcite, marcasite, galena, sphalerite, native silver, and pyrolusite, and also cerargyrite, erythrite, and annabergite. The native silver occurs in the form of wires, leaves, and nuggets in replacement bodies, veins, and vug-linings, and lies in the cleavage cracks of other minerals or is a crustification on earlier-formed minerals.

The mode of occurrence of silver in the secondary deposit of vein material in Silver Islet vein system is essentially similar to that of other silver deposits found elsewhere in other veins or vein systems throughout this region. In the writer's opinion it is probable that all these other silver deposits are also of secondary origin and that they and the secondary deposit at Silver Islet resulted from the action of circulating underground waters which took into solution primary silver-bearing minerals of the veins to be precipitated in porous rocks where chemical and physical conditions suitable for precipitation were encountered. The mineralized veins occur in or close to the diabase intrusives of the region, and it is believed that both the intrusives and the primary minerals of the veins came from the same source, namely, a deep-seated magma. During the progress of intrusion, when the upper parts of some of the intrusives had consolidated and while the lower parts were yet fluid, it is supposed that mineralized magmatic waters accumulated in the consolidating lower parts. These waters ascended into fissures developed in the rocks above, and there precipitated their load.

ECONOMIC POSSIBILITIES

The chief feature of economic interest in the vein systems, as indicated by production in the past, is silver ore. The ore-bodies so far found have been mined out, but many known veins of the silver-bearing type have not been thoroughly explored and it is possible that silver concentrations occur in them. It is probable that veins occur in drift-covered areas. In many such areas faults are suspected to occur and in some cases their probable positions are indicated by topographic forms; these faults are presumably like those in which the known veins have been found, and it is possible that silver deposits occur in them.

Known deposits of lead and zinc minerals are numerous and widely distributed; none of the mineralized vein-systems is entirely free of these minerals. No profitable lead-zinc mines have yet been developed. It is possible that larger bodies of well-mineralized lead and zinc-bearing vein material remain to be found. Where seams rich in lead and zinc minerals occur in gangue of commercial value, as at Neepatyre mine, high-grade lead-zinc ore could be produced by hand cobbing.

Several veins in various parts of the region are similar in general character to those now being worked for vein material, consisting chiefly of coarsely crystalline calcite. The deposits of this character now being worked are of sufficient size to permit of operations being carried on at present rates for many years.

Concentrations of barite of possible economic value are known on Jarvis and McKellar islands and elsewhere.

(1)[1] SILVER ISLET MINE

History

Silver Islet mine (Plate VI) is 6 miles east-northeast from Thunder cape (Map 1902). At one time it was the most productive silver mine in Canada. Excellent and interesting records of its early history have been published, the most comprehensive of which are by E. D. Ingall[2] and A. Blue[3]. Parts of these records have been embodied in the following statement.

The mining location in which Silver Islet mine was developed, was taken up in 1846 by Joseph Woods. A report by Wm. E. Logan,[4] dated 1847, describes a dislocation about 5 miles eastward of Thunder cape, and mentions a metalliferous lode in the Woods location, striking north-westerly, which has probably some connexion with the dislocation. For 22 years the mining location was almost entirely neglected, but in 1868, after silver had been found near Fort William and farther west, the Montreal Mining Company determined to make a systematic exploration of this and their other locations along the north shore of lake Superior. They were probably influenced in taking this step by the Ontario Government's action of imposing a tax of 2 cents an acre on Lake Superior mining locations.

Mr. Thomas Macfarlane took charge of the company's exploration party and reached the Woods location on June 23, 1868. He had read Logan's report and had determined to make a complete geological map of the location. An accurate survey of the shoreline was undertaken and while planting pickets on the numerous islands fronting the location, an assistant,

[1]This number and the numbers attached to the names of other properties, localities, etc., are locality numbers and appear on the accompanying map, No. 276A.

[2]Ingall, E. D.: Geol. and Nat. Hist. Surv. of Canada, 1887, pt. H, pp. 27-40.

[3]Blue, A.: 6th Rept. Ont. Bureau of Mines, 1896, pp. 125-157.

[4]Logan, W. E.: Rept. to Commissioner of Crown Lands, 1847, pp. 26-27.

Gerald C. Brown, landed on a rock island, which measured 80 feet across, and rose only 10 feet above the lake, and observed galena-bearing vein material. Macfarlane then visited the island, which shortly afterwards he named Silver islet, taking with him three men. One of these, John Morgan, found, in the vein system close to the water, the first piece of native silver. One blast was sufficient to detach all of the silver-bearing vein matter there visible above the surface of the lake. Examination of the vein system for a short distance out under water revealed the presence of rich silver ore. Upon leaving the Woods location in the autumn of 1868, Macfarlane's party brought away with them specimens valued at $1,200 taken from the outcrop of Silver Islet vein system.

During the summer of 1869, 9,455 pounds of ore valued at $6,751.67 were produced and shipped to Montreal. In August, 1869, the party working under Macfarlane began to sink a shaft. In the spring of 1870, 17,669 pounds of picked ore valued at $18,291.39 were sent to Montreal.

In September, 1870, the Montreal Mining Company sold all its property to New York and Detroit capitalists and Wm. B. Frue was placed in charge of the development of Silver Islet mine. Under his direction cribwork was built around the island and mining proceeded continuously until the autumn of 1873. During this period masses of rich silver ore were encountered from time to time down to a depth of 360 feet, in expansions of veins and in breccia cement in the vein system, and more than 2,000,000 ounces of silver was produced.

During the winter of 1873-74, severe storms damaged the cribwork around the islet and carried away part of the main breakwater. These damages were repaired. The years from 1874-8 were devoted almost entirely to exploration and a very considerable amount of diamond drilling was done. In 1877, between August and December, 23,850 ounces of silver were obtained by stoping in the upper part of the mine. At this time the only known remaining silver ore in the vein system lay between the upper stope in the mine and the lake above, and it was proposed to remove it by substituting for it an artificial arch. Preliminary work was done with this end in view, but the plan was not carried out.

In August, 1878, further rich silver ore was encountered at a depth of 150 feet by drifting southerly on the third level. Subsequent development revealed the presence of additional bonanza ore for 50 feet southerly from the discovery point and downward for 100 feet; and 800,000 ounces of silver were produced from this mineralized mass. After the removal of this ore, shaft and drifts were opened in the mine until the workings reached, as reported, a depth of 1,230 feet. The vein system was locally mineralized in an irregular manner with silver. The only important concentration reported to have been found between depths of 360 feet and 1,230 feet was on the ninth (960-foot) level near its southern end; it yielded about $30,000 worth of silver.

The non-arrival of a cargo of coal in the autumn of 1883 caused the suspension of work early in 1884 and the mine flooded. The total silver production up to this time was valued at $3,250,000.

In the early part of 1920, the firm of Jamison and Peacock of Duluth took an option on part of the Woods location, including Silver islet, but no part of the mainland. It was their intention to explore for veins or vein systems paralleling the Silver Islet vein system and crossing the dyke within which the silver ore of Silver Islet mine was found. It was hoped that information could be obtained by working on the ice and that the following summer's work would be guided by these results. Unfortunately ice did not form that winter and when spring came there was no further basis for the expectation that another vein would be found than the inference previously derived from geological studies and the existence of a submerged parallel vein to be seen off Catholic point.[1]

In 1920 the mine was pumped out to the fourth level and the exposed vein system carefully sampled. In the beginning pumping was done by forcing compressed air down a small pipe put inside the large pipe of the old Cornish pump in the inclined shaft. The valve at the third level prevented the small pipe going any deeper than this. Subsequently a force pump was installed. From the assay results, the company was able to estimate the ore in sight and to plan further exploration. The mine was allowed to become flooded and the formation of ice was awaited. The winter of 1920-21 proved no more favourable than the previous winter, ice strong enough to bear the drill did not form.

Diamond-drill holes were bored easterly and southerly from the east end of the islet. The former intersected a small vein, which can be seen in the shallow water, and it was found to be similar to Silver Islet vein, the sample showing a low silver content. The southerly drill hole traversed diabase, graphitic granophyre, and Animikie shale.

In May, 1921, an exploratory drift was started from the fourth level and driven southwesterly along Silver Islet dyke. The diabase dyke, through which the drift ran, was uniform and dense and required no timbering, the blasted out rock was dumped down the inclined shaft, no rock being hoisted except specimens. The power plant ran the drills, ventilated the mine, and pumped 132 gallons a minute. At 40 feet, a 2-inch vein trending north 45 degrees west was encountered; it carried white calcite, quartz, galena, zinc blende, and a little argentite. At 723 feet a fault with gouge and a vein stockwork were reached, and, simultaneously, jetting streams of water began to pour in. The drift was extended for 127 feet in spite of the ever-increasing difficulties resulting from augmented flows of water, and revealed a 10-foot vein system (723 feet to 733 feet) of the same general character as the Silver Islet vein system; it held galena and sphalerite but no visible silver. Beyond this (783 to 783½ feet) a 6-inch parallel vein of a similar character was intersected. The trend and dip so far as could be learned were nearly parallel to those of the Silver Islet vein system. Attempts were made to check the inflow of water by driving wooden plugs in the larger openings and by forcing a special cement into others. Most of the power previously used in mining operations had to be diverted to the pumps and the working shifts became short and infrequent. Before abandoning the project, diamond-drill holes were run: one for 431 feet westerly beyond the drift, and others, angling holes, that intersected the 10-foot vein to the north, south, and below the drift. Small patches of graphite-bearing rock were encountered in the course of these

[1]"Silver Islet and Vicinity"; Trans. Can. Inst., Min. and Met., 1920, pp. 402-418.

developments, but no considerable quantity was found at any place. All work in the new drift ceased in November, 1921, and the mine was allowed to become flooded again.

In 1922 some of the rock ore that was known to exist in the roof was mined after pumping out to a depth of 60 feet. No new veins were opened up and the work ceased when the limit of safety (6 feet locally) was reached. The mine was allowed to fill with water again August 15, 1922. The 20,040 pounds of ore shipped from the selected rich ore raised at this time, had a silver content of 16,652 ounces with a gross value of $10,971.97. Some of the blocks were very rich in both the complex silver ore previously called animikite and in wire silver (Plate VI).

Mr. D. C. Peacock kindly supplied the following information:

"For doing the exploration work at Silver Islet during 1921 and 1922 we installed and used the following machinery:

1–100 h.p. upright boiler 100 pounds steam pressure.
1–45 h.p. locomotive type boiler 100 pounds steam pressure.
1–12 by 14 by 12 straight line air compressor.
1–12 by 12 by 18 straight line air compressor.
The rated capacity of these two air compressors was approximately 500 cubic feet free air per minute.
1–6-inch by 8-inch duplex steam hoist.
1–150-gallon duplex steam pump.
1–250-gallon duplex steam pump.
1–Air lift consisting of 200 feet of 6-inch and 275 feet of 5-inch black pipe inside of which was a 2-inch inserted joint air pipe.
2–D x 61 Sullivan air drills.
1–Jackhammer air drill.

The approximate cost of pumping the water out of the fourth level was $4,000. This includes only the labour and supply cost while pumping was in progress, and does not include the preliminary expense of installing the machinery and repairing the buildings and head frame.

The total cost of all our operations there was as follows:

1920, estimate	$10,000 00
1921 and 1922—actual	74,081 57
Total	$84,000 00"

Geological Relations

In the vicinity of Silver islet there is a succession of Animikie shaly sediments, 1,200 feet or more thick, dipping at a very low angle east-southeast. The sediments are cut by several dykes of diabase which strike northeasterly and dip steeply toward the southeast. The sediments and some or all of the dykes have been dislocated by a system of faults that strike northwesterly across the dykes. Vein material cements the fissures in the faults and fault-zones, which make up the fault system, and locally, as in Silver Islet mine, this material contains silver.

Silver Islet dyke, the dyke that underlies Silver islet, is 350 feet wide near the surface; its width, as revealed by the mine workings, decreases to 250 feet at a depth of 560 feet and this width is maintained to a depth of 1,100 feet. The dyke has been traced 1,600 feet northeasterly and about 1,200 feet southwesterly from Silver islet. It is inferred that the diabase dyke exposed on Pyritic and Ship islands is the southwesterly continuation of Silver Islet dyke. The general strike of the dyke is north 50 degrees east and the dip is 75 degrees towards the southeast. The foot-wall of the wider part of the dyke dips about 60 degrees southeast.

The dyke consists chiefly of dense, hard, massive, greenish grey diabase, composed essentially of plagioclase and augite with ilmenite and apatite as accessory constituents. Pink and grey graphitic granophyre, similar to granophyre exposed on Pyritic island, occurs in the dyke near its southern wall and in contact zones a few feet wide around included blocks of Animikie sediments.

Silver Islet dyke is cut on the island by a fault zone which in the mine workings varies in width up to 50 feet and has been revealed for a length of 1,800 feet. Its strike is approximately north 35 degrees west and its dip is between 70 and 80 degrees toward the northeast. The inferred northwesterly continuation of this fault zone crosses Burnt island; and its supposed further extension on the mainland has been traced discontinuously as far as Morgan's junction, which is $1\frac{5}{8}$ miles north 32 degrees west from Silver islet. Movements within the fault zone have dislocated the dykes and Animikie strata traversed by it and have developed gouge, slickensided surfaces, shear zones, and fault-breccia, all of which have been observed in Silver Islet mine. Silver Islet dyke on the northeast side of the dislocation shows, at depth, in the mine workings, a shift of 80 feet northwesterly relative to the part of the same dyke on the southwest side (*See* Figure 1). The majority of the slickensided surfaces observed are on nearly vertical planes and the striations, though not all parallel, are such as would be produced by up and down movement. If it be assumed that only vertical movement has taken place, the horizontal shift of 80 feet exhibited by the inclined dyke could have been produced by a downthrow of 300 feet on the easterly side of the fault zone.

In some places in the mine gouge appears as sheets of grey and black, clayey material a few inches thick and with lengths and depths measurable in yards. Shear zones occur where movement has been along nearly parallel planes spaced at intervals of a few inches. The attitude of the gouge sheets and shear zones is approximately the same as the general strike and dip of the fault zone.

The rocks within the fault zone have been fissured and brecciated in different degrees in different places. In general there has been more brecciation and a development of wider fissures in diabase than in Animikie sediments. Where the fault zone passes through Silver Islet dyke there is a fault-breccia locally 20 feet wide, but which, traced across the dyke in the upper workings of the mine, divides into two zones, each between 10 and 15 feet wide, which farther on unite to enclose a lenticular mass of rock 20 feet wide, 240 feet long, and extending from the surface to a depth of 200 feet below lake Superior. Fissuring occurred in the rocks marginal to the fault-breccia and also in the breccia blocks.

Vein System

The fissures in the fault zone are cemented by vein-forming minerals. These minerals form a cement between blocks of rock in the fault-breccia and also occur as a tangle of veins which ramify in various directions through the fissured rock. The boundaries between the rock and the cement are sharply defined. Vein-forming minerals also occur in irregular-shaped nodules and lenticular masses within gouge (Plate VI) and they locally permeate the gouge for an inch or so beyond the boundaries of the nodules and lenses.

The vein system (by vein system is meant all of the various structures composed of vein-forming minerals in the fault zone) as found in Silver Islet mine, is distributed through a mass of rock 1,800 feet long, 1,230 feet deep, and with widths varying from a few inches up to 50 feet. Individual veins are less than a foot wide and the majority of them are less than one inch wide; masses of breccia cement, however, have been observed with dimensions up to 3 feet measured in three directions at right angles to one another. The volume of vein material is relatively greater, and it is less intimately intermingled with the country rock in that part of the vein system that occurs in diabase than in the part in Animikie sediments. The average total width of material in the vein system within the diabase is estimated at between 8 and 10 feet, and about three-quarters of this occurs as breccia cement; the corresponding figure within the Animikie sediments is roughly between 2 and 4 feet.

Mineral Assemblages in the Vein System

Primary Deposits. Two generations of vein-forming minerals occur in the vein system, a primary deposit and a secondary deposit, each with distinctive characteristics. The secondary deposit occurs as veins and replacements in the primary.

The primary deposit makes up about nine-tenths or more of the volume of the vein system as observed in the abandoned workings of Silver Islet mine. It is continuous throughout the exposed length, width, and depth of the vein system, and occurs as breccia cement and as a tangle of veins ramifying in many directions through the fault zone. In general the primary deposit is fine grained and of uniform structure. The following minerals occur in the primary deposit: silver, argentite, niccolite, galena, sphalerite, marcasite, cobaltite, smaltite, domeykite, chalcopyrite, tetrahedrite, quartz, rhodochrosite, and a carbonate (referred to as dolomite) containing variable amounts of calcium, magnesium, and manganese, and varying in colour from buff to pink. In addition breithauptite, millerite, and arquerite though they have not been observed are supposed to be present, as indicated by chemical analyses.[1]

The greater part of the primary deposit consists of a mixture of fine-grained, pink and buff dolomite and quartz. In narrow veins quartz predominates, whereas in breccia cement and wider veins dolomite predominates. All gradations occur between parts consisting almost entirely of

[1]*See* Parsons, A. L., and Thomson, E.: "Contributions to nadian Mineralogy, 1921" University of oro Studies, Geol. Series, No. 12, p 25

dolomite and other parts consisting almost entirely of quartz. Calcite and barite occur in small amounts, and so far as known are not restricted in their distribution to any particular part of the deposit. Grains of galena and sphalerite are widely disseminated in small amounts, chalcopyrite is less abundant and less uniformly distributed.

Silver, argentite, niccolite, galena, sphalerite, marcasite, cobaltite, smaltite, domeykite, chalcopyrite, tetrahedrite, breithauptite, millerite, and arquerite occur microscopically intergrown in granular and dendritic forms, commonly about one-tenth inch in diameter. The intergrown aggregates occur in clusters, varying in degree of compactness, in seams and through irregular-shaped masses in parts of the primary deposit that are characterized by an abundance of pink and buff dolomite. Seams up to 4 inches wide and 6 feet long have been observed. The irregular-shaped masses have dimensions ranging from a few inches to a foot and are separated from one another by distances ranging from a few inches to several yards. So far as known these mineralized masses are small and widely separated except where silver ore was found and there they formed an important part of the vein system. The distribution of the ore in the mine, as indicated by the stopes, is shown in Figure 1; ore also occurs in the roof above the highest stope.

The several minerals in the intergrown units are of such small dimensions that they can be identified only by mineragraphic methods. When examined by the unaided eye, some units differ in appearance from others, due to differences in the proportions of the constituent minerals or to their manner of arrangement. It is probable that macfarlanite, animikite, and huntelite, which have been described[1] as minerals occurring in Silver Islet mine, are intergrown units that differ in appearance from one another. Parsons[2] reports that specimens of macfarlanite and animikite were found by E. Thomson to consist of silver, niccolite, smaltite-chloanthite, galena, and sphalerite. Huntilite has not been examined by mineragraphic methods.

The several minerals in the microscopically intergrown units meet each other along irregularly curved and straight boundaries, and they are grouped in a variety of different ways. The silver in some units is more intimately intergrown with smaltite and niccolite than with the other minerals. In general the arrangement of the minerals in the intergrowths indicates that they formed at approximately the same time. All the minerals of the primary deposit are locally intimately mixed and in general are not banded, zoned, nor otherwise arranged in a manner to permit of deductions regarding their sequence of deposition.

Secondary Deposits. The secondary deposits make up about one-tenth or less of the volume of the vein system as observed in the abandoned workings of Silver Islet mine. They consist of discontinuous replacement bodies, vug linings, and veins. These have been observed by the writer in the mine between the surface and a depth of 220 feet. Within this vertical distance they are more prominently developed near the surface

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[1]Macfarlane, T.: Trans. Am. Inst., Min. Eng., vol. 8, p. 238.

[2]Parsons, A. L.: Economic Deposits in Thunder Bay District; Ann. Rept. Ont. Dept. of Mines, vol. XXX, 1921, pt. 4, pp. 34-36.

than at depth. Ingall[1] reports that vugs were found in the deep workings of the mine and large crystals of galena occurred in a vug at a depth of 560 feet. It is probable that the secondary deposit occurs throughout the vein system to a depth of at least 560 feet.

The secondary bodies range in dimensions from minute forms up to masses measurable in feet. The larger are replacement bodies and vug linings, and have been observed by the writer only in that part of the primary deposit that consists chiefly of dolomite. They are separated

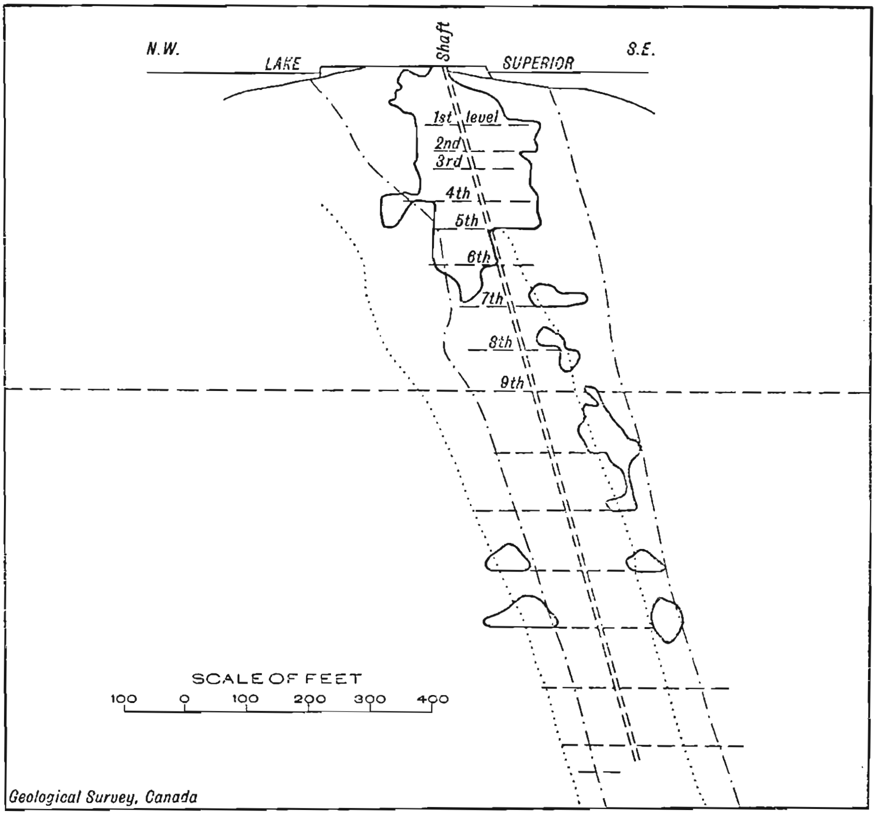

Figure 1. Silver Islet mine (after E. D. Ingall): diagrammatic vertical section along vein system, showing positions of shaft, the various levels and outlines of stopes. The two walls of Silver Islet dyke on the southwest side of the fault zone (the vein system lies in this zone) are shown by two peck-and-dot lines; the two walls of the same dyke on the northeast side of the fault zone are shown by two dotted lines.

from one another by distances ranging from a few inches to several feet. The smaller units occur as veins, discontinuous incrustations along fissures and replacement bodies; they locally permeate the primary deposit and the adjoining country rocks in such a manner as to form approximately

[1]Ingall, E. D.: Geol. and Nat. Hist. Surv. of Canada, 1887, pt. H, p. 28.

half of the volume in masses of several cubic feet. In parts of the vein system, several feet in length, they are spaced at intervals of several inches and make up only a minute fraction of its volume.

The secondary deposit exhibits a wide range of textures; in some places there are coarsely crystalline aggregates, in others there are powdery incrustations, and locally the two are intimately associated. There is commonly either a banded or a crustified structure in those parts of the secondary deposit that consist of two or more minerals.

The following minerals occur in the secondary deposit: quartz, calcite, barite, marcasite, galena, sphalerite, silver, argentite, pyrolusite, cerargyrite, erythrite, and annabergite. The last-named three minerals are reported to have been found only in the upper part of the mine within a few feet of surface. In specimens examined by the writer, erythrite and annabergite occur as films encrusting tiny metallic aggregates in the primary deposit and as stains extending out from them for a fraction of an inch into the surrounding rock. Pyrolusite occurs in very small amount in seamlets in rhodochrosite and also as a powdery incrustation on calcite crystals in vug linings in the upper part of the mine.

Calcite is the most abundant and widely distributed mineral of the secondary deposit. It occurs alone or in association with other minerals in replacement bodies, vug linings, and veins. It is white or colourless and coarse grained. Some vugs are lined with the variety known as dog-tooth spar, and the individual crystals attain lengths of an inch or more.

Marcasite, galena, and sphalerite occur, in some places separately and in some places together, with their individual characteristic crystal forms well developed within masses of calcite or as an incrustation on free-growing crystals of calcite in vug linings.

Barite was observed by the writer at only one place in the mine, and there in a vug-filling, encrusted on the inner surface with white calcite. The barite is white, and the mass is made up of a number of platy, crystalline growths between $\frac{1}{2}$ inch and 1 inch in diameter, radiating out from centres.

Silver, in the form of wires, leaves, and nuggets, occurs in veinlets, replacement bodies, and vug linings. Leaves of silver have been observed in cleavage cracks of calcite in the secondary deposit. Most of the observed silver occurs as bunches or clusters of gnarled wires, commonly $\frac{1}{2}$ inch thick and between $\frac{1}{2}$ inch and 3 inches long, in the central part of vug linings, one end of each wire being attached to calcite or other mineral and the other end unattached. Specimens of such clusters observed by the writer have volumes of silver varying up to 1 cubic inch. Argentite occurs as leaves in the cleavage cracks of other minerals.

No data are available whereby precise figures can be given regarding the amount and distribution of the secondary native silver, but the following excerpt[1] indicates that it formed masses of considerable size ". . . a winze. . . to the 4th level, 60 feet, was sunk literally through native silver, the metal standing out boldly from the four walls of the winze." So far as known, the secondary silver was localized in the vein system close

1,E. D.: Op. cit., p

to the silver-bearing part of the primary deposit either in contact with it or not more than a few feet distant from it.

Ore. The silver ore (Plate VI) in Silver Islet mine consisted of the argentiferous parts of both the primary and secondary deposits in the vein system. The primary ore was made up largely of microscopically intergrown mixtures of several minerals, including native silver and argentite lying in a gangue of dolomite and quartz. As already stated, the individual intergrowths were commonly one-tenth inch in diameter, and were more or less densely clustered in the gangue to form discontinuous, irregularly shaped masses and seams in relatively wide fissure fillings and in breccia cement. These parts of the vein system lay within Silver Islet dyke adjacent to any of the rocks found within the walls of the dyke, namely, diabase, granophyre, and Animikie sediments. They did not occur in the Animikie sediments beyond the walls of the dyke. They were localized in the positions indicated by the stopes (*See* Figure 1) and lay chiefly between the surface and a depth of 360 feet. The secondary phase of the ore consisted of wires, leaves, and nuggets of native silver, and leaves of argentite in masses larger than those containing silver minerals in the primary deposit. The masses were grouped in pockets and irregularly distributed through the vein system in the general vicinity of the primary ore. Presumably they were found chiefly in the stopes. The primary and secondary phases of the ore are not differentiated in the available mining records, but available notes regarding the character of the ore being developed in the mine at different periods lead the present writer to infer that the greater part of the secondary phase was found above a depth of 250 feet. A mass particularly rich in the secondary phase known as the second bonanza, occurred between depths of 150 and 250 feet; it was 5 feet wide, 50 feet long in its upper part, and tapered out downward. This mass yielded 800,000 ounces of silver.

Materials in Cavities in the Vein System. Saline solutions containing chlorides of calcium, sodium, magnesium and potassium, calcium carbonate, and calcium sulphate accompanied by inflammable gas existed under great pressure in fissures and vugs irregularly distributed through the vein system between depths of 160 feet and 1,230 feet below the surface. The composition of the inflammable gas is not known. It may have been hydrogen sulphide, which was detected in the mine in 1920, or it may have been a hydrocarbon.

A sticky, brownish grey, clayey material was observed as a coating on the walls of fissures and as accumulated masses, measuring several inches in three directions at right angles to each other, in the bottom parts of cavities in the vein system. This material is probably chiefly saponite. It was probably derived from gouge in the fault zone and brought into the vein system by circulating underground waters. The material was used by the early miners to stick candles to the walls of the workings.

Mineral Assemblages in the Vein System beyond Silver Islet Dyke. An exploratory drift on the ninth or 560-foot level of the mine was driven northwesterly along the vein system for 720 feet beyond the edge of Silver

Islet dyke. Three diabase dykes were crossed at distances from Silver Islet dyke as follows: 156 to 160 feet, 280 to 320 feet, and 440 to 560 feet, and a fourth dyke was entered at 680 feet and at the face; at 720 feet, the other edge of the dyke had not yet been met. The rock between the dykes was Animikie shale. In this drift the contrast between the character of the vein system in shale and in diabase is reported to have been very apparent. In diabase the fissure fillings were relatively wide, in the shale they were mere stringers. The vein material in two of the above-mentioned dykes is said[1] to have been highly mineralized, but no further details are given.

The extension of the vein system northwesterly from Silver islet, appears as breccia cement in outcrops on Burnt island. Prior to 1884, a shaft 100 feet deep was sunk on the vein system here. The vein material visible in the dump and in outcrops consists of quartz, white calcite, purple fluorite, and small amounts of disseminated galena, sphalerite, chalcopyrite, and pyrite.

The next exposure of the vein system is on the mainland at Silver Islet landing, a few yards northwest of Capt. J. W. Cross' house, where, in Animikie sediments, a network of quartz stringers carries a small amount of galena.

Farther northwest at the northwest corner of Surprise lake and also 200 feet west of this point, there are veinlets of quartz and galena. At the former locality a shaft 40 feet in depth was put down.

Farther on, at a place 100 feet south of Mud lake, a tangle of galena-bearing quartz veinlets has been exposed in a trench and test pit.

Still farther northwest the vein system intersects the "anorthite" dyke at a place 850 feet east of the head of Perry bay. A shaft was here sunk to a depth of 100 feet. The dump now conceals the surface of the rock in this vicinity. Fragments of vein material on the dump consist of a mixture of fine-grained quartz and pink dolomite sparsely mineralized with disseminated galena and zinc blende, and similar in appearance to vein material in Silver Islet mine. Other fragments of vein material consist of quartz, white calcite, and marcasite, all coarse grained. A mass one cubic foot in volume was observed consisting entirely of marcasite. Capt. Cross reported that a sample of the mineralized pink dolomite had yielded upon assay silver at the rate of 10 ounces to the ton.

About 100 yards northwest of the previously mentioned shaft a few small stringers consisting of quartz, calcite, chalcopyrite, and galena occur in an outcrop on the Perry dyke. Between 10 and 100 feet northeasterly from the outcrop there are caved trenches indicating that the early operators searched for the vein system at this locality.

Morgan's junction lies about 1,000 feet northwesterly from the mineralized stringers in Perry dyke. There are no outcrops along the inferred position of the vein system between these points. At Morgan's junction a shaft was sunk 60 feet on the vein system. On the dump there are fragments of vein material consisting of a mixture of fine-grained quartz and

[1]Ingall, E. D.: Op. cit., p. 35.

pink dolomite through which galena and zinc blende are irregularly disseminated. It is reported, by Ingall[1] that galena carrying silver at the rate of 19 ounces to the ton was obtained from this shaft.

Immediately north of the shaft there is a diabase dyke which stands up like a wall. It strikes northeasterly and along its southeastern wall, which shows a chilled edge, there is a vein of coarse-grained white calcite between 1 and 2 feet wide. Both vein and dyke have been traced for hundreds of feet both to the northeast and southwest. No vein material such as came from the shaft has been found in the vein, and the dyke, as exposed, is not cut by a vein. Possibly this dyke is later than the silver-bearing vein.

North and northwesterly from Morgan's junction observed faults and inferred faults occur, in the positions shown on Map 1902. Veins have been observed in some of these, as on the east side of Mountain lake and also between 3,000 and 4,000 feet southeast of Mountain lake, where there are veins, less than a foot wide, of quartz and calcite. South of Red Sandstone lake there is a vein of barite 3 inches wide. It is possible that some of these veins are part of the extension of Silver Islet vein system.

Faults Parallel to Silver Islet Fault Zone. Both northeast and southwest of the main fault zone that passes through Silver Islet are other parallel or nearly parallel faults which dislocate Silver Islet dyke and in them mineralized vein material was found by Mr. D. C. Peacock in 1921 and 1922. A vein, about 4 inches wide, visible through shallow water about 500 feet northeast of the fault zone, was sampled in a diamond-drill core and found to have a low silver content. The vein material was said to be similar to that in Silver Islet mine. In a drift in Silver Islet dyke at a depth of 220 feet, a 2-inch vein striking northwest was encountered 40 feet southwest of the ore-bearing fault zone. It consisted of white calcite, quartz, galena, zinc blende, and a little argentite. Between 683 and 693 feet southwest of this vein there was a fault breccia cemented in part with vein material consisting of a fine-grained mixture of pink dolomite and quartz through which galena and sphalerite were irregularly disseminated. A system of fissures and cavities in the fault zone allowed jetting streams of water to pour into the workings. Fifty feet southwest of this fault zone a 6-inch vein was intersected, filled with similar vein material.

The exploratory drift terminated 70 feet southwest of the vein intersection and a horizontal diamond-drill hole was bored in a southwesterly direction from the end of the drift for 431 feet. These operations revealed no additional veins in Silver Islet dyke.

It is highly probable that a vein system which is visible through water 10 feet or more in depth, a few feet offshore from the projecting points along the northeast side of Perry bay, is the northwesterly extension of the vein system (fault-breccia cement) found in the exploratory drift between 723 and 733 feet southwest of the vein system at Silver islet. The sub-

[1]Ingall, E. D.: Op. cit., p. 30.

merged vein system as observed off Catholic point, the east headland of Perry bay, has the appearance of breccia cement and a tangle of small veins in a zone about 15 feet wide.

About 1,000 feet north of Middlebrun bay, there is a fault striking north-northwest; and, in an exposure of a few square yards, there are ramifying veinlets up to 2 inches wide and consisting of calcite, barite, and galena. The latter mineral is not abundant.

Submerged veins, which may be in faults parallel to Silver Islet fault zone occur: 1,200 feet south of the wharf (as shown on Map 1902) in Camp bay; about 700 feet east of a small island about half a mile east of Tee harbour; and about 300 feet northeast of Ship island. At each of these localities the vein material, which gleams white on the lake bottom visible to a depth of 20 feet, appears to extend over a width of 4 feet or more and can be traced for several yards along a northwest direction.

NORTH LAKE AREA

The most westerly occurrence of veins of the silver-bearing type of which there is a record is in North Lake area, mapped by J. E. Gill[1] in 1924. On the map of this locality three faults are represented: (1) extending 2,500 feet east from the east headland of Bridge bay on the north shore of North lake; (2) extending 5,700 feet south along the east shore of Shekaka lake to the north shore of North lake; and (3) an inferred fault in a drift-covered area, extending for a mile, south 20 degrees east from Sack bay on North lake to the east shore of South lake.

These faults occur in Animikie iron formation, diabase sills, and the granite floor. A general note by Gill[2], which refers to various localities from North lake east to Silver mountain, is that where.... "actual fault planes could be observed, they were found to have been sealed by vein material mostly quartz and calcite...." It seems probable that such vein material was observed along one or both of the two first-mentioned faults listed above.

BISHOP LAKE AREA

Bishop Lake area, which lies about 8 miles northeast of North Lake area, is a rectangle measuring 4 miles east and west by 3 miles north and south. It was mapped by J. E. Gill in 1924.[3] Seven faults are shown on this map. They traverse Animikie iron formation, diabase sills, and the batholithic granite on which the Animikie sediments lie. They are represented as extending for distances measurable in thousands of feet and striking north, east, northwest, or northeast. The previously quoted statement by Gill applies to these faults and, therefore, it may be assumed that some or all of these faults were observed by Gill to be occupied by veins consisting largely of quartz and calcite and resembling veins known elsewhere to be silver-bearing.

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[1]Gill, J. E.: "Gunflint Iron Bearing Formation, Ontario"; Geol. Surv., Canada, Sum. Rept. 1924, pt. C, Fig. 3, p. 44.
[2]Op. cit., p. 84.
[3]Op. cit., Fig. 4, p. 46.

LITTLE GULL LAKE AREA

Little Gull lake lies about 2¼ miles north of Gravel Lake station on the Port Arthur, Duluth, and Western branch of the Canadian National railways. A map by Gill[1] depicts the geology of about 10 square miles in this vicinity. In this general neighbourhood a number of veins of the silver-bearing type are known to occur. The more important occur on the Silver Fox, Mink, and Silver Glance properties.[2]

(2) *Silver Fox*

This property embraces two veins on the east side of the hill known as Mink mountain and along whose southern edge the railway passes. One of these veins is in the northeast part of mining location R 367 and is the eastern end of the Hurlburt vein described by Ingall.[3] The other lies 100 yards north at the same elevation, is in the southeast part of mining claim TB 4417, owned by John McGugan, and on which exploration work for iron ore was in progress in 1927.

On the southerly or main vein an adit has been driven westerly into the side of the hill. The mouth of the working has caved, but from a consideration of the amount of material on the dump it is estimated that the adit probably extended for a distance of about 100 feet. An adit has also been driven on the northern vein, its mouth is also caved and no details regarding the workings are available.

The vein material consists of coarse-grained white calcite, white quartz, and a little amethyst. The vein material as found on the dump includes many angular fragments of country rock. The northern vein passes through red jasper taconite and shaly iron formation. The inclusions in the southern vein are grey, cherty, magnetite taconite. The veins are not now visible, due to the slump of drift material on the side hill where the workings were placed. The trend of the workings, however, indicates that the southern vein strikes west and the northern vein south 65 degrees west. The width of the brecciated zone in which the vein material occurs is estimated at approximately 6 feet in each case, and the vein material makes up about half this width. The blocks of rock in the dump show a ramifying network of small veins traversing country rock as well as masses of vein material up to 2 feet in diameter enclosing fragments of wall-rock. Specks of galena are sparsely disseminated in the vein material in the southern dump. Silver is not known to have been found on this property, nor any other valuable metallic mineral other than galena.

(2) *Mink*

The vein on this property is in the southeast part of mining location R 213, on the north side of Mink mountain, a few hundred feet north of the capping diabase sill. It is exposed half a mile west of the Silver Fox workings.

[1] Idem., Figure 5, p. 48.
[2] The positions of mining claims are shown on blue prints issued by the Ontario Department of Mines, Toronto.
[3] Ingall, E. D.: Geol. and Nat. Hist. Surv. of Canada, 1887, pt. H, p. 101.

It was worked prior to 1890 and at that time a shaft was sunk 100 feet. The vein occurs in a fault that passes through flat-lying Animikie iron formation. It consists mainly of white crystalline quartz with a small amount of white calcite. It is reported by Mr. T. E. Brown of Wolfe that several spectacular samples of native silver were removed from this vein during the period of development. There is no record that any considerable body of silver ore was encountered. The vein strikes north 70 degrees west and dips 75 degrees toward the south. It is 4 feet wide, containing many small angular inclusions of the wall-rock. The shaft is now full of water and the character of the vein material was ascertained from a study of the upper part of the vein and the dump. The extension of the vein on the surface is concealed, but the position of the fault in which it occurs has been mapped by Gill through a distance of 1,200 feet.

(2) *Silver Glance*

The Silver Glance vein is on mining location X 50 and lies about ½ mile southeast of Little Gull lake. Prior to 1890, a shaft was sunk to a depth of 30 feet on it. Flat-lying Animikie iron formation on this property has been dislocated by a fault, mapped by Gill for a distance of 1,500 feet. In the immediate vicinity of the shaft exposures across the fault show a shatter zone, 5 feet wide, striking north 55 degrees east and dipping northwesterly, cemented by a composite vein. Coarsely crystalline white quartz and calcite were the only minerals observed in this vein, in 1927.

(2) *Geroux*

The Geroux vein is on mining location R 230, about one-third mile southeast of the Silver Glance vein. Prior to 1890, a shaft 25 feet deep was sunk on it, Animikie iron formation on this property is dislocated by a fault that strikes north 80 degrees east and dips vertically. A shatter zone, varying in width up to 5 feet, along the fault, is cemented by a composite vein. The vein is exposed in the immediate vicinity of the shaft and east of it in small outcrops at intervals of a few hundred feet over a distance of half a mile. Coarsely crystalline white quartz and calcite were the only vein minerals observed, in 1927.

(3) *East End of Little Gull Lake*

At the outlet of Little Gull lake a vertical fault strikes north 55 degrees east, in granite. It is cemented with a quartz-calcite vein, 2 feet wide, exposed for a length of 50 feet.

About 3,000 feet east of Little Gull lake, a fault striking north 55 degrees east, in granite, crosses Whitefish river (*See* map by Gill). On the river banks and in several small outcrops, west of the river, distributed through a total length of 300 feet, the vein is 2 feet wide and consists of quartz and calcite.

(3) *Mining Location X 34*

Laplante's vein is on mining location X 34 a short distance east of Whitefish river, where the previously described vein outcrops. It is described by Ingall[1] as follows:

" On the line of junction between the Animikie and Archæan (Early Precambrian) rocks, test shafts have been sunk on two veins running parallel to each other on either side of a ridge of the latter, which is flanked on both sides by the Animikie jaspers and cherts. The shaft on the east vein is about 30 feet in depth and sunk on an indefinite vein or lot of branches and stringers distributed through a dark green, slickensided, chloritic material, which may be possibly part of the vein, and having a general dip toward the northwest, whereas the strike is northeast. In the 30-foot shaft on the opposite side of the ridge, a well-defined, solid, 4-foot vein is visible going down about vertically as far as followed. It has evidently faulted the enclosing rocks, as the one wall consists of gneiss, etc., of the above-mentioned ridge, whereas the ferruginous, jaspery, and cherty beds form the opposite or west wall. Just at the top of the shaft the original contact of these two systems of rocks is well shown, the gneiss being overlain by a thin sheet of jasper in a horizontal position, which at places has been denuded off so as to be no thicker than one's hand."

(3) *Mining Location R 432*

On mining location R 432 a composite vein is exposed 1½ miles northeastward from the outcrops of Laplante's vein, of which it may be a continuation. The country rock is granite and gneiss. A shaft 6 feet by 6 feet has been sunk on the vein to a depth of approximately 10 feet and the vein has been trenched 40 feet northeast from the shaft. The composite vein occurs in a shattered fault zone in granite, slickensides being plainly visible. The vein material is coarsely crystalline white calcite, buff-coloured, ferruginous dolomite, and white quartz. Small specks of galena are disseminated through it. The vein trends north 63 degrees east and dips vertically. The composite vein is now visible through a distance of 10 feet only, in the vicinity of the pit, and makes up approximately a quarter of the volume of the fault zone, 6 feet wide.

(4) *Mining Location X 124*

Near the middle of the west boundary of mining location X 124, 1¾ miles northeasterly from the previously mentioned outcropping vein on mining location R 432, there is a tangle of quartz veinlets traversing a zone 20 feet wide, in granite. No development work is known to have been done on this property. A dozen veins and veinlets ranging up to 3 inches in width occur in the 20-foot zone. It is estimated that the total amount of vein material would make up approximately 3 feet. Locally several veins coalesce, and at one place a resulting width of 16 inches was noticed. The general strike is north 75 degrees east and the dip is vertical. The vein zone was traced, on a bare-glaciated outcrop, 50 feet. The greater part of the vein material consists of white quartz. The wider veins show banded deposits of white quartz, white calcite, green fluorite, and amethyst. Free-growing amethyst crystals project into vugs.

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[1]Ingall, E. D.: Op. cit., p. 102.

(4) *Mining Location X 32*

In the southwest part of mining location X 32, 2¼ miles north of the previously mentioned deposit on location X 124, there is a composite vein, one foot wide, striking north 70 degrees west in granite. The dip is approximately vertical. No development work was observed at this occurrence. The veins consist entirely of white crystalline quartz through the distance of 30 feet over which they were observed. No metallic minerals were noticed. This vein lies about 600 feet southwest of a prominent, diabase-capped hill.

ARROW LAKE AREA

Mining Location K 155

It is reported by Mr. T. E. Brown of Wolfe that a calcite vein approximately 2 feet wide outcrops on the shore at the southwest end of Arrow lake. No work has been done on the vein at this location, and no further particulars are available.

(5) *Mining Location XL 18*

Mining location XL 18 is south of Arrow lake and about 4 miles east of the head of the lake. On it an exposure of a calcite vein occurs approximately one-half mile south of Arrow lake and less than one-quarter mile west of Little Whitefish lake. A pit 5 feet deep and 5 feet square has been sunk on the vein. The vein is 3 feet wide, strikes north 30 degrees east in diabase, and dips 70 degrees northwest. The vein consists of coarsely crystallized calcite; no metallic minerals were observed. This mining location is said to have been the first property west of Fort William to be staked for silver.

(6) *Mining Location R 277*

The mining location is on a point on the north shore of Arrow lake approximately 2 miles from the east end of the lake. On it is exposed a calcite vein 12 to 18 inches wide. The vein strikes east and is vertical. The vein minerals are chiefly coarsely crystallized calcite. Green fluorite occurs locally in the vein with widths of 2 inches and lengths up to 2 feet. Smoky, milky, and amethystine quartz also appear. No metallic minerals occur in the vein material, but specks of pyrite are disseminated in diabase inclusions and in the adjacent wall-rock. The vein is exposed for a distance of 100 feet west from the shore. No development work has been done on it. About 300 feet north an amethyst-calcite vein, 4 inches wide, strikes north 30 degrees east, and is exposed over a distance of 150 feet.

(7) *Mining Location T 11*

Frog lake is a small expansion of Sand river, about a mile above where the river discharges into the east end of Arrow lake. Mining location T 11 borders the east side of Frog lake and the river above. A number of narrow quartz stringers occur in diabase at the northeast corner of Frog lake. They lie in a shatter zone, approximately 7 feet wide, exposed for a length of 30 feet, and trending about north 75 degrees east. The stringers are ½ inch to 2 inches wide and are vertical. The only vein minerals are amethystine quartz and chalcedony. No development work has been done on this property.

(7) *Mining Location W 279*

This mining location adjoins location X 11 on the north. A shatter zone cemented by numerous quartz veinlets occurs in the southwest corner of claim W 279 and outcrops on the east bank of Sand river. The shatter zone is 30 feet wide and is exposed for 50 feet back from the river. The strike is south 80 degrees east and the dip vertical. Veinlets up to 2 or more inches wide cut a rather coarse-grained diabase. The vein minerals are predominantly amethystine and white quartz with some chalcedony and a very small amount of calcite. No development work has been done on this deposit.

(8) *Mining Locations X 143 and R 301*

These adjoining locations are on the south shore of Atik lake, which drains to Round lake on Sand river and lies a little more than ½ mile north of a deep bay in the north shore of Arrow lake close to the east end of the lake. A quartz vein 3 inches wide occurs about 10 chains south of Atik lake in the northeast corner of claim X 143. The vein trends 20 degrees south of east, is vertical, and is exposed at intervals over a distance of 400 feet, the eastern exposures being in the adjoining claim, R 301. The vein has well-defined walls and lies in coarse-grained diabase. The vein minerals are massive quartz and milky coloured crystals of quartz. The diabase is intensely fractured parallel to, and over a width of, several hundred feet on each side of the vein, but no mineralization was observed across this zone.

WHITEFISH LAKE AREA

(9) *Mining Location R 119*

A shatter zone cemented with calcite occurs along the base of a bluff about ½ mile west of Medicine bluff and about ¾ of a mile southwest from the western end of Whitefish lake. The mineralized zone strikes 12 degrees south of east, dips vertically, and occurs in flat-lying, cherty iron formation at the base of the bluff and in the overlying diabase for a vertical distance of 40 feet. The shatter zone has a width of 5 feet and is exposed only along the face of the bluff. Coarsely crystalline calcite composes approximately 75 per cent of the vein material, the remainder being crystalline quartz. No metallic minerals were noticed. A trench 50 feet long by 4 feet wide and several feet deep, and also a small pit, had been excavated prior to 1890, but are not now in condition for examination.

(9) *Mining Location R 208—Medicine Bluff*

This mining location is on the south shore of Arrow lake at its head, and is somewhat more than ½ mile east of mining location R 119. Available information regarding a vein on this property is given by Ingall[1] as follows:

"The work to the end of 1886, consisted of a small crosscut driven about 30 feet through the argillite into the side of the bluff near the top to intersect the vein, which here dips at 80 degrees to the north, from the end of which drift a little pit has been sunk. The vein trends south 75 degrees east. These developments have not been prosecuted far enough to prove much about the vein."

(10) *Scripture's Vein and Caldwell's Vein*

Ingall has described Scripture's and Caldwell's veins as occurring along a trail from Whitefish lake to Little Gull lake. Scripture's vein was said to be 1¼ miles northwest of the mouth of the creek entering the west end of Whitefish lake, north of Castle creek. Caldwell's vein was stated to be half a mile east of Scripture's along the same trail.

These veins were not identified in 1927 and the trail referred to in the original description is no longer in use. According to Mr. Ingall's report and map Scripture's vein strikes east, dips steeply to the south, is 4 feet wide, and consists of coarsely crystalline white quartz and amethyst. It occurs in a fault in Animikie iron formation. An open-cut had been driven into the hillside upon which the vein was exposed at the time of Mr. Ingall's examination in 1887. Caldwell's vein strikes northwest and dips steeply to the south. It occupies a fault passing through Animikie iron formation, the overlying shales, and a diabase sill above. Little or no work had been done on the vein by 1887 according to Mr. Ingall.

(10) *Mining Location R 345*

This mining location lies about 1 mile west and a little north of the west end of Arrow lake. On it on the north side of the railway right-of-way a vein is exposed on the side of a hill. It strikes north 25 degrees west and dips 85 degrees toward the south. A pit approximately 10 feet deep has been sunk in the side-hill. The vein is 4 feet wide and consists of coarsely crystallized white calcite and white quartz. It occupies a fault in flat-lying, grey, cherty taconite. The amount of displacement cannot be determined. The vein is visible only at the pit.

(10) *Mining Location T 173 (Including Queen Mine)*

On the east-facing cliff of a hill lying approximately one mile directly north of the west end of Whitefish lake, on mining location T 173, an adit has been driven 30 feet westerly along a vein into the hill. The vein strikes south 72 degrees west and dips 85 degrees toward the south. It has a maximum width of 6 feet and locally divides into two or more veins with an aggregate width also of 6 feet. The vein consists of coarsely crystalline white calcite with small amounts of coarsely crystalline white quartz at the walls of the vein and in vugs. The vein occupies a fault

[1] Ingall, E. D.: Op. cit., p. 100

passing through Animikie iron formation and a capping diabase sill. The rocks on the southern side of the vein have been downfaulted through a distance of 40 feet relative to rocks on the north side. The capping diabase sheet forms the southern wall of the vein at the mouth of the adit; the northern wall is Animikie iron formation.

The workings on the eastern part of mining location T 173 are said to be known as the Queen mine. An adit commences 16 chains east-northeast of the previously mentioned adit 80 feet lower on the same hill. The mouth of the adit is now caved. The size of the dump indicates that the adit probably extended into the hill about 100 feet. The hill rises 75 feet above the adit and the vein has been stripped above the mouth of the adit at three localities separated from each other by about 20 feet. The vein strikes east and dips vertically. It is 4 feet wide and consists of coarsely crystalline calcite, and white and bluish quartz. The country rock is grey, cherty taconite. Along the walls of the vein the rock has been brecciated. Except on the side-hill, the drift-covering in this vicinity appears to be several hundred feet thick.

(10) *Mining Claim TB 3027—Wolverine Mine*

The Wolverine mine is located near the northwest corner of mining location E 36, the west half of which is now known as TB 3027, and is now owned by James Little of Port Arthur. Some exploration work has been done on this claim in a search for iron ore. Location TB 3027 adjoins T 173 on the east and the Wolverine mine workings lie approximately 10 chains northeast of the adit of the Queen mine and at the same elevation. A shaft was sunk prior to 1890 to a depth of 90 feet and the vein was stripped for a distance of 30 feet in the vicinity of the shaft. The mine buildings were destroyed by fire in 1926. No work has been done on the vein during the last 40 years. The vein trends northeast and dips at 85 degrees to the southeast. It consists of 2 feet of solid, white, coarsely crystallized calcite with numerous small stringers of white calcite and quartz ramifying through the wall-rock for a distance of one foot on either side of the main vein. The country rock at the surface is grey oolitic chert, a phase of the Animikie iron formation. The brecciated blocks in the walls of the vein show slickensides. The vein probably occupies a fault, but the amount of displacement has not been determined. Blocks of hematite-bearing jasper taconite penetrated by vein material, occur on the dump, indicating that the lower workings penetrated this phase of the iron formation.

(11) *Arrow River and Whitefish Lake Mining Companies*

Mr. Ingall reported that 1½ miles west of the west boundary of Strange township and 2¼ miles north of the western end of Whitefish lake, the Arrow River and Whitefish Lake Mining Companies had done a small amount of testing, both working on the same vein. The work done consisted of two shafts sunk on the vein, each about 30 feet deep and approximately 900 feet apart, with some little workings on the outcrop between them. On a second vein about a half mile south of the previously mentioned workings a couple of shallow pits were sunk. The northern vein trends east and is approximately vertical. The southern vein trends north 70 degrees east and dips 70 degrees to the north. The northern vein has the character of a breccia-cement, the solid vein material varying in width from 4 to 10 feet. The vein material is of calcite, which locally shows curved cleavage faces, and of quartz. A greenish black material, probably chlorite, occurs as streaks through the vein. The country rock is Animikie iron formation. The southern vein is of similar mineral composition and is enclosed in the same Animikie rocks.

(12) *Mining Location R 192*

A road goes north from Whitefish river along the west limit of Strange township. In the south part of lot 12, concession IV, a vein has been exposed on the road. No development work has been done on the vein. It strikes north 70 degrees west, and is vertical. It is 3 feet wide and contains abundant, small, angular inclusions of wall-rock. It is exposed for a distance of 8 feet. The vein consists of white quartz. The country rock is flat-lying Animikie iron formation. Within 200 feet of the exposure a cliff rises 40 feet. Somewhat less than a quarter mile southeast of this cliff granite is exposed underlying the Animikie at an elevation approximately 50 feet below that of the vein outcrop.

(12) *Mining Location Y 5*

This mining location is crossed by Whitefish river at a place about 3 miles northeast of the west end of Whitefish lake. According to Mr. Ingall's map a vein on this claim strikes north 20 degrees west across Whitefish river at a point a half mile west of the west boundary of Strange township.

(12) *Mining Claim TB 6588*

A composite vein crosses Whitefish river in the central part of mining claim TB 6588 at a point 50 chains northwest of the northwest corner of the south half of lot 12, concession III, Strange township. This property is owned and operated by the Tyee Stucco Works of St. Boniface, Man. The vein material is being used as a surface dressing on stucco. During the winter of 1926-27, 600 tons were shipped via Mackey station to Manitoba. The vein material has been mined in an open-cut 60 feet long, 20 to 30 feet deep, and 6 feet wide. The vein material seals a fault zone that is exposed 120 feet along the surface, trending north 75 degrees east, and dipping vertically. Quartz-sealed fracture zones occur in small outcrops along the inferred east extension of the vein at 10 chains from the workings at the river. The composite vein crosses Whitefish river and on the west bank is offset 20 feet. The vein material consists chiefly of coarsely crystalline white calcite with small amounts of white quartz in the form of seamlets and vug linings. The operators report that small specks of native silver and galena occur sporadically. The country rock is flat-lying Animikie iron formation.

(13) *Mining Location Y 2*

A vein occurs in the southeast corner of mining location Y 2[1] $1\frac{1}{2}$ miles due north of Wolfe station. No work has been done on this property. The vein material is entirely calcite and cements a fracture zone 1 foot wide and exposed for 25 feet. It strikes north 83 degrees east and is vertical. The country rock is a capping sill of diabase, 40 feet thick, resting on Animikie iron formation.

(13) *Mining Locations E 17 and R 190*

A vein occurs at a fall on Whitefish river approximately 2 miles northwest of Silver Mountain station, near the boundary between mining locations E 17 and R 190 (*See* Map 213A). No development work has been done on the vein. It strikes north 25 degrees east, is vertical, and can be traced 50 feet on the surface. The vein fills a fracture zone $1\frac{1}{2}$ feet wide. The vein material is predominately calcite, but a small amount of quartz is also present. The country rock is Animikie iron formation.

(13) *Star Mine*

On the southern half of concession V, lot 5, Strange township (*See* Map 213A), there is a property locally known as the Star mine. Prior to 1890, two pits each 75 feet deep and located $\frac{1}{2}$ mile apart, were sunk on a vein system. The vein material occurs in a fracture zone 8 to 10 feet wide and which can be traced 1,000 feet striking north 70 degrees east. The dip is 75 degrees south. Spectacular crystals of clear quartz up to $2\frac{1}{2}$ inches in diameter can be obtained from the east dump. Indications of crustified banding were observed on pieces taken from the dump, the minerals being colourless quartz, calcite, green fluorite, and amethyst. A few small crystals of pyrite and also calcite encrust the larger quartz crystals. About 25 per cent of the mineralized zone consists of inclusions of wall-rock. The country rock is flat-lying Animikie iron formation.

A vein system, which may be the continuation of that of the Star mine one, appears in concession V, lot 3, Strange township, on North river near its junction with Whitefish river. It strikes north 70 degrees east, and dips steeply to the south, occupying a shatter zone in flat-lying, grey, cherty iron formation. The minerals observed were quartz and calcite.

(13) *Mining Location Y 4*

On mining location Y 4, concession IV, Strange township (*See* Map 213A), $2\frac{1}{2}$ miles due north of Wolfe, a composite vein 8 to 10 feet wide occurs. Two test pits, each 50 to 60 feet deep and approximately $\frac{1}{4}$ mile apart, had been sunk on it prior to 1890. The composite vein trends north 65 degrees east and dips 75 degrees southeast. It can be traced continuously over a distance of 600 feet. The vein material is quartz. The country rock is Animikie iron formation. The extension of this composite

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[1] Geol. Surv,. Canada, Map 213A. Kakabeka sheet, Thunder Bay district, Ont.

vein, where it appears on the north bank of Whitefish river about 1¼ miles westerly from the workings, is in granite. It there consists of some twenty quartz veinlets averaging ½ inch in width distributed over a width of 20 feet.

(14) *Mining Locations R 80 and R 81*

The Sunset Lake vein occurs in mining locations R 80 and R 81 on the north shore of Sunset lake about ½ mile south of the east end of Whitefish lake. Prior to 1890 an open-cut 6 feet deep was excavated for a length of 15 feet on the vein on the western part of mining location R 81 about 150 feet north of the lake shore. The vein trends north 75 degrees east and dips 80 degrees towards the north. It is 2 feet wide and cements a shatter zone in diabase. The vein shows an imperfect banding with about 1 inch of green fluorite along the walls. The greater part consists of coarsely crystalline white calcite; white quartz and amethyst with well-developed crystal terminations occur in seamlets and as vug linings.

(15) *Mining Location R 61 (Scripture's Vein)*

Scripture's vein occurs on mining location R 61 on the east-facing cliff of Silver bluff, 1½ miles southeast of Silver Mountain station (*See* Map 213A). The vein has been stripped for a vertical distance of 25 feet on the upper part of the cliff. It is naturally exposed for 20 feet below on a sheer part of the cliff and 75 feet below this there is an adit, the mouth of which has caved. From the amount of material exposed on the dump it appears probable that the adit is not more than 25 feet long. The vein is from 2 to 3 feet wide, and a few parallel stringers up to 2 inches in width occur within 2 feet of the walls of the main vein. It trends north 75 degrees west and dips 85 degrees toward the north. The vein consists of coarsely crystalline white calcite and barite, with green fluorite in discontinuous bands an inch or two in width along the walls. In the central part of the vein there are irregular developments and vug linings of white and amethystine quartz with well-terminated crystals. Throughout the greater part of the vein the coarsely crystalline barite is the most abundant mineral constituent. The upper 25 feet of the vein, as exposed, is in diabase, the lower part is in grey taconite, the beds dipping 2 degrees towards the southwest. The contact between the sediments and the overlying diabase sill occurs on a sheer cliff and the amount of dislocation along the fissure occupied by the vein is apparently about 4 feet. There is a notch on the side of the diabase cliff and a drift-covered valley extends from it north 75 degrees west on the top of the hill.

SILVER MOUNTAIN AREA (*See* MAP 213A)

(15) *Augusta Mine*

On the north half of concession I, lot 1, Strange township, on the west side of a hill, a composite vein about 4 feet in width is exposed. It has been explored by an adit 100 feet long and by a shaft sunk from a point 100 feet below the adit. The dump from the workings has been used in recent years for road metal.

The hill is capped by a diabase sill 50 feet thick, below this are flat-lying Animikie sediments 100 feet thick consisting chiefly of black shale. The rocks have been dislocated by a vertical fault striking south 82 degrees east, vertical slickensides are visible on the south wall of the adit. There is a brecciated zone averaging 4 feet in width along the fault. The brecciated zone is cemented with vein material; as exposed in the shale, it consists of white and pink calcite, green and purple fluorite, pyrite, galena, and quartz. The galena is irregularly distributed and is not abundant. Vein material in the diabase is not exposed.

(16) *Silver Mountain Mines*

A vein system which crosses Silver mountain in Lybster township has been developed by the East End and the West End, Silver Mountain mines. The former embraces mining locations R 53 and R 54; the latter consists of mining locations R 55, R 56, and R 57 (*See* Map 213A).

The discovery of rich silver ore in this vein was made in the autumn of 1884 by Mr. Oliver Daunais. He and his associates took up locations including the vein for a length of over a mile. The property was then dealt with in separate halves known as the East and West ends, respectively. The former was shortly afterward leased to American capitalists on a twelve months' option and they commenced operations in the spring of 1885, and continued with a considerable force until the end of the same year, when, after expending about $10,000 in work, their option expired. The mine reverted to the original owners with whom the Messrs. Trethewey, who had formerly managed Silver Islet mine, became associated. During the year 1886 a small amount of development work was carried on and resulted in the striking of some silver ore in the upper tunnel, some little distance beyond the point where the American company discontinued work where the vein had been poor. The Silver Mountain Mine Company, Limited, was organized in Liverpool, England, in the autumn of 1886. They purchased the East End and carried on development operations between the years 1886 and 1892.

Operations on the West End property were carried out in the winter of 1885-1886. In 1886 the property was bonded by the Silver Mountain Mine Company, but after a little work had been done with very encouraging results the parties became involved in litigation as to who should have control. Work ceased and in 1887 two shafts and a pit were the only workings recorded in Mr. Ingall's report. West End Silver Mountain mine was actively worked between 1898 and 1903 and it contributed almost all of the $363,681 worth of silver ore that was produced from this district during this period.[1] In 1911 N. L. Bowen reported that little work was being done at the time of his visit. The mine was kept pumped out and where a good pocket was shown on any of the faces a shot was put in and the best taken. In this way a carload of ore was made up from time to time, but no attempts were made to mine large quantities and produce concentrates as was formerly the practice.

[1]Bowen, N. L.: 25th Ann. Rept., Ont. Bureau of Mines, 1911, pt. 1, p. 129.

In 1924 West End Silver Mountain mine was leased by the Tyee Stucco Works Company of St. Boniface, Manitoba. The vein material was mined, hand-sorted, and shipped from Silver Mountain Station to Manitoba for use as a dressing on stucco work, the coarsely crystalline calcite of the gangue being the material particularly desired. Mr. George Smith, who was in charge of operations in 1927, stated that the production during 1924, 1925, 1926, and up to July, 1927, totalled 6,000 tons. Some of this material was obtained from the waste rock dumps of the silver mine and part from open-cuts on the vein.

For a few years prior to 1927 the waste rock of the dump of East End Silver Mountain mine, including black shale and vein material, has been used for road metal in Lybster township.

Silver mountain is a mesa capped by a diabase sill, the erosion remnants of which vary from a few feet up to 100 feet in thickness. Beneath the sill are nearly flat-lying Animikie shales more than 100 feet thick.

A fault zone striking east and dipping between 80 and 85 degrees to the north crosses the mesa. The rocks on the north side show a downthrow varying between 65 and 80 feet relative to those on the south. The fault zone follows a depression, averaging 100 feet in width, and in which there is an extensive deposit of drift.

The fissures along the fault zone have been cemented with vein material. In the diabase along the top of the mesa simple veins up to 6 feet in width occur. In the Animikie shales the vein material occurs as breccia cement and in a tangle of veins, some of which are a few feet wide, but the majority are only a few inches wide and are distributed irregularly through a zone the width of which, as partly revealed in the outcrops and workings now accessible, varies between 10 and 100 feet. The 100-foot width is exposed at only one locality, namely, 1,600 feet east of the most westerly shaft on West End Silver Mountain mine.

The vein system has been traced for a mile along an east direction where it crosses the mesa, for about one-half mile along a west-northwest direction down the western flank of the mesa, and for about one-half mile along a northeast direction down the slope on the eastern side of the mesa. Ingall[1] says,

"that a theory was at first held locally that there were two veins at the east end, and that the portion of the vein striking northeast was a branch of the main vein. . . whilst it was believed that the main vein must continue on its original course (east) down the valley. A careful examination, however, shows no grounds for such a supposition."

The vein material consists of the following minerals: calcite, barite, amethystine, smoky, and white quartz, green and purple fluorite, zinc blende, galena, pyrite, chalcopyrite, native silver, and argentite.

The most abundant of the vein minerals are calcite and quartz; they are intimately associated and occur throughout the greater part of the vein system. Where fissure fillings are more than a foot wide calcite predominates over all other constituents.

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[1]Ingall, E. D.: Geol. and Nat. Hist. Surv. of Canada, 1887, pt. H. p. 88.

Barite occurs, in wide fissure fillings, as coarsely crystalline seams up to a foot in width and several yards in length. Such seams have been observed only in the upper part of the vein system lying in or near diabase.

Fluorite occurs along the walls of veins as discontinuous seams of irregular width, commonly a few feet or yards long and an inch or so wide. The seams are more abundant along the walls of veins less than a foot wide than in wider veins, and fluorite is absent from most of the wide veins. In some veins green and purple varieties of fluorite are interbanded in bands averaging one-tenth inch in width and roughly paralleling the walls of the vein, but in some seams one or other variety is present alone. A dark purple, almost black, variety, rare in the district, occurs near the east end of the vein system as exposed in mining location R 54.

Galena and sphalerite are sparsely disseminated through the greater part of the vein system. Small local concentrations occur in intimate association with fluorite in seams commonly less than an inch wide along the marginal part of some veins. Chalcopyrite occurs in very small amount in some of the small concentrations of galena and sphalerite.

Pyrite occurs in small amount along the middle of some veins and as an incrustation on calcite and amethyst in the walls of vugs.

No silver was observed in the vein system as exposed in 1927. It is reported by Ingall[1] that both native silver and argentite occurred. "The latter is the most common, forming films, sheets, and solid nuggets often several ounces in weight, whilst the former occurs in films, but more often in fern-like and wire forms."

Concentrations of rich silver ore presumably occurred in a few widely spaced pockets. The following information is based on a statement by Ingall.[2] Rich ore occurred at discovery pit (No. 4) on the slope on the eastern side of the mesa, and it was estimated that several tons with an average silver content of between 1,000 and 2,000 ounces a ton were available in this vicinity. Rich ore was present in a small vein 120 feet north of No. 4 pit; in a small vein about 230 feet southwest of No. 4 pit; in No. 2 level 120 feet underground and about 520 feet west-southwest of No. 4 pit, and at "several other spots in the vein," none of it so rich as near No. 4 pit. No extensive ore-body was found. Present information indicates that all known ore-bodies have been extracted; the development work seems to have been sufficiently thorough to exhaust the possibility of there being any large ore-bodies in the upper 200 feet. Whether or not small ore-bodies may remain between the mine workings remains to be proved by further exploration. Further study of the faulting on Silver mountain seems warranted in the expectation of finding mineralized vein material between the known vein system and Lizard lake, which lies 2,000 feet to the south, in mining location T178 (Map 213A) where an inferred fault occurs.

(17) *Crown Point Mine*

Crown Point mine is on mining locations R 95 and R 83 (*See* Map 213 A) adjacent on the north to East End Silver Mountain mine. It was discovered shortly after Silver Mountain vein system was found in 1884. On

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[1] Ingall, E.D.: Op. cit., p. 89.
[2] Ingall, E.D.: Op. cit., p. 90.

the main vein two adits, each between 100 and 150 feet in length, and three crosscuts, each less than 50 feet long, had been driven prior to 1887. A plan and section of these workings is given in Mr. Ingall's report. During the examination of 1927 it was found that at 140 feet easterly from the mouth of the lower of the two adits and along the continuation of the vein a trench had been dug trending north and approximately 350 feet long. The loose blocks of Animikie shale above the caved walls of this trench are the only present indications of what was here encountered. At the southern end of this trench there is a pit 8 feet by 4 feet by 10 feet. At 35 feet east of this pit there is a shaft 6 feet by 12 feet and 20 feet deep. Fifty feet east from the shaft there is a pit 7 feet deep. Forty-five feet east of this pit a dump at the mouth of an adit is to be seen. It was estimated that this was at an elevation approximately 60 feet lower than adit No. 2. Its mouth has caved and cannot be entered. The dump here is approximately of the same size as that of dump No. 1.

At 650 feet northwest of the upper adit of Crown Point mine, a vein 2 feet wide, striking north 83 degrees west and dipping vertically, has been exposed in the capping diabase sill by a trench 2½ feet wide and 20 feet long. Forty feet below on the side of the hill there is an adit that extends into flat-lying Animikie shale. The vein is not exposed in the adit and Mr. Ingall reports that the attempt to trace the downward extension of the vein at this point was discontinued "owing to the parties who were prosecuting the work, finding that the vein was not on their own property."

The main vein of Crown Point mine occupies a fault passing through flat-lying Animikie shales and an overlying diabase sill. The south side has moved, relatively, downward through a distance of approximately 15 feet. Slickensides are prominently exposed on the southern side of the upper adit and indicate that the principal movement was approximately vertical. The vein as exposed in the upper adit is locally 4 feet wide and divides and re-unites through a shatter zone having a width of about 6 feet. The vein system has a general strike of south 85 degrees east and a dip of 80 degrees toward the south.

The vein material is of the same character as that of the Silver Mountain vein system. The veinlets in the shatter zone and the walls of the wide vein are encrusted with quartz, green and purple fluorite, calcite, and amethyst. The central part of the wider vein consists chiefly of coarsely crystalline calcite through which there are seams of barite and quartz. Galena and zinc blende occur irregularly disseminated and locally concentrated in small seams along with the fluorite. Mr. Ingall reports that argentite in leaf and nugget form was found locally in the vein.

(17) *Mining Location R 64*

Several large veins occur on mining location R 64 (*See* Map 213 A). They vary in width from 3 to 8 feet. In the veins various forms of quartz preponderate and are accompanied in places by varying proportions of green fluorite, calcite, and occasionally a little barite. At one exposure, a vein consists almost entirely of solid vitreous quartz, and has a marked, banded or "combed" appearance due to different-coloured layers (amethyst, white, translucent, etc). The fluorite seems to have been mostly deposited between the irregular surfaces of these layers. The metallic minerals zinc blende, galena, and pyrite occur occasionally, in disseminated grains, and in the case of pyrite also as very thin films coating cleavage planes, jointing, etc. The enclosing rocks are of Animikie iron formation.

The work done has been confined to tracing the veins and sinking shallow test pits on their outcrops.

(17) *Mining Location R 70*

In the northeast part of mining location R 70 (*See* Map 213A) two nearly parallel veins have been developed. They strike approximately east and are about 10 chains apart. On the southern vein two test pits, 100 feet apart, have been sunk to depths of 4 and 7 feet, respectively. On the northern vein an open-cut has been driven 20 feet into the west side of Silver hill and at the portal a shaft has been sunk at least 25 feet. Two smaller open-cuts have been made one above and one below that previously mentioned; the three open-cuts are within a horizontal distance of 50 feet.

The southern vein is 2 feet wide and occurs in a fracture in diabase. The northern vein where exposed is in a fault shatter zone 4 feet wide traversing flat-lying Animikie iron formation; the eastern extension of the vein presumably passes through a diabase sill capping Silver hill. The strike of the southern vein varies from south 75 degrees east to south 65 degrees east, the dip is 80 degrees south. The northern vein strikes north 77 degrees east and dips 75 degrees south.

The southern vein consists of coarsely crystalline white calcite and associated green fluorite, barite, colourless, and rarely amethystine, quartz, and pyrite.

In the case of the north vein, vein material makes up approximately one-third of the substance within the shatter zone. It shows the same mineral assemblage as the southern vein, with the exception that no barite is visible. Mr. Ingall reports that a little silver and argentite were found in this vein.

(37) *Mining Location R 79*

In the southeast part of mining location R 79 (*See* Map 213A), about one-quarter mile northwest of the previously described open-cut on Silver hill (mining location R 70), a vein has been reported by Mr. Ingall, on which he says a little test work has been done. It strikes south 65 degrees east, dips 70 degrees north, and occurs in Animikie iron formation. Mr. Ingall says,[1] R 79 vein is filled at one place with a gangue of saccharine quartz and spar; the latter, mostly calcite, whilst at another opening it consists altogether of compact, vitreous, iron-stained quartz. It carries a little disseminated pyrite, galena, and zinc blende.

(18) *Mining Location R 135 (Woodside's Vein)*

In the central part of R 135 (*See* Map 213 A), about 10 chains northwesterly from the bridge over Whitefish river on the Fort William-Whitefish highway, there is a tangle of veins 12 feet wide occupying a shatter

[1]Ingall. E.D.: Op. cit., p. 95.

zone in granite. The vein system is exposed over a length of 15 feet in the vicinity of a shaft. It trends south 30 degrees east and dips 80 degrees south. The vein material consists of white calcite, white and amethystine quartz, green and purple fluorite, galena, pyrite, and zinc blende. Mr. Ingall reports,[1] " That the pyrite occurs occasionally in peculiar ring-like or rather more hexagonal arrangement in the calcite, the centres of the rings, etc., consisting also of the latter mineral."

The shatter zone includes blocks and small angular fragments of granite and Animikie iron formation. The veinlets that make up the vein system are for the most part less than 4 inches wide and within the width of 12 feet they make up approximately one-quarter of the total volume. The fluorite-bearing veinlets showing an imperfect banding have been dislocated by fractures that have been cemented by quartz and amethyst-bearing veinlets. The galena and zinc blende are sparsely disseminated through the fluorite-bearing parts of the vein.

Mr. Ingall reports,[2] " The work done up to the middle of October, 1886, consisted of some explorations and pits in the outcrop of the vein over a distance of about 100 yards, and of a 25-foot shaft sunk on the hanging-wall which had just reached the vein at that depth."

(19) *Mining Location R 115*

Tchiatin's vein occurs on mining location R 115 (*See* Map 213A) three-quarters of a mile south-southeast of Hillside station. Two shafts 25 and 50 feet deep respectively and 50 feet apart have been sunk on this vein. The vein has been partly exposed by test pits and trenches between the shafts.

The vein occupies a fault in Animikie shale and iron formation. The vein has a width of about 18 inches. It strikes east and dips 70 degrees to the south.

The vein material consists of fine and coarse-grained white quartz, amethyst, white calcite, and green fluorite. Parts of the veins are locally well mineralized with galena and sphalerite.

(19) *Mining Location R 111*

There is a vein on mining location R 111 about 1¼ miles south-southeast from Hillside station (*See* Map 213A). Within a distance of 100 feet along the vein is a series of test pits and trenches which are now caved. The drift covering at this point is approximately 3 feet thick. The vein seals a fault in Animikie iron formation and has a width of 1½ to 2 feet. The vein strikes south 60 degrees east, and dips steeply toward the north. Quartz, calcite, green fluorite, galena, and zinc blende comprise the vein minerals.

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[1]Ingall, E.D.: Op. cit., p. 96.
[2]Ingall, E.D.: Op. cit., p. 96.

(20) *Mining Location R 110*

Silver falls is on Silver Falls creek near the southwest corner of mining location R 110 (*See* Map 213A) half a mile west of a point on a road, $2\frac{1}{2}$ miles south of Nolalu village. A composite vein crosses Silver Falls creek 800 feet northeast of the falls. Mr. Ingall reports[1] "That to the end of 1886 the work done consisted of a 50-foot shaft sunk on the vein, from which, at a depth of 45 feet, a crosscut 15 feet in length was driven across it. Besides this, some surface strippings were made extending over a distance of about 50 yards of the outcrop of the vein." In 1927 it was observed that a pit had been sunk 15 feet northwest of the shaft, that an open-cut had been driven from the creek southeast along the vein for 30 feet, to within 8 feet of the pit, and that a stripping 40 feet by 4 feet had been made at a point 20 feet northwest of the creek where the drift covering is 4 feet deep. Slumping has occurred around all these workings.

The composite vein is exposed for part of its width in the bed of Silver Falls creek, which is here approximately 20 feet wide. It occupies a fracture zone 15 feet wide in cherty magnetite-taconite, dipping 50 degrees northeast. The aggregate width of vein material measured across the fracture zone is about 4 feet. The composite vein strikes south 55 degrees east and dips 75 degrees southwest. The vein material consists of quartz, amethyst, white calcite, purple fluorite, barite, and, locally, pink dolomite. Galena, chalcopyrite, and pyrite are sparingly disseminated through parts of the vein.

Steeply inclined beds of Animikie iron formation are exposed in the bed of Silver Falls creek for a distance of 400 feet across their strike. Several branching veinlets of quartz up to an inch in width are exposed at intervals of a few feet or yards throughout this distance. The general strike of these is southeasterly within a few degrees of the direction of strike of the beds. Their dip is nearly vertical. Thirteen hundred feet south of the workings, there is an outcrop of flat-lying Animikie iron formation. A dyke of fine-grained diabase about 100 feet wide outcrops at Silver falls, trends southeast, and lies between the outcrops of steeply inclined Animikie iron formation to the northeast and the outcrops of flat-lying beds to the south.

(21) *Palisades Mine, Mining Location R 98*

On mining location R 98 (*See* Map 213A) near the middle of its western boundary, a composite vein outcrops on the side of a hill that rises about 40 feet from a drift-covered plain. Mr. Ingall reports.[2]

> "The developments to the end of 1887 consisted of a crosscut tunnel driven south into the base of the hill, about 40 feet below the outcrop of the vein and the base of the trap sheet, which at a distance of 50 feet in from its mouth has intersected the vein, from which point a shaft has been sunk on it, said to be 50 feet deep, and to have shown the enclosing rock to be argillites all the way down. At the edge of the tunnel the vein consists of numerous branches and stringers distributed for a distance of about 10 feet in the argillites."

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[1] Ingall, E.D.: Op. cit., p. 95.
[2] Ingall, E.D.: Op. cit.

The vein occurs on the farm now held by Mr. E. Harri. He reports that the adit could be entered until 1926. Its mouth is now blocked by slumped drift. The old road that at one time connected Murillo and Silver mountain is still in good repair in the immediate vicinity of this property and connects with the modern system of highways to the east.

The vein occurs in flat-lying, soft, black, Animikie shales. Above them is a diabase sill interpreted by Mr. Ingall as a sheet branching from a diabase sill, approximately 100 feet thick, which caps the shales on Palisades hill.

The composite vein strikes south 70 degrees east and dips 70 degrees north. The vein material is very similar in appearance to that in West End Silver Mountain deposit, in that it shows banded fluorite with green and purple varieties interlayered. The greater part of the gangue material is calcite, and white and amethystine quartz. Small amounts of galena, zinc blende, and pyrite occur locally. Mr. Harri estimated that the vein material, which is distributed through a fracture zone 10 feet wide, has an aggregate width of 2 feet.

MARKS TOWNSHIP

Lot 12, Concession I

Echo lake (*See* Map 213A) is near the northwest corner of lot 12, concession I, Marks township. A road from Nolalu leads to the south half of lot 1, concession VII, Strange township, from which point a footpath goes northerly three-quarters of a mile to the west end of the lake. It is reported that a vein from which beautiful crystals of amethyst have been taken occurs in the vicinity of Echo lake. Presumably the vein is of the silver-bearing type. No particulars are available as to its precise location or other features. Four notches or ravines were observed in the bare granite hills that rise 100 feet above the lake. It is possible that the reported vein occurs in one or other of these notches.

(22) In the south half lot 4, concession VI, Marks township, several half-inch veinlets with a general trend northeast and composed of quartz and amethyst occur in granite distributed over an area measuring 200 feet square. No metallic minerals were observed.

O'CONNOR TOWNSHIP

(23) *Lot 11, Concession III*

On the south half of lot 11, concession III, O'Connor township (*See* Map 213A), two trenches each about 20 feet long and up to 4 feet in depth have been dug, one 350 feet southeast of the other and the more westerly one lying 25 chains east of the middle of three alined mesas known as the Sisters. In the rock piled at the sides of these trenches, there is vein material of the silver-bearing type. The northwest trench trends north 20 degrees east; the other north 70 degrees east. There were no exposures in the immediate vicinity when examined in 1927. The vein material consists of quartz and calcite. In blocks of rock on the dump, veins 2 inches in width cut Animikie iron formation.

(24) *Mining Location T 143*

A vein is prominently exposed on the north bank of Pitch creek in the west part of mining location T 143, concession II, O'Connor township (*See* Map 213A). In 1927 the properties embraced by T 143 and the adjoining T 144 belonged to the municipality of O'Connor township, due to the non-payment of taxes by former owners. The vein occupies a fault in a flat-lying, black, shaly phase of Animikie iron formation. This rock consists chiefly of black shale with lenses of oolitic chert an inch or so thick, occurring at intervals of a few inches and making up about one-tenth of the total volume. No development work, other than stripping, is known to have been done on the vein. The vein strikes north 55 degrees east and dips between 50 degrees and 75 degrees southeast. It is exposed for a length of 150 feet and is 5 feet wide. The vein consists chiefly of coarsely crystalline, platy barite, white calcite, and quartz, with small amounts of green fluorite and a little disseminated galena. The barite makes up approximately one-third of the total volume and is intimately associated with the calcite.

(25) *Lot 9, Concession I*

A vein occurs on the south half of lot 9, concession I, O'Connor township (*See* Map 213A), on a property owned by Mr. Robert Hymers of Hymers. It has been exposed in workings on the east side of a diabase-capped hill, 50 feet north of the road that runs westerly between Gillies and O'Connor townships. An open-cut has been driven south 80 degrees west into the hillside along the vein for a distance of 25 feet, and on the face of this hillside along the vein for a distance of 25 feet, and on the face of this working the vein is exposed through a vertical distance of 15 feet. The vein occupies a fault in flat-lying, wavy-bedded greenalite-taconite of Animikie age. It strikes north 80 degrees east; the southern wall is vertical, the northern dips approximately 75 degrees south. The vein is 2½ feet wide in the upper part of the workings and 6 inches wide in its lowest exposure. Two-thirds of the volume of vein material consists of coarsely crystalline, interfering platy, white barite. The other non-metallic minerals, in order of abundance, are: coarsely crystalline white calcite, green fluorite, and white quartz. Small showings of galena and zinc blende occur locally in the vein.

(26) *Empress Mine—Royal Vein*

In the centre of lot 1, concession II, O'Connor township (*See* Map 213A), a little over half a mile from the junction of the Beaver mine road and the Fort William-Whitefish highway, two parallel composite veins occur on the north side of a drift-covered hill.

A test pit 6 feet deep has been sunk on the southern vein; on the other vein, which lies about 100 feet north, a shaft 30 feet deep, two test pits, and several open-cuts have exposed the vein, discontinuously, for a length of 400 feet.

The southern composite vein occupies a shatter zone 3½ feet wide in flat-lying Animikie iron formation. It strikes north 86 degrees east and dips vertically. The vein material is concentrated in two parallel fissure fillings, the north one has a width of 14 to 22 inches, the south one is 4 inches wide; the intervening rock is cut by small branching stringers. Calcite and white quartz occur in approximately equal amounts, accompanied by some amethyst and small amounts of zinc blende and galena.

The northern composite vein occupies a fracture zone 3 feet to 3½ feet wide in Animikie iron formation. It strikes north 82 degrees east and dips vertically. The vein material is largely concentrated in a vein 1 to 2½ feet wide; its southern wall is well defined, whereas on the north side it is adjoined by fractured rock in which there is a ramifying network of stringers. The vein material consists of white calcite, quartz, zinc blende, and galena. The zinc blende makes up approximately 2 per cent of the exposed vein material, galena makes up a much smaller proportion.

RABBIT MOUNTAIN AREA (*See* MAP 213A)

A group of diabase-capped mesas occurs in the townships of O'Connor, Paipoonge, Gillies, and Scoble near their adjoining corners. This group forms a small northern extension of a table-topped highland. Rabbit mountain is the best known of the named mesas in the group and the numerous mines and veins in this vicinity have been referred to by Mr. Ingall as the Rabbit Mountain group.

Oliver Daunais, a trapper and explorer, located in 1882 the first discovered vein of this group having had it pointed out to him by an old Indian; this vein later on was developed as the Rabbit Mountain mine. The other veins that have been mined were discovered shortly afterward and were developed during the eighties. There was a general cessation of development in the silver mines in 1892 and only very little ore has since been produced from the Rabbit Mountain group of veins, though prospecting and testing operations have been carried on from time to time on certain properties. During the summer of 1927, Beaver mine was dewatered and tested by Mr. S. H. Brockunier for Kirby Thomas of New York. Rabbit Mountain mine and adjacent properties were acquired by Mrs. J. T. Cryderman and others in 1926, and surface explorations were in progress on this property in 1927.

(27) *Peerless Mine*

The shaft of Peerless mine is on the south half of mining location R 158, Gillies township (*See* Map 213A), 1,000 feet northwest of the house of W. Landversicht, the owner. The shaft is said to be 40 feet deep and has been full of water since about 1890. It lies within a few feet of the left bank of a creek that flows northwest. No rock outcrops in the vicinity of the shaft, but from a study of the dump and the rock at the collar of the shaft it is evident that vein material here cements a fault breccia in interlayered cherty taconite and shale. The vein system is chiefly of an interlacing network of veinlets and stringers. The vein minerals are quartz, calcite, and green fluorite through which pyrite and galena are sparsely disseminated.

(28) *Porcupine Mine*

The Porcupine, Badger, Climax, and West Beaver mines adjoin one another and their workings are on a closely related system of veins that appear in notches around the sides of a small diabase-capped upland, lying about three-quarters of a mile northwest of Rabbit mountain.

Porcupine mine is on mining location T 96, in Gillies township (*See* Map 213A), and is reached by a road leading a quarter of a mile south-east from a point on the Fort William-Whitefish highway 2 miles northeast of the branch road to Hymers.

Work was commenced at this mine in the spring of 1884, and was continued spasmodically until 1887. Mr. Ingall reports Mr. T. A. Keefer, one of the owners, as saying that about $10,000 had been expended up to that time and that this expenditure had been more than repaid by the sale of the ore obtained. Bowen[1] records that between 1892 and 1911 this mine had been reopened a number of times. The ore from Porcupine mine was treated at the mill of the adjoining Badger mine and it is recorded that the combined production of the two mines had a value of $300,000.[2]

The principal mine workings consist of two groups of adits driven northeasterly into the west side of a hill on the property, and two shafts on the north side of the hill. The hill is capped by a diabase sill about 60 feet thick; Animikie shales 100 feet thick are exposed under the diabase. The rocks dip at a low angle toward the northeast. They have been faulted at three localities. A fault occurs at the position of the southerly group of adits, it strikes north 50 degrees east and dips steeply south; the rocks on the northwest side have moved downward about 10 feet relatively to the rocks on the southeast side. A second fault occurs 600 feet northerly from the first; it strikes north 80 degrees east and dips about 80 degrees south; the dislocation is 8 feet and the downthrow side is on the south. Two hundred feet northeast of the second-mentioned fault, a shaft 30 feet deep exposes rock traversed by a fissure striking north 60 degrees east. No. 1 shaft lies about 1,000 feet east-northeast from the above-mentioned shaft, and there a fault strikes about north 65 degrees east and dips between 75 and 80 degrees southeast; the amount of the dislocation is 16 feet and the downthrow side is on the southeast. Fissures occur along the faults and have been cemented by composite veins.

In the first-mentioned fault the composite vein varies in width from 6 inches to 2 feet. It consists of white quartz, calcite, green and purple fluorite, and small amounts of disseminated galena and sphalerite.

In the second fault the composite vein varies in width from 1 to 4 feet. It consists chiefly of white calcite, white and amethystine quartz, green and purple fluorite, galena, zinc blende, and pyrite; chalcopyrite and pyrrhotite are sparsely disseminated through the vein material. At one place there is a seam 3 inches wide and 2 feet long, consisting of white witherite, the carbonate of barium, in radial, fibrous, crystalline aggregates. This occurrence is unique in this region. So far as known[3] witherite was first dis-

[1]20th Ann. Rept., Ont. Bureau of Mines, vol. XX, pt. 1, p. 131.
[2]Bowen, N. L.: Op. cit., p. 132.
[3]*See* Ingall, E. D.: Geol. and Nat. Hist. Surv. of Canada, 1887, pt. H, p. 71.

covered in Canada at this locality. Part of the vein material consists of argentite in nugget and leaf form and silver in wire and mossy forms; these minerals occur in vugs and along the cleavage planes of other minerals in the composite vein. It is said[1] that the composite vein at this locality was developed over a length of 200 feet and to a depth of 100 feet, and that pockets, rich in argentite and holding some native silver, with maximum dimensions of a few feet, were irregularly distributed and separated by several feet from one another, and that the vein material between the pockets was non-argentiferous. At the shaft 30 feet deep, the exposed fissure fillings are veinlets filled with quartz. At No. 1 shaft there is a composite vein similar in mineral composition to that in the first mentioned. Some blocks of vein material on the dump contain leaf argentite. The silver minerals occupy vugs and cleavage planes in certain of the gangue minerals; they appear to have been deposited later than the greater part of the vein material.

(28) *Mining Location T 200*

On mining location T 200 (*See* Map 213A), one-quarter of a mile south of the southern vein of the Porcupine mine, there is a caved adit on the western side of the same hill on which the Porcupine workings are located. No vein is visible. The material on the dump is shale with veinlets of quartz, calcite, and pyrite. The adit trends north 45 degrees east. Fifty feet south of the adit, there is a trench 60 feet long in drift.

(28) *Badger Mine*

The Badger mine is on mining location T 201 (*See* Map 213A), Gillies township. It adjoins Porcupine mine on the east and is accessible by a road leading to the Porcupine mine and thence to the Fort William-Whitefish highway. Test work by American capitalists was in progress in 1887; mining was most active between 1887 and 1891. It is reported by Mr. Robert Hymers who worked at the mine that the owners ceased operations in 1891 but that the wages of the miners were not paid in full and, therefore, permission was obtained by the miners to work the mine, with the result that, within a short time, a sufficient amount of ore was extracted, under Captain Sherer, to pay their claims in full. The Badger and Porcupine mines are reported to have produced $300,000 worth of silver ore.

The depths of the shafts and the disposition of the underground workings are not known, but the approximate dimensions of the various dumps are as follows: upper dump, No. 1 vein, 80 feet by 60 feet by 15 feet; lower dump, No. 1 vein, 300 feet by 20 feet by 20 feet; upper dump, No. 2 vein, 100 feet by 30 feet by 10 feet; and lower dump, No. 2 vein, 40 feet by 30 feet by 15 feet.

The material on the dumps consists chiefly of fissile black shale used locally as road metal. The ruins of many buildings are to be seen near

[1]Hymers, Robert: Oral communication.

the workings, two log cabins were still standing in 1927. The ruins of the stamp mill are on Silver creek about one-quarter mile east of the workings.

The veins of Badger mine are 170 feet apart at the shafts and occur in flat-lying Animikie shale, and a diabase sill which caps these strata.

The southern or No. 1 vein is composite and occurs in a shatter zone 6 feet wide along a fault on the southern side of which the rocks have moved relatively downward 15 feet or more. The fault strikes north 40 degrees east and dips steeply southeast. The vein material consists of calcite, white and amethystine quartz, green and purple fluorite, yellow and black sphalerite, galena, and a little pyrite; leaf and nugget argentite are said to have occurred abundantly in pockets a few feet in diameter and spaced at intervals of scores of feet.

The northern or No. 2 vein is inferred to be about 4 inches wide judging from the material in the dumps. The workings indicate a trend of north 65 degrees east. The vein consists chiefly of white quartz with smaller amounts of white and pink calcite, green and purple fluorite, zinc blende, and galena.

(28) *Climax (or Keystone) Mine*

Climax mine is on mining location T 145 (*See* Map 213A), O'Connor township, adjacent on the north to Porcupine mine. The Fort William-Whitefish highway crosses the mining location diagonally. For a time the property was called Keystone mine.

A small amount of rich silver ore was produced in 1891 from one of the veins on this property. These workings are now caved. Minor operations are said to have been carried on at several different times in later years; the most recent (prior to 1927) being in 1911 and 1912 when a shaft was sunk 80 feet on the southern vein.

On this property, on the west side of a hill of shale capped by a diabase sill, there are three composite veins striking northeasterly; No. 2 is 150 feet southeast of No. 1, and No. 3 is 300 feet southeast of No. 2. Each has an average width of 1 foot. The northern or No. 1 vein occurs in a shatter zone in shale, strikes north 80 degrees east, and dips 78 degrees south. Where now exposed in the shaft, the total width of vein material varies from 3 to 6 inches. No. 2 vein strikes north 78 degrees east and dips 85 degrees south. The shatter zone is traversed by numerous veinlets and has a width of 20 inches in the shaft where it occurs in shale a few feet below the base of the capping diabase sill. Vein No. 3 strikes northeast and dips 60 degrees north. It occupies a fault; the rocks on the south have moved relatively downward 30 feet. The composite veins consist of calcite, white and amethystine quartz, green and purple fluorite, and zinc blende, galena, pyrite, and argentite. The argentite is irregularly distributed in pockets in leaf and nugget forms, and it is said to have been more abundant on the hanging-wall side than on the foot-wall of the inclined veins within the composite veins.

(28) *West Beaver Mine*

West Beaver mine is on mining location T 140, O'Connor township (*See* Map 213A), adjacent on the northeast to the Climax mine. On this property, there are two composite veins. One of these is known as the Little Pig vein and is exposed 150 feet south of the Fort William-Whitefish highway, on the northern side of a hill of flat-lying shale overlain by a diabase sill. Vein No. 2 lies about 15 chains south of Little Pig vein on the east side of the same hill and is accessible by a road leading southerly from the highway a few hundred feet westerly from Silver creek.

The Little Pig vein was worked in 1885 and 1886 by three crosscut tunnels, about 200 feet apart, driven into the base of the hill about 40 feet below the outcrop of the southeasterly dipping vein. From the ends of two of the tunnels, drifts were driven on the vein for an aggregate distance of 60 feet. No. 2 vein was worked in 1911. An adit was driven along the vein for 250 feet and a shaft 80 feet deep was sunk to meet the adit. The ruins of the shaft house and a building at the mouth of the adit were to be seen in 1927. All machinery had been removed.

Little Pig vein is now exposed for a distance of 400 feet along the northern face of the hill; it strikes north 77 degrees east and dips about 70 degrees southeasterly. It occurs in a shatter zone 4 feet wide in flat-lying Animikie shale through which limy concretions up to 2 feet in diameter are distributed. Vein material makes up a little more than half of the material in the shatter zone. It consists of coarsely crystalline white calcite, colourless and amethystine quartz, green and purple fluorite, with sphalerite and smaller amounts of galena, pyrite, and argentite.

No. 2 vein is known through a distance of 300 feet and is now exposed in the diabase a few feet above and below the collar of the shaft. It occupies a shatter zone 1 to 2 feet wide, trending north 40 degrees east and dipping vertically. Many of the more prominent veinlets within the composite vein strike in a more easterly direction than the general vein system. The vein materials are the same as those found in the Little Pig vein together with minor amounts of rose quartz, pyrrhotite, and chalcopyrite. In the dump, blocks of vein material show groups of associated minerals in crustified or banded arrangements with veinlets cutting across previously formed parts of the vein. The earliest mineral assemblage to form in the vein system seems to consist of intimately associated, fine-grained, white quartz, white and buff calcite of medium texture, green fluorite, sphalerite, galena, a little chalcopyrite, and occasional small nuggets of argentite. A somewhat later generation consists of coarsely crystalline white calcite and green fluorite. A still later development is of coarsely crystalline quartz prisms with well-terminated pyramid faces projecting into the median part of the vein or into vugs; the tips of the large quartz crystals are amethystine and on them there is occasionally a later deposit of tiny pyrite cubes, black sphalerite, slender crystals of dog-tooth spar (calcite), and purple fluorite. Leaf argentite is associated with the latest formed vein materials and also occupies joints and cleavage planes in various parts of the vein system.

(28) *Silver Creek Mine*

Silver Creek mine is on mining location T 95, Gillies township (*See* Map 213A). The northwest quarter of this location in which the old workings occur, is embraced in a recently staked claim of 40 acres, TB 4563.

Work was initiated on this mine in 1885. Shortly afterward an interest was sold by the original owners to the same American capitalist who owned Beaver mine. Under the new owners a little more work was done under the management of Mr. Crowe, who is reported[1] to have stated that good ore was struck in the bottom of the shaft. Mr. T. A. Keefer, one of the owners, reported that the total amount expended was $3,000 and that silver ore of approximately this value was produced prior to 1887.

Mr. Ingall reports that a 70-foot tunnel was driven into the base of the hill on the course of the vein system and that from a point midway along this tunnel a shaft was sunk to a reported depth of 70 feet. All the silver ore found in this vein system is said to have come from the bottom of the shaft. In recent years a few feet of mineralized rock has been removed to a height of 20 feet above the portal of the tunnel.

The rocks in the vicinity of the mine are flat-lying Animikie shales (in which limy concretions, shaped like curling stones, occur) overlain by a diabase sill. The rocks have been dislocated by a fault striking north 65 degrees east and dipping 80 degrees southeasterly. The amount of dislocation is between 10 and 15 feet and the downthrow side is on the southeast. A fissured and brecciated zone up to 4 feet wide occurs along the fault. It is cemented with vein material. The vein minerals are white calcite, white and amethystine quartz, green fluorite, galena, zinc blende, pyrite, and argentite, named in order of relative abundance. Argentite was observed in leaf form in the cleavage cracks of calcite in blocks of vein material in the dump; it was not observed in place in the vein system as exposed in 1927.

(29) *Beaver Mine*

Beaver mine is on mining location T 97, O'Connor township (*See* Map 213A), 5 miles southwest of Stanley village. It is accessible by a road half a mile long branching south from the Fort William-Whitefish highway.

A vein was discovered on this property shortly after Rabbit Mountain vein was located, and development work commenced in 1884. In March, 1887, rich ore was discovered and by July a large tonnage was proved. Mining continued until 1891 when, after producing half a million dollars' worth of silver, operations ceased. In the autumn of 1907 the mine was pumped out and a new mill installed. "With the first run, it is said, the mill was found to be of faulty construction, the whole was closed down."[2] Between June and October 1927 the mine was dewatered down to the 200-foot level and an examination was made by S. H. Brockunier, mining engineer, for Kirby Thomas of New York. The present writer and George B. Langford of Cornell University made independent geological studies on the property while the underground workings were accessible.

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[1]Ingall, E. D.: Geol. and Nat. Hist. Surv. of Canada, 1887, pt. H, p. 75.
[2]Bowen, N. L.: 20th Ann. Rept., Ont. Bureau of Mines, vol. XX, pt. 1, p. 129 (1911).

The workings at Beaver mine consist of two vertical shafts, four levels, and a system of adits and winzes distributed in such manner as to develop a vein through a length of 900 feet and a depth of 400 feet. There is also a crosscut drift 330 feet long. A diamond-drill hole was bored to a depth of 800 feet below the lowest level.

The upper workings are in a mesa that rises about 200 feet above a plain to the north. The mesa is capped by a diabase sill 50 feet and less in thickness. Under this is nearly flat-lying Animikie shale 400 feet thick, succeeded downwards by iron formation between 700 and 800 feet thick. It is reported by S. W. Ray of Port Arthur that the diamond-drill hole penetrated through the Animikie strata into rocks that resemble the Keewatin.

Faults occur in the rocks on the mesa, and the fissures along them have been cemented by veins. The main vein averages 3 feet in width and lies in a fault zone that strikes north 36 degrees west and dips toward the southwest at a steep angle, with local variations in dip and strike; the rocks on the southwest of the fault have moved relatively downward 30 feet. Veins, nowhere known to be more than 16 inches wide, occur along two minor faults that formed somewhat earlier than the main fault and trend northeast and are crossed, nearly at right angles, by the main vein.

The veins, where they occur between walls of diabase, are simple fissure fillings; where they occur in shale they are composite and locally have the character of breccia cement. The main vein, as observed in the diabase, has an average width of 3 feet; its downward continuation in the shale is a network of small veinlets and irregular-shaped breccia cement, mainly concentrated within a zone of fissured and shattered rock about 3 feet wide but with branching veinlets extending outward for several feet into the wall-rock. The maximum width of vein material exposed in the cross veins is 16 inches and throughout the greater part of their exposed lengths they are 2 inches or less in width.

The vein material in both the main and cross veins is of the same general character. It consists of an intimate mixture of: calcite, barite, green and purple fluorite, colourless and amethystine quartz; zinc blende and galena; small amounts of pyrite and chalcopyrite; and locally pockets richly mineralized with argentite in nugget and leaf form, together with a little native silver. Inflammable gas was encountered in the mine workings.

Silver ore was found at various elevations between the highest and lowest workings and between all the different varieties of wall-rocks in the mine. The largest and more closely spaced concentrations of ore occurred in the vein material within the Animikie shale and less than 125 feet below the diabase capping sheet. Mr. Brockunier estimates that the average silver content of the vein material in this zone is, or was, 210 ounces to the ton; the composite vein and breccia cement is so distributed in the shale that in order to mine a 3-foot width he estimates that two-thirds of the material would be waste. Some 80 tons of this material exists above the lowest adit, but it is doubtful whether this could be removed with safety.

The general conclusion is that the main vein has been mined out; and that although silver values up to 134 ounces to the ton have been found in the cross veins their widths as exposed, commonly less than 2 inches, are too small to admit of profitable development. There is a possibility that veins other than those now known occur on the property.

(29) *Beaver Junior*

The Beaver Junior property lies immediately north of the Beaver on mining location T 142, in the southeast part of O'Connor township (*See* Map 213A). The Fort William-Whitefish highway passes through the property.

Work has been done on two nearly parallel veins about 700 feet apart and which lie within a half mile north of the northern surface workings on Beaver mine. The more southerly of the two veins, known as the North Bluff vein, has been worked by a crosscut adit driven northerly from the base of the hill. The entrance was covered in 1927 by material slumped from the hillside above. The size and nature of the dump indicate that drifting or sinking was done on the vein from this adit. A second crosscut adit, 8 feet long, has been driven into the shale just below the diabase contact 50 feet north and 50 feet above the first-mentioned adit, this crosses the vein which is here exposed at surface. The work on the northern or Big Harry vein consists of an adit 50 feet or more in length driven along the vein in shale 15 feet below the base of the capping sill of diabase.

Between the two veins in a notch on the western end of the hill another caved adit in shale trends north 30 degrees east. Stringers of quartz and calcite striking in this direction may be seen in the capping diabase sill a few feet above the mouth of the adit.

The dissected tableland on which the veins occur, consists of flat-lying Animikie shale with a capping sill of diabase 30 feet or more thick, as exposed on the marginal cliffs. The base of the diabase sill on the north side of the ridge, near the Big Harry vein, is 1,015 feet above sea-level; 700 feet south, the base is at an elevation of 1,030 feet.

One hundred feet west-southwest from the mouth of the adit on the Big Harry vein, a fault trending east and west and with a downthrow of 15 feet on the south was observed, a tiny quartz stringer occurs in the fault.

North Bluff vein is a composite vein 4 feet wide, part of which consists of a simple vein 8 inches wide. The general strike is north 85 degrees east and the dip appears to be nearly vertical; the simple vein dips 60 degrees to 70 degrees northerly. The simple vein consists chiefly of barite with some white quartz and calcite; other portions of the composite vein show the same minerals associated with amethyst, green and purple fluorite, pale yellow sphalerite, and pyrite. Transparent, well-formed crystals of barite up to 1½ inches in diameter occur through the creamy white, medium-textured, crystalline aggregates of barite. Big Harry vein is nearly solid. Its upper part, in the diabase, is 20 inches wide; the lower part, in shale, divides into numerous veinlets in a zone 3 feet wide. The vein strikes east and dips 70 to 75 degrees north. The rock north of the vein has been down faulted relatively, between 1 and 2 feet. Coarsely crystalline white calcite makes up the middle part of the vein; colourless, amethystine quartz occurs along the walls and also lines vugs. Sphalerite and nuggets of argentite occur, the latter intimately associated with quartz crystals which occur in vugs.

(30) *Lot 1, Concession F, Paipoonge Township*

Elgin vein occurs in lot 1, concession F, Paipoonge township (*See* Map 213A). The lot adjoins the Beaver Junior property on the northeast. The Fort William-Whitefish highway passes less than one-quarter mile northwest of the vein.

Workings are distributed over a distance of 320 feet along the vein. From west to east they consist of: shaft, No. 1, approximately 50 feet deep, two test pits approximately 15 feet deep at 180 and 220 feet respectively from the shaft; and 100 feet beyond is shaft No. 2 about 25 feet deep. Part of the dump from shaft No. 1 has been used for surfacing roads. Several caved trenches occur between the shafts, blocks of vein material have been piled along the sides of some of these and only a little of the vein was exposed in these trenches in 1927.

Elgin vein occurs in a fracture zone in flat-lying Animikie shale in a depression, 120 feet wide, between two diabase-capped mesas of which the southern is downfaulted 50 feet relative to the northern.

The fracture zone is 20 feet wide. Its upward extension appears locally, with a width of a few feet, along the northern face of the capping diabase of the southern mesa. The diabase rises 30 feet above the collar of shaft No. 1. A network of veins averaging 2 to 3 inches wide ramify through the fracture zone and make up about a quarter of its volume. The vein material consists of colourless, smoky, and amethystine quartz, white calcite, abundant purple fluorite, with smaller amounts of white and yellow varieties, through which are disseminated zinc blende and galena and some pyrite and chalcopyrite. Silver values of approximately 10 ounces to the ton are reported from this vein by Ingall.

(30) *Rothwell Mine*

Rothwell mine is in lot 5, concession D, Paipoonge township (*See* Map 213A). The Fort William-Whitefish highway passes a few hundred feet north of the northwest corner of this lot. A shaft 20 feet deep and a trench 30 feet long occur on this lot. The rocks exposed in the workings are flat-lying black shales. A fracture zone 2 feet wide, striking north 50 degrees east and dipping vertically, occurs in them. A few veinlets, up to 2 inches in width, ramify through the fracture zone. The veinlets consist of white and amethystine quartz and calcite.

(30) *Lot 3, Concession D, Paipoonge Township*

A composite vein occurs in lot 3, concession D, Paipoonge township. A pit, a few feet deep, was sunk on the vein. The rock in the pit is flat-lying black shale, which extends under a sill of diabase exposed a few feet west of the pit. The rocks have been faulted along a zone about 4 feet wide, striking north 65 degrees east and dipping at a steep angle toward the north. A composite vein composed of several veinlets, up to 1 inch wide, occurs in the shatter zone. The veinlets consist of coarsely crystalline quartz.

(30) *Lot 2, Concession D, Paipoonge Township*

A composite vein occurs in lot 2, concession D, Paipoonge township (*See* Map 213A). No development work was observed, in 1927, on this property. Flat-lying black shales capped by a diabase sill have been dislocated by a fault striking north 60 degrees east and dipping almost vertically; there has been a downthrow of 10 feet on the southerly side. A fracture zone about 6 feet wide is exposed for a distance of 40 feet in a notch in the edge of the diabase sill. Several small veins, up to 4 inches in width, occur cementing fissures in the fracture zone; they consist of calcite and white and amethystine quartz.

(30) *Lot 1, Concession D, Paipoonge Township*

A composite vein occurs in lot 1, concession D, Paipoonge township (*See* Map 213A). So far as known no development work has been done on it. The vein is naturally exposed in a notch on the side of a diabase sill. The strike of the vein is approximately north 50 degrees east and the dip vertical. The vein is exposed for a length of 6 feet; there is a width of 3 feet of solid vein material and adjacent to this on the northwest side, there is a zone 1 foot wide of fissured rock cemented with a network of veinlets up to ½ inch wide. The vein minerals are calcite and colourless quartz.

(30) *Mining Location T 151*

On mining location T 151 (*See* Map 213A), stripping has been done over a length of about 30 feet in a notch on the side of a diabase sill capping flat-lying shales. A fissure, striking north 75 degrees east and dipping vertically, in these rocks, is occupied by a vuggy vein 4 inches wide. The vein minerals are calcite and colourless quartz. The latter mineral, with well-developed crystal terminations, lines the vugs.

(31) *Lot 6, Concession C, Paipoonge Township*

At the west end of lot 6, concession C, Paipoonge township (*See* Map 213A), a 30-foot shaft has been sunk. The shaft was filled with water in 1927. The dump material indicates the probable occurrence of a vein having a width of 12 inches or more distributed through brecciated Animikie iron formation. The long dimension of the shaft collar is in the direction north 83 degrees west, and this is probably the strike of the vein. The surface, in the vicinity of the workings, is drift covered.

Coarse, white calcite constitutes the bulk (80 per cent) of the vein minerals on the dump. Associated with the calcite are colourless quartz, pale green fluorite, sphalerite, and galena.

(31) *Victoria Mine*

A composite vein is exposed in the northwestern corner of lot 7, concession C, Paipoonge township (*See* Map 213A), about 1¾ miles southwesterly from Stanley station. The Fort William-Whitefish highway passes about 100 feet to the south of the pit, 8 feet in depth, which was sunk prior to 1887 and was known as Victoria mine.

The property is owned by John McClure of Fort William. He stated in 1927 that no development work had been done in recent years. The composite vein, which strikes north 85 degrees east and dips steeply toward the north, cements a fracture zone 4 feet in width, in cherty, flat-lying, Animikie iron formation. The vein system can be traced over a distance of 800 feet westerly from the pit.

The vein filling composes about one-quarter the volume of the cemented fracture zone and consists of coarsely and finely crystalline white and pink calcite, amethystine and rust-stained and colourless quartz, and pale green and purple fluorite. The metallic minerals observed are galena, sphalerite, and pyrite. Specimens richly mineralized with galena and sphalerite have been obtained near the pit and low silver values, up to a few ounces to the ton, are said to have been obtained by assay.

(32) *Lots 10 and 11, Concession C, Paipoonge Township*

A composite vein strikes across the southwest corner of lot 11, concession C, Paipoonge township, and may be seen immediately north of the Harstone-Stanley road about 1½ miles westerly from Stanley station. The owner, Mr. S. F. Jones, of Fort William, sunk a test pit on the vein in 1927.

In lot 10, about one-quarter mile easterly from the above workings and a few feet south of the road, there is a parallel composite vein on which a 12-foot shaft was sunk several years ago.

The two veins are similar in that they occupy nearly parallel shatter zones, approximately 700 feet apart, in flat-lying greenalite taconite of the Animikie iron formation.

The northerly vein system can be traced 450 feet easterly from the working and has an average width of about 8 feet. The strike is north 73 degrees east and the dip is vertical. The southerly vein strikes north 77 degrees east and dips 85 degrees toward the south.

The vein material that comprises about 70 per cent of the volume of each composite vein consists mostly of coarsely crystalline, colourless, pale amethystine, and rose quartz which is frequently rust stained. White calcite and pale green fluorite occasionally occur. Galena and pyrite are irregularly concentrated in the veins.

(33) *Mining Location T 146*

Mining location T 146 (*See* Map 213A) lies immediately south of Beaver Mine property T 97. It embraces the northerly facing cliff of the northwestern part of Rabbit mountain. Near the middle of the location some work has been done on the Black Fox vein, which strikes north 80 degrees east from a small notch. In 1927 the mouths of two caved adits were noted about 150 feet northeast of the notch and 20 feet below the base of the diabase sill. A dump, measuring approximately 50 feet by 5 feet by 7 feet, extends from the mouth of the adits. One adit appears to trend south 10 degrees east into the shale, the other south 35 degrees east. Above these at the base of a diabase sill, there is a pit 5 feet deep. No vein material is exposed in place near these workings. On the dump, however, are blocks of shale penetrated by veins up to 4 inches in width and consisting of white and amethystine quartz, calcite, and small amounts of zinc blende and pyrite.

An old plan of the Beaver and adjoining properties in the possession of Mr. Louis Fenning shows the Black Fox vein extending about one-quarter mile easterly from the above-mentioned small notch with a strike of north 80 degrees east. Two thousand feet easterly from the notch there is a larger notch in the northeastern part of the location and there is here an adit driven 60 feet southeasterly into shale. A tiny seamlet of calcite occurs on the west wall of the adit. No vein is exposed on the cliff face near the mouth of the adit which, apparently, had been driven to crosscut a supposed extension of the Black Fox vein. Available information indicates that there is no southeasterly-trending vein, which might represent an extension of Beaver Mine vein, exposed on the northwest part of Rabbit mountain.

(33) *Mining Location R 48*

A group of caved pits and trenches was observed in 1927 on mining location R 48 on the east-facing slope of Rabbit mountain near its north end (*See* Map 213A). A few masses of vein quartz were found among the fragments of Animikie shale piled around the workings. No metallic minerals occur in the quartz masses that were examined. At a point a few feet west of, and above, the most westerly pit the horizontal contact between the Animikie shale and the overlying diabase sill, which caps Rabbit mountain, is 20 feet lower than the corresponding contact exposed a few yards southeast of this point. It is inferred that a fault occurs within the drift-covered area, a few yards wide, and that probably a vein of the silver-bearing type occurs in it.

(33) *Rabbit Mountain Mine*

Rabbit Mountain mine is 4½ miles southwest of Stanley station on the Canadian National railways, from which point it may be reached by wagon road. It is on old mining locations T 39 and T 40, the positions of which are shown on Map 213A.

Silver was discovered in a vein at this locality in 1882, by Oliver Daunais. During the following 5 years the property changed hands several times and development work proceeded spasmodically, with forces varying from two to sixty men. The mine was worked by shafts, levels, and cross-cuts, which extended along the main vein system for 370 feet, and to a depth of 290 feet. Rich silver ore was barrelled and sent away to smelters; low-grade ore was passed through a stamp mill and Frue vanners and the concentrates similarly shipped; silver was recovered from the slimes, which passed over the vanners, by treatment on the property. The total production from the mine was about 50,000 ounces of silver.

In 1927, mining location T 39 was owned by Mr. George Harris, of Fort William, and associates, and mining location T 40 by Mrs. J. T. Cryderman, of Fort William, and associates. In recent years surface work of an exploratory nature has been carried on by the present owners. At the time of the writer's visit the underground workings were filled with water.

Rabbit Mountain mine is in a drift-covered valley a few hundred yards wide trending northeast between cliffs, which are capped by diabase sills between 80 and 100 feet thick overlying flat Animikie shales. The valley slopes gently upward toward the southwest and its lower part, northeast of the mine shafts, is underlain by Animikie shale. In the immediate vicinity of the mine shafts there is a diabase sill between 5 and 30 feet thick overlying the Animikie shale, and farther southwest the thickness of the sill increases. The base of the sill in the cliff southeast of the mine is about 175 feet above the base of the sill in the valley and the latter is about 100 feet lower than the base of the sill on the cliff north of the mine in mining location T 57. A bench, a few feet wide, of diabase, projects through the talus on the lower part of the slope of the cliff on the north and Animikie sediments are exposed in contact with the southeast side of the diabase along a brecciated fault zone. It is not known whether this diabase mass is a dyke or a down-faulted part of the sill that caps Rabbit mountain. It is possible that all the above-mentioned diabase masses are parts of one sill and owe their different altitudes to faulting.

Other faults are known to occur in the valley in addition to that previously mentioned as occurring on the northwest slope. They strike northeast. Of these, the farthest northwest, as observed in mining location T 57, dips between 60 and 70 degrees northwest; 400 feet southeast of it a fault in the valley dips between 50 and 60 degrees southeast and at a depth of 70 feet joins the main fault, which dips between 65 and 70 degrees to the northwest. Along all the faults there are brecciated zones that vary in width from 3 feet to 20 feet and have been cemented by vein material in the form of composite veins and breccia cement. Within each of the vein systems single veins have widths of more than 1 foot for lengths of a few yards. The northwesterly vein system is almost continuously exposed for 450 feet southwest from the west boundary of mining location T 40, and its further extension for 500 feet is inferred from the position of workings known as Rabbit Mountain Junior mine, on mining location T 57, where vein material was found. The vein system in the valley has been discontinuously exposed in many trenches through a length of 800 feet, and the first level of Rabbit Mountain mine extends northeast for 300 feet beyond the surface exposure, thus giving a known length of 1,100 feet.

The vein minerals are quartz, amethyst, calcite, barite, green and purple fluorite, sphalerite, galena, pyrite, chalcopyrite, argentite, and native silver.

The only mineral concentration of economic value that has been found is silver ore. Silver minerals were not observed in place in 1927, but blocks of silver ore were found on the dump. The blocks consisted chiefly of coarsely crystalline white calcite with minor amounts of all the above-mentioned vein minerals, including argentite and silver in leaf form along cleavage cracks in the calcite and in tiny crevices among the several other minerals. Rich silver ore is reported to have been found in each of the vein systems on the property. Mr. Ingall reports[1] that very good ore was exposed by a blast put into the northwest vein system at a point about 300 yards north-northeast from No. 2 shaft. No further information is available regarding the occurrence of silver ore in this vein system.

The following note regarding the localization of the ore in the vein system in the valley is based on Mr. Ingall's report. Most of the ore taken out of Rabbit Mountain mine up until May, 1887, came from three masses whose positions are shown as stopes C, D, and E in a figure in Ingall's report. Stope C is between depths of 24 and 40 feet below the top of No. 1 shaft; it is 16 feet long and 8 feet wide. Stope D is 30 feet northeast of stope C, between depths of 8 and 32 feet; it is 35 feet long and 6 feet wide. Stope E is 80 feet northwest of stope D, between depths of 8 and 32 feet and is 80 feet long and 16 feet wide. The wall-rock of the vein system at these places is Animikie shale. The vein system in the diabase sheet above these places carried some rich ore and the original discovery at the surface was said to have been so rich as to cause great excitement in the district. Mr. Ingall reports that at depths greater than stopes C, D, and E, good ore was struck from time to time and that he saw a rich specimen taken from a depth of 160 feet.

The ore that was barrelled and sent to smelters from the mine contained over 1,000 ounces of silver to the ton. It is recorded that some of the ore milled on the property contained about 80 ounces of silver to the ton.

(33) *Rabbit Mountain Junior Mine*

Rabbit Mountain Junior mine is on mining location T 57. Caved workings were observed in 1927 about 500 feet southwest of the outcrops on the northwest vein system described under Rabbit Mountain mine. Mr. Ingall reports[2] that at this place, described by him as being about 400 feet northwest of shaft No. 2 of Rabbit Mountain mine, a shaft was sunk 75 feet, and that the work done seems to have yielded little silver. The shaft is said to have been sunk on a vein 4 to 5 feet wide in a diabase sill. The strike of the vein is approximately northeast and it dips 75 degrees to the southeast. The vein minerals are calcite, white and amethystine quartz, green fluorite, zinc blende, chalcopyrite, and pyrite.

PAIPOONGE TOWNSHIP, NORTHEAST OF RABBIT MOUNTAIN

(34) *Big Bear*

The Big Bear vein is near the west side of lot 34, concession II, Paipoonge township (*See* Map 213A), one-quarter mile north of the south boundary of the township. The vein is exposed on both banks of a small stream about 600 feet above its junction with Oliver creek.

[1] Ingall, E. D.: Geol. and Nat. Hist. Surv. of Canada, 1887, pt. H, p. 70.
[2] Op. cit., p. 71.

The development work done, following the discovery of the vein in 1886, consists of an adit driven about 20 feet along the vein from the east bank of the stream, and of a pit 20 feet deep, on the west bank, 100 feet south of the adit. Slumped drift material now obscures the adit mouth. The test pit has been sunk on a narrow quartz veinlet. Mr. Cook, a local farmer, reports that the assessment work was directed by Mr. T. A. Keefer, who owned the property at that time.

The composite vein strikes north 83 degrees east and occupies a fracture zone, 2 feet wide, in black, flat-lying Animikie shale. In this vicinity the shale is heavily drift covered, outcrops occurring only along the banks of the creeks. The gangue minerals observed on the dumps are, in order of abundance, calcite, colourless and amethystine quartz, green and purple fluorite. The usual metallic minerals, zinc blende, galena, and pyrite, occur. Mr. Ingall states that samples of ore obtained from the outcrop were claimed to have assayed 8 to 124 ounces of silver a ton.

(35) *Federal Mine (Copeland's Vein)*

Copeland's vein, as it is locally called, outcrops on the north bank of Oliver creek in the south half of lot 26, concession B, Paipoonge township, 2½ miles southeast from Stanley station (*See* Map 213A).

Workings extend 160 feet along the vein and lie immediately north of the creek. There are two shafts 90 feet apart, the main or west shaft having a depth of 20 feet or more and the east shaft having a depth of 10 feet. A drift, now partly caved, has been driven 60 feet easterly along the vein from the bottom of the main shaft. Fifty feet west of the main shaft a small test pit has been sunk, but does not now disclose the vein. Mine buildings were destroyed by fire in 1925. A large boiler was the only equipment seen on the property in 1927.

A fault zone in horizontal, black Animikie shale, strikes south 61 degrees east, dips 70 degrees toward the southeast, and has an average width of 2 feet. Owing to a mantle of drift, 6 feet to 20 feet thick, natural outcrops are to be found only along the bed of the stream. Along the fault zone, as exposed, there is only a slight brecciation of the north wall-rock, whereas the south wall-rock is highly shattered and shows, on a horizontal surface, two sets of fissures intersecting at an angle of 45 degrees.

A composite vein cements the fissures in the fault zone. The vein material consists of pink and white calcite; colourless, amethystine, and rose quartz; green, purple, and yellow fluorite; buff-coloured barite, zinc blende, galena, pyrite, marcasite, and argentite. The greater part of the vein material is coarsely crystalline, white calcite. The metallic minerals make up approximately one-tenth of the vein matter as exposed, and they are listed above in their order of relative abundance. Argentite occurs in small amount as films or in leaf form in cleavage cracks in calcite.

(36) *Parsons' or Lily of the Valley Mine*

Two nearly parallel composite veins near the middle of lot 19, concession IV, Paipoonge township, about 3¼ miles southwest of Rosslyn village,[1] were located by Mr. Parsons who, it is reported, mined

[1] Geol. Surv., Canada, Map 198A. Fort William and Port Arthur sheet, Thunder Bay district, Ont.

some few tons of ore averaging 1,000 ounces of silver a ton. There has been no production of silver ore from this property since 1892.

The north vein has been exposed by cross trenches at intervals of 20 feet, for a distance of 120 feet. A shaft, 15 feet deep, has been sunk at the west end of the workings. On the south vein, 60 feet south from this shaft, there is a second shaft 50 feet deep. Stripping extends for distances of 40 feet along the south vein on either side of the shaft.

The composite veins seal shatter zones in grey, flat-lying Animikie shale. The north vein strikes south 72 degrees east, dips vertically, and has a width of about 3 feet. The vein material constitutes about one-half of the volume of the cemented shatter zone and is almost entirely confined to two veins, each 8 inches to 10 inches wide, separated by $1\frac{1}{2}$ feet of shale which here and there is penetrated by ramifying quartz stringers. One of the 8 to 10-inch veins consists chiefly of coarsely crystalline calcite, whereas the other is almost entirely colourless and pale amethystine quartz.

The south vein has an average width of 12 inches and contains little brecciated country rock. It trends south 63 degrees east and dips vertically. The vein material is predominately coarsely crystalline calcite. The gangue minerals that are common to both veins, in addition to those mentioned, are rose quartz and green fluorite. Metallic minerals make up between 2 and 3 per cent of the vein material. They include light-coloured and black sphalerite, galena, pyrite, marcasite, and leaf argentite.

(37) *Paresseux Rapids Vein*

Paresseux Rapids vein (*See* Map 198A) is exposed on both shores of Kaministikwia river. South of the river, on lot 20, concession A, Paipoonge township, it appears as a composite vein, 20 feet wide, ramifying through fissured greenalite-taconite, a phase of Animikie iron formation. Vein material makes up approximately one-tenth of the volume of the fissured zone and forms veinlets $\frac{1}{4}$ inch to 3 inches wide. The general trend of the composite vein is north 55 degrees east through the exposed length of 200 feet. North of the river, on lots 20 and 21, concession I, Paipoonge, no work had been done; small veins in the composite vein are well mineralized with galena, zinc blende, and a little chalcopyrite.

Those individual veins of the composite vein that exceed one inch in width commonly show banding, the following minerals being exhibited in the order as stated, in passing from the walls toward the middle: green fluorite, milky and white quartz, calcite, amethyst, and pyrite. Sphalerite and galena are intimately associated with the fluorite. No silver has been found, so far as known, in this vein. The galena and sphalerite are too widely disseminated to be profitably worked as ores of lead and zinc.

PEARSON TOWNSHIP[1]

(38) *Henrietta Mine*

The Henrietta mine is on mining location P 27, which lies almost entirely within the north half of lot 17, concession IV, Pearson township, but extends a few hundred feet east into the north half of lot 16. The

[1]The northwest corner of Pearson township is 5 miles east-southeast from Silver mountain.

greater part of the location is now on property owned by Mr. Wark, but the eastern portion in lot 17 is on the property of Mr. Harvey Woodbeck. It is reached by a road that extends southerly from a system of highways serving the agricultural district in Gillies township.

A shaft 50 feet deep was sunk on the vein between the years 1885 and 1887, after which time no further work was done. The vein occupies a fault that traverses flat-lying Animikie shales and greywacke, and a diabase sill some 50 feet or more thick. The rocks on the south side of the vein have been down-faulted relatively about 40 feet, and Animikie sediments above the sill are exposed on the south wall of the vein. The north wall of the vein at the shaft consists of diabase that stands up as a prominent mesa, bounded by cliffs approximately 30 feet high. The shaft is on the southeast extremity of this mesa.

The vein strikes south 65 degrees east, and dips vertically or steeply toward the north. The vein material occupies a width of about $2\frac{1}{2}$ feet within a shatter zone 6 feet wide, and is in the form of three veins, each 8 or more inches wide and which unite and divide below the surface. The vein material consists of coarsely crystalline white calcite, a small portion of which is clear and transparent (Iceland spar), through which pyrite is sparsely disseminated. Silver ore is not known to have been found here.

(38) *Hidden Treasure Mine*

The Hidden Treasure mine is on mining location E 135, the greater part of which lies within the south half of lot 16, concession IV, Pearson township. It was worked between 1886 and 1888, and has since lain idle. The workings lie one-quarter mile southeast of Henrietta mine. An old road at one time connected these properties.

The vein was worked by three adits driven into the side of a hill, one above the other and at intervals of about 40 feet. All are now caved, but, from the volume of dump at their mouths, it appears that the lowest adit was the principal opening penetrating the hill approximately 40 feet.

The workings are on the side of a hill of horizontal Animikie sediments with a thickness of 100 feet, capped by a diabase sill 50 or more feet thick. The sediments are chiefly thinly laminated, dark grey shales interbedded with massive beds of greywacke up to 2 feet thick.

The vein occurs in a fault, the rocks on the northern side of which have moved almost horizontally, but slightly downward, in an easterly direction with respect to the rocks on the south as indicated by slickensides in a small notch in the diabase above the adits. The vein system, as exposed, consists of two veins each averaging 3 inches wide; they are separated by 1 to 2 feet of country rock, strike south 55 degrees east, and dip vertically. The vein material consists of intimately associated barite and calcite in about equal proportions. Well-formed, transparent, and pale brown barite crystals up to one-half inch in length are numerous. Pink and white varieties of calcite occur. No metallic minerals were observed.

(38) *Lot 16, Concession IV, Pearson Township*

On the north half of lot 16, concession IV, Pearson township, the property of Mr. Harvey Woodbeck, a network of calcite veins, with an aggregate width of 1 foot, occurs in a fault shatter zone 3 feet wide. The composite vein strikes south 75 degrees east and dips vertically. The country rock where exposed is diabase. The diabase rises as a ridge trending approximately northwest. It is not certain whether the diabase body is a sill remnant or a large dyke. No mineral other than calcite was observed in the vein material.

NEAR KAKABEKA FALLS

Veins of the silver-bearing type occur at the following localities: 700 feet north of the east end of Stephen lake (39); on mining location D 4, Oliver township (40); half a mile northwest of Kakabeka falls (41); and at a point described by Mr. J. Merrifield of Kakabeka Falls as being in the bed of a creek 2 miles north-northeast of the outlet of Twist lake.

The vein on mining location D 4 outcrops on the south bank of Kaministikwia river with a width of 4 feet, and trends south 12 degrees west. The vein cuts hornblende schist traversed by pegmatite dykes; the foliation of the schist strikes north 80 degrees east. The vein holds horses of schist and of pegmatite and also small blocks of Animikie conglomerate and iron formation. The vein has been stripped for over 200 feet southerly from the shore, exposing small concentrations of galena and chalcopyrite. Beyond this point the main vein is concealed but a network of smaller mineralized veins that here branch out from the main vein can be traced south 30 degrees west, in discontinuous outcrops for 100 feet.

An inferred fault trends in a northeasterly direction through the drift-covered area between a quarter and a half mile north of Kakabeka falls. South of this area, in the bed of Kaministikwia river about half a mile above Kakabeka falls, the writer observed a small amount of argentite in an irregular veinlet 3 feet long and richly mineralized with galena.

OLIVER TOWNSHIP

(42) *Lot 11, Concession I*

Composite veins, possibly belonging to one system, occur on the south half of lot 11, concession I, Oliver township (*See* Map 213A). This property is owned by Mr. T. Kellow who states that a test pit 5 feet deep was sunk on one of the veins prior to 1887 by Mr. George Garrow who formerly owned the property. A small amount of stripping and test-pitting has been done in recent years in the vicinity of the outcrops. The veins occupy fault zones in interbedded shaly and cherty phases of Animikie iron formation.

One group of outcrops occurs east of the southwest corner of lot 11, where a composite vein 35 feet wide crosses the road from lot 29, concession 3, Neebing township, and can be traced north 65 degrees east for approximately 200 feet. At this point a test pit 4 feet deep shows numerous tiny veinlets, some striking north 65 degrees east and some due east. The country rock is iron formation, locally folded and faulted, but with a general dip of 25 degrees toward the south. The composite vein consists of a multitude of tiny quartz veinlets and a few longer veinlets 2 inches wide. At certain points several veins unite and have aggregate widths up to 6 inches. The vein material makes up approximately 10 per cent of the cemented fault zone. Nine-tenths or more of this material is white crystalline quartz. Chalcopyrite occurs abundantly in certain tiny veinlets that ramify through the iron formation exposed in the test pit, and here makes up about one-tenth of the vein material. The owner reported that an assay, made in 1925, of the chalcopyrite-bearing material from the pit, yielded gold at the rate of $3 to the ton, and silver 16 ounces to the ton.

Three hundred feet northwest of the southeast corner of lot 11, a composite vein, 12 feet wide, has been stripped over a length of 20 feet. The country rock is black chert and a shaly phase of the iron formation. The rock dips 20 degrees toward the south. The composite vein consists of a multitude of tiny veinlets up to one-half inch in width showing a general trend approximately east. The vein material consists of white, smoky, and amethystine quartz crustified on the walls of the veinlets. Crystalline aggregates of galena up to one-quarter inch in diameter are sparsely disseminated through some of the wider veinlets. It is inferred that this composite vein is the easterly extension of the composite vein observed in the pit one-quarter mile west of this point.

In the field of arable land, 250 feet northeast of the southwest corner of lot 11, occurs a vein on which a 4-foot pit was sunk prior to 1887. The country rock is flat-lying black shale and cherty iron formation. The vein strikes north 15 degrees west and dips vertically. It is exposed over a distance of only 5 feet, is 1 foot wide, and consists of finely crystalline white quartz. Possibly this vein joins the first-mentioned composite vein lying less than one-quarter mile southeast.

Lot 7, Concession I

Prior to 1890 a shaft 20 feet deep was sunk through boulder clay at a point 400 feet northeast from Murillo station (*See* Map 198A), near the northeast corner of lot 7, concession I, Oliver township. The property is now owned by James Stevenson. In 1927 no consolidated rock was visible in the immediate vicinity of this shaft. It is reported that the work was done in an unsuccessful attempt to find a silver-bearing vein.

(43) *Lot 6, Concession II*

About 650 feet north of a house about one-half mile east of Murillo, on the north side of Oliver road in the south half of lot 6, concession II, Oliver township (*See* Map 198A), there is a shaft 80 feet deep, and 150 feet west there is another shaft 30 feet deep. These were sunk prior to 1890, on a composite vein composed of a network of veinlets ramifying through greenish grey cherty taconite in a zone at least 20 feet wide. The taconite beds have been downfaulted on the southern side of the vein and in its immediate vicinity they dip as high as 35 degrees toward the south. The general strike of the composite vein is east; it dips approximately 45 degrees toward the north. The vein material makes up about one-fifth of the volume of the rock in the cemented shatter zone and it consists chiefly of white quartz, a small amount of calcite, and sparsely disseminated galena. No silver has been reported from this locality.

(43) *Lot 5, Concession II*

Prior to 1890, a shaft was sunk 100 feet, at a point 1,200 feet north of Mr. Chas. Hill's house on the south half of lot 5, concession II, Oliver township. This place is approximately one-half mile easterly from the workings on lot 6, concession II. The shaft is now nearly full of water. The country rock is grey, cherty Animikie iron formation. The shaft has been sunk on a composite vein, approximately 10 feet wide, which is composed of a vein 1 foot wide and numerous parallel and branching veinlets less than 1 inch wide. The composite vein is not now exposed at the surface, but inferences drawn from an inspection of the walls of the shaft indicate that the general trend is north 50 degrees west and the dip about vertical. The vein material consists of coarsely crystalline, white calcite, white, yellow, and amethystine quartz with small amounts of pyrite and galena, and a later development of marcasite. Silver is not known to have been found in this vein.

(44) *Lots 6 and 7, Concession IV*

About 2½ miles north of Murillo (*See* Map 198A) a creek flows easterly across the road running north between lots 6 and 7, a quarter of a mile north of the south boundary of concession IV, Oliver township. A test pit has been sunk in the bed of the creek 200 feet west of the road in the south half of lot 7, now owned by Mr. Scott, and a second pit was sunk 400 feet east of the road and south of the creek on the south half of lot 6, concession IV, now owned by Mr. J. E. Fenton. The country rock is cherty taconite of the Animikie iron formation. The vein on which the pits have been sunk is not now exposed at the surface, but from a consideration of the material in the dumps and the walls of the pits, it appears that it is at least 1 foot wide and strikes north 70 degrees west. The dip could not be determined. The vein consists of fine and coarsely crystalline white quartz. Local concentrations of pyrite occur in the iron formation along the walls of the vein.

(45) *Lot 1, Concession V*

About 1890, a 20-foot shaft was sunk on a vein on lot 1, concession V, Oliver township, at a point approximately 1,800 feet west and 1,900 feet south of the northeast corner of the lot. This locality is about 3 miles north of Baird station (*See* Map 198A). The property is now owned by Mr. Trenks of Port Arthur. The country rock is amphibolite and diorite. A composite vein occupies a brecciated fault zone 5 feet wide and can be traced for 100 feet. Slickensides are plainly visible on the north wall and indicate that the rock moved relative to the adjacent southerly rocks, downward obliquely toward the east. The vein strikes north 65 degrees east and dips vertically. The vein matter makes up approximately one-half of the volume of the cemented brecciated zone. It consists of green fluorite, coarsely crystalline white calcite, white and amethystine quartz, and a small amount of galena and zinc blende. No silver has been reported from this property.

PAIPOONGE TOWNSHIP

(46) *Lots 4 and 5, Concession A*

On the north bank of Kaministikwia river on lots 4 and 5, concession A, Paipoonge township, Dr. Bell reports that there is a vein 3 to 4 feet wide trending northeast.[1] " It contains a little copper pyrites, iron pyrites, and galena in a gangue of barite, quartz, calcite, and fluorite."

(47) *Algoma Mine*

Algoma mine is north of Kaministikwia river on lot 1, concession IV, Paipoonge township. The most easterly workings are on the road running north along the east boundary of Paipoonge township, nine-tenths of a mile north of Arthur street (*See* Map 198A). Five pits at intervals of 100 feet to 150 feet with intervening trenches and strippings expose a vein for 660 feet, west from this point. Work was performed on this property prior to 1870. It has remained idle for many years.

The country rock is cherty Animikie iron formation, brecciated and disturbed in the vicinity of the vein. The vein consists of a cemented shatter zone traversed by large and small veins that appear to have been developed after a second movement. The cemented shatter zone extends across the entire width, 35 feet, of exposed rock. The individual veins range from 1 foot to 6 feet in width. The vein system strikes east and dips vertically. The individual veins pursue irregular courses and vary in width even within short distances. The greater part of the wider veins consists of coarsely crystalline white calcite through which specks of galena and zinc blende are sparsely disseminated. The vein material cementing the shatter zone shows the following minerals in intimate association: calcite, white, rose, and amethystine quartz, with irregular segregations of galena, zinc blende, chalcopyrite, and pyrite. Some of the veinlets, less than one inch in width, are richly mineralized with metallic minerals, but the vein system on the whole is not heavily mineralized.

NEEBING TOWNSHIP

(47) *Neepatyre Mine*

Neepatyre mine is the name of a property now held and worked by Mr. Alf. Cooper of Fort William, on lots 24 and 25, concession V, north of Kaministikwia river, Neebing township. It embraces the property formerly known as Walbridge mine and adjoins Algoma mine on the east.

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[1]Ingall, E. D.: Geol. and Nat. Hist. Surv. of Canada, 1887, pt. H, p. 66.

Seven veins are known on this property. The development work carried on by Mr. Cooper since 1925 has been mainly on the easterly continuation of the Algoma Mine vein, which crosses the road between Neebing and Paipoonge townships, nine-tenths of a mile north of Arthur street (*See* Map 198A). One thousand feet east of the road this vein is naturally exposed in the bed of a creek. Six other nearly parallel veins are said to be exposed in the bed of the same creek within 1,500 feet northerly of the main vein. One of these lies 1,200 feet to the north and is 24 feet wide, the others range from 2 to 6 feet in width.

According to Mr. Peter McKellar,

"the property which became known as the Walbridge mine was purchased by Detroit capitalists in 1863 for $1,200 or $1,400. Development work was carried on during the summer of 1863 and the following winter on the 24-foot vein which trends east and west and dips at a high angle to the south. The vein carries galena, zinc blende, copper, and iron pyrites in bunches, stringers, and disseminated in grains through a gangue of calcite and quartz. Some trenching was done on the back of the lode at various places and a 40-foot shaft was sunk on the copper-bearing part of the lode. The miners said there was a 2 to 3-inch streak of ore in the bottom of the shaft and the vein increased in richness in depth. The developments were made with a view to selling the mine but not having been successful in this, no more work was done."

In 1925, Mr. Cooper commenced operations on the composite vein 100 feet wide lying 1,200 feet south of the Walbridge vein. He reports that there were no previous workings here. In July, 1927, the workings consisted of three open-cuts disposed in an east-west line along the vein. The main, or No. 1, pit lies 600 feet east of the township boundary road. It is 110 feet long, 30 feet wide, and with a maximum depth of 12 feet. Open-cut No. 2, 400 feet east of the east end of No. 1, is on the bank of the creek at the foot of a cascade which has a drop of 60 feet. It measures 30 feet by 30 feet, and has a maximum depth of 6 feet. Open-cut No. 3 is 800 feet east of No. 2. It measures approximately 30 feet by 20 feet; and part of the vein, which here forms a south-facing cliff 6 feet high, has been mined to a depth of 6 feet.

The vein material is at present being mined for its gangue minerals, particularly coarse-grained calcite, which is crushed and screened to three sizes which are marketed respectively as pebble-dash for stucco work (average diameter one-quarter inch), chicken grit (average diameter one-eighth inch), and finer material for land plaster.

In July, 1927, the vein material was being blasted out of the main open-cut. The calcite-bearing vein material is separated by hand from the country rock and piled on 6-mesh wire screens measuring 6 feet by 12 feet and washed by a stream of water from a flexible flume brought from a stream above. The loaded screens are hoisted by crane to the feed table of the mill at the top of the north embankment of the open-cut. The washed material is fed to a jaw crusher by hand, it then passes through a grizzly which returns all particles over one-half inch in diameter for recrushing. The material less than one-half inch in diameter that passes through the grizzly is dropped from a bucket conveyor on jigs that separate the material into the three sizes as mentioned above. These products are marketed in 100-pound bags. The machinery is operated by a gasoline engine. Mr. Cooper stated that, prior to July 1927, 150 tons had been marketed; the greater part of this production was in 1926. Late in 1927, low values in gold and silver were obtained by assaying grab samples of galena-bearing vein material and it was stated that it was proposed to separate the metallic minerals and possibly the barite for separate treatment in the future.

The country rock is red and green cherty taconite of the Animikie iron formation and is nearly flat-lying, except in the immediate vicinity of the vein where it is highly disturbed in a wide shatter zone. North of the vein in the vicinity of No. 3 open-cut, the upper layers of the iron formation for a depth of 3 feet are relatively rich in iron oxides; an intimate mixture of hematite and magnetite makes up approximately one-half of the volume of the rock. The vein-cemented shatter zone has a width of 100 feet and trends east and west. Within the shatter zone there are simple veins, vein stockworks, and vein material occurring as cement around brecciated fragments of country rock. Gradational changes occur between these various types.

In open-cut No. 1 the vein material is almost solid for a width of 30 feet through a length of 110 feet and consists of seams up to 6 inches wide composed of intimately associated white quartz, green fluorite, galena, and yellow sphalerite disposed as if along walls of original channels. The greater part of the vein material in open-cut No. 1 consists of coarsely crystalline, white and pale purplish calcite through which galena and chalcopyrite are sparsely disseminated and in which vugs and small channels are lined with white and amethystine quartz. This vein matter has been deposited between or around disjointed fragments of vein material like that forming the previously described nearly solid mass measuring 30 feet by 110 feet. In open-cuts Nos. 2 and 3 the vein system is of the same general character, showing a width of 10 feet or more of coarsely crystalline calcite. There are in addition barite veins that appear to be later than the rest of the assemblage. In open-cut No. 2 a 2-foot vein of barite trends south 60 degrees east through the main vein. It consists of transparent pale brown crystals of barite surrounded by coarsely crystalline, pink, interfering platy aggregates of the same mineral. In open-cut No. 3 the barite is white and coarsely crystalline and is intimately associated with coarsely crystalline calcite. Most of the calcite in all exposures is white; occasionally crystalline aggregates up to 2 inches on edge are transparent and colourless. By careful sorting it is thought that Iceland spar suitable for optical purposes could be obtained.

(47) *Eastern Extension of the Neepatyre Vein*

Mr. Cooper reports that a vein which he believes to be the extension of the Neepatyre mine vein is naturally exposed in a small outcrop in lot 23, concession V, Neebing township, north of Kaministikwia river and 17 chains east of open-cut No. 3, Neepatyre mine.

Three-quarters of a mile east of this point a test pit 5 feet deep has been sunk in lot 20, concession V, on the east side of Neebing river in a composite vein that traverses poorly exposed, cherty, Animikie iron formation. The full width of the vein is not exposed, the part visible is 4 feet wide and consists chiefly of white quartz, a little calcite, and amethyst, sparingly mineralized with galena. Other test pits are said to lie along an approximately east course in lot 20 and in lot 19 on the east. According to local residents these pits were sunk about 1864; no metallic contents of commercial value are known to have been found. These veins and others which occur on lots 16 and 17, between 2 and $2\frac{1}{4}$ miles east of Neepatyre mine, are probably connected with the vein system of which Neepatyre vein forms a part, but none of them appears to be the Neepatyre vein.

(48) *Lot 20, Concession III*

Mr. A. Cooper reports the discovery by him of a vein of quartz and calcite 4 feet wide, trending northeasterly through Animikie iron formation, approximately 100 yards southeast of the Arthur Street bridge over Neebing river (*See* Map 198A). This locality is near the northeast corner of lot 20, concesssion III, north of Kaministikwia river, Neebing township.

Mr. A. Cooper reports that a boulder of vein material richly mineralized with native silver was found many years ago on the surface of the drift about 300 feet northeast of the southwest corner of lot 19, concession IV, north of Kaministikwia river, Neebing township.

(48) *Lot 17, Concession IV*

On the northern half of lot 17, concession IV, north of Kaministikwia river, Neebing township, the property of Mr. J. John, a shaft was sunk many years ago to a depth of 25 feet on a vein at least 2 feet wide and cutting Animikie iron formation dipping 4 degrees east. The vein consists of quartz, calcite, and amethyst. Its strike is approximately northeast on the same lot, about 100 yards both north and south of this point; the surface layers of greenalite-taconite have been removed for road-metal and in each of these exposures several veins fill fractures along joint-planes trending north and northeasterly. The parallel veins of each system are spaced several feet apart. The largest is locally 2 feet wide; the average width of all the veins is approximately 3 inches. The veins consist of quartz, calcite, amethyst, locally well mineralized with galena, chalcopyrite, and zinc blende. None of these veins is sufficiently large and rich enough to be of commercial value. Barite veins up to 3 inches in width cement certain fractures in both of these exposures.

(48) *Lot 17, Concession V*

On lot 17, concession V, Neebing township, about 660 feet south of the northeastern corner, a composite vein is exposed in the southern cliff of a knoll. This property is owned by Mr. A. Cooper of Fort William. No development has been done on the vein. The hill is composed of Animikie iron formation. The composite vein occupies a fault zone; the rocks on the southeastern side have moved relatively downward through a distance of approximately 20 feet. In the vicinity of the vein the beds dip 15 degrees toward the south-southeast. On the wall of the cliff a vein of barite 2 feet wide strikes north 85 degrees east and dips 60 degrees north. The barite is of coarse texture and platy habit. This vein can be traced westerly for 30 feet to where it appears to join another vein, 1½ feet wide, striking north 65 degrees east and dipping 75 degrees northwest. The second vein consists of banded, fine and coarsely crystalline, white quartz, purple fluorite, and small amounts of galena. This vein is discontinuously exposed over a length of 20 feet.

These veins are east of Neepatyre vein and in line with it. It is possible that they are branches of a large vein system lying in a concealed part of a fault zone. The greater part of this lot is mantled by drift.

MCINTYRE TOWNSHIP

(49) *Lot 47*

Seven small, undeveloped veins occur within a distance of 100 feet in the bed of a creek in the northwest quarter of lot 47, McIntyre township, approximately 1¼ miles east of Baird post office (*See* Map 198A). The country rock is cherty and shaly Animikie iron formation dipping 2 degrees south-southwest. The veins occupy fractures along joint-planes and their average width is about 2 inches. They strike between 25 degrees and 35 degrees east of north. The vein material consists of calcite, white and amethystine quartz. A small amount of galena was observed in one of the veins.

(50) *Mining Location C*

Major H. Ruttan of Port Arthur reports that a quartz vein carrying chalcopyrite strikes north 65 degrees through Animikie iron formation on mining lot C within 200 feet north of Oliver road, 5 miles west of Port Arthur post office. A reference was made to this vein by Mr. Ingall in his report of 1887. It was not found by the writer in 1927.

(50) *Mining Location D*

Major H. Ruttan reports that a barite vein trends north 60 degrees east through Animikie iron formation near the east boundary of lot D, McIntyre township, on the Oliver road.

(51) *Lots 1 and 2*

Major H. Ruttan reports that he has record of a quartz vein, striking north 65 degrees east, and extending from the southwest corner of lot 1 across this and the adjoining lot 2, a distance of approximately one mile. These lots lie south of Oliver road, between 1½ and 2½ miles west of the city limits of Port Arthur.

(51) *Lot 54*

In the southwest quarter of lot 54, McIntyre township, a low ridge of shale underlain by a diabase sill forms a prominence, 4 acres in area, in the extensive muskeg that lies west of the southern part of Port Arthur. A composite vein of quartz cements a fault zone, 3 feet wide, and strikes north 65 degrees east. The rock on the northwest has been relatively downfaulted approximately 6 feet. In the vicinity of the vein the shale dips 16 degrees northwest. The general dip of the sill and shale remote from the vein is 10 degrees south-southeast. No feature of immediate economic interest was noted in connexion with this vein. The geological relations, however, are very similar to those found in the Hewitson quarry 2 miles to the northeast; at the latter locality the vein material is silver bearing.

(52) *Lot G (North Shore Vein)*

A shaft was sunk prior to 1890 on the east side of Neebing river, in lot G, McIntyre township, $1\frac{1}{4}$ miles east-southeast of Morgan school on John street (*See* Map 198A). The shaft is now used as a well.

The workings on the vein comprise the shaft, 115 feet deep, the stripping of the vein and small test pits east of this point through a distance of 400 feet.

The country rock is cherty Animikie iron formation. The vein occupies the fault fracture. The rock has been downfaulted on the south and slickensides show plainly on the northern wall. The vein strikes east and is vertical. It is composed of fine-grained white quartz, with a small amount of coarsely crystalline, colourless quartz projecting into vugs. Some of the crystals are 4 inches in diameter and show perfect pyramidal terminations. The vein is 20 feet wide and well defined. It locally encloses many small blocks of iron formation dislodged from the wall. These make up approximately one-third of the volume of the vein. The vein was traced for 800 feet east of the shaft and its apparent continuation was traced discontinuously through the adjacent lots H and I, over a distance of one mile, the strike changing progressively in each outcrop to a somewhat more northerly course. It crosses John street in the northwest corner of lot K, striking north 60 degrees east. Two thousand feet in a direction north 75 degrees east from this point, a composite vein is exposed on the banks of McIntyre river in mining lot M, McIntyre township, about 600 feet north of John street. On the north bank, it is well exposed for a length of 400 feet along a south-facing cliff 10 feet high. The country rock at this locality is Animikie iron formation, nearly flat-lying. Test pits 20 feet and 6 feet deep, respectively, have been sunk on the vein and a considerable amount of stripping has been done adjacent to the natural outcrops. The composite vein strikes north 78 degrees east and dips 80 degrees southeast. It is distributed through a shatter zone 40 feet wide. The largest single vein is 4 feet wide. Numerous small veins ramify through the shatter zone, the vein material making up about one-half of the total volume. The vein consists almost entirely of white quartz, a little calcite, and specks of pyrite and galena were observed locally. The only feature observed of possible economic value is the quartz. At certain localities, particularly on lot H, large, colourless, transparent crystals, suitable for optical purposes, might be found.

(53) *Lots 24 and 25 (Mitchell Vein)*

The Mitchell vein is exposed on the south half of lots 24 and 25, McIntyre township, 2½ miles northeast of Morgan school (*See* Map 198A). It crosses the road that runs through these lots at a point 1½ miles west of the Dawson road.

This vein is said to have been intensively explored by Peter Mitchell during the period of active silver mining in this district. The present road runs between two of the shafts sunk by him. One, on the south side of the road, in lot 25 on property owned by Richard Heyder, is 60 feet deep, the other 16 feet deep lies 200 feet in a direction north 70 degrees east on the north side of the road in the south half of lot 24, on property now owned by Albert Schimbke.

The country rock is Animikie iron formation consisting of thin layers of chert and iron carbonate dipping 3 degrees toward the east. The vein cements a shatter zone along a fault that trends north 70 degrees east. The vein material is solid for a width of 6 feet and ramifies through an additional 4 feet of brecciated material along the walls. It consists of coarsely crystalline calcite, white quartz, and a small amount of amethyst and sparsely disseminated chalcopyrite and pyrite. No silver is known to have been found.

(54) *Emmon's Mine*

Emmon's mine is on lot A, McIntyre township, on the Dawson road about 5 miles from Port Arthur.[1] Dr. Selwyn, who visited it in 1872, stated that a pit had been sunk 20 feet on a thick vein of white calcite mixed with quartz often showing amethystine colours, both minerals holding thin strings and cubic crystals of galena and also spots of mispickel, pyrite, and, more rarely, chalcopyrite. Three pits older than that regarded as the main working occur within 600 feet northeast of it. They are on a group of rocky knolls which rise about 50 feet above the surrounding muskeg, near the middle of the eastern side of lot A. The hills are composed of a complex assemblage of granite-gneisses with inclusions of altered Keewatin lavas, cut by dykes of pegmatite and lenticular quartz veins. A dyke of hornblende porphyrite 6 inches wide intrudes the complex. This dyke and the older rocks are traversed by veins of the silver-bearing type which occupy straight-walled fractures along fault planes. The vein that has been worked is 8 feet wide, strikes north 65 degrees east, and dips 60 degrees north. Along its continuation east from the main pit a vein 2 feet wide strikes north 35 degrees east for a distance of 60 feet. Lack of exposures does not admit of a positive interpretation as to whether this represents a change in width and direction of the main vein, or whether it is a branch or intersecting vein.

The vein material consists of coarsely crystalline calcite, white quartz, and amethyst through which galena, chalcopyrite, and pyrite are irregularly disseminated in very small amounts. Several quartz veins up to 6 inches in width are exposed at various points throughout this lot. No silver or other mineral of economic value is known to have been found in any of these veins.

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[1]Ingall, E. D.: Op. cit., p. 67.

(54) *Dawson Mine*

Mr. Ingall's report[1] of 1887 mentions that the vein worked at Dawson mine on location R 2 strikes east-northeast near the junction of the Animikie and older rocks. A series of caved trenches and pits were observed by the present writer on location R 2, McIntyre township, 300 feet northeast of Dawson road, three-quarters of a mile northwest of Jumbo Gardens post office (*See* Map 198A). These workings are on a small, rocky hill and extend almost continuously in a northwest direction for 500 feet. It is possible that there are other old workings on this property that have not been found. The workings are in green, cherty taconite near the base of the Animikie series. A few yards north of the workings the iron formation lies horizontally, as a scale less than 5 feet thick, on the ancient complex of crystalline rocks, consisting here of granite-gneiss with inclusions of hornblende and chlorite schist. East of the workings the exposures are of diabase, presumably erosion remnants of a sill, intrusive into the Animikie iron formation. The precise contacts between the various rocks are drift covered.

In the caved trenches numerous small quartz veins up to 4 inches in width are to be seen. These trend in various directions; the largest strikes east. It is possible that the observed veins are part of a large composite vein, all or part of which trends northwest along the line of workings. The greater part of the vein material consists of white quartz, of fine and coarse texture; white calcite occurs in some of the wider veinlets. Pyrite and chalcopyrite occur locally in small amounts.

(54) *Lot 17 (Osmun Vein)*

A composite vein is exposed on the east half of the west half of lot 17, McIntyre township, about a mile north of Jumbo Gardens (*See* Map 198A). The property is owned by Mr. Osmun. A shaft, said to be 75 feet deep, was sunk on the vein many years ago, at a point approximately 1,500 feet northeast of the southwest corner of lot 17. Four shallow test pits also were sunk on the vein, all these being within a distance of 400 feet.

The composite vein occupies a shattered fault zone 6 feet wide traversing nearly flat-lying shale and cherty iron carbonate of the Animikie iron formation. Vein material makes up one-half of the volume of this cemented shatter zone. The largest single vein is 8 inches wide. The vein strikes north 70 degrees east and dips vertically. It consists of an intimate association of white quartz, amethyst, pink and white calcite, purple fluorite, and very small amounts of galena and chalcopyrite.

(55) *Lot 53*

In an old quarry on Central avenue, lot 53, McIntyre township, in the southwestern part of the city of Port Arthur, about one-half mile east of the Golf Club, a system of six veins, trending northeasterly, is exposed on a surface 400 feet across. This locality is three-quarters of a mile southwest of the Hewitson quarry. All the veins occupy fault fractures in

[1] Ingall, E. D.: Op. cit., p. 68.

nearly flat-lying Animikie sediments. The amount of dislocation is apparently greatest at a position now occupied by a 14-inch vein of barite which strikes north 50 degrees east. The rock on the northwest side consists of dark grey shale; the rock on the southeast is cherty carbonate, a phase of iron formation interpreted as occurring at a lower stratigraphic horizon than the shale. A few feet south of the barite vein there is a vein striking north 31 degrees east, one foot wide, and consisting of calcite, quartz, and purple fluorite. Twenty-five feet west there is a parallel vein also south of the barite vein. It has a width of 4 inches and in the few feet through which it is exposed, is filled with anthraxolite. One hundred feet northwest of the barite vein there is a network of stringers which locally unite to form a vein approximately one foot wide trending north 60 degrees east. This vein is an intimate assemblage of quartz, calcite, barite, and purple and green fluorite. A small amount of leaf argentite was discovered here by R. Thomson, in 1923. Other veins that probably form part of the same vein system are exposed within 100 feet north of the one previously described and in them the following minerals were observed: quartz, amethyst, calcite, barite, purple and green fluorite, sphalerite, and marcasite.

Four hundred feet south-southwest from the old quarry there is a second shallow excavation in which small veins occur trending northeasterly. These show all minerals above mentioned. Anthraxolite is prominently exposed filling parts of veins in this locality.

(55) *Hewitson Quarry and Stewart Quarry, Port Arthur*

Stewart quarry is at the north end of May street where an excavation about 100 yards in diameter is now filled with water. Hewitson quarry is almost one-half mile to the southwest and about a mile east-northeast of the Golf Club, where the rock has been removed to depths up to 20 feet in an area measuring 125 yards by 75 yards. The rocks in this vicinity are exposed only along a ridge that slopes at a gentle angle toward the southeast. A diabase sill, locally 15 feet thick, extends past both quarries. It lies between thinly laminated, dark grey shale in which calcareous, pyrite-bearing concretions up to 4 feet in diameter occur. Both the upper and lower contacts of the diabase sill may be seen on the west side of the southwestern (Hewitson) quarry. Several faults and small veins are exposed in the workings. These trend at various angles and intersect in an irregular pattern. The observed dislocations are in a fault zone, the general strike of which is probably northeast.

During the summer of 1910 a vein in the southwestern quarry was found to be locally well mineralized with argentite and native silver; the vein is 1 foot wide and strikes north 80 degrees east. In 1923 Mr. Jones of Duluth road, Port Arthur, discovered silver in a vein in the southern bank of the northeastern quarry; it cuts diabase, is 6 inches wide, and strikes north 25 degrees east. Both veins consist of purple and green fluorite, quartz, calcite, and sphalerite in addition to the silver-bearing minerals. Both are exposed through lengths of less than 20 feet. Some of the small veins in the Hewitson quarry are cemented almost entirely with quartz, and others with barite. These appear to be intimately related to the silver-bearing veins. No attempt has been made to develop silver ore at this locality. The known silver-bearing veins are small and do not appear to be sufficiently well mineralized to warrant mining operations. It is possible that further exploration along the north side of the ridge in which the quarries lie, might reveal mineralized veins of economic interest.

Other Veins in the City of Port Arthur

It is reported that native silver was found in small amount in a vein encountered while making an excavation for the cellar of a residence at the north end of Banning street. In 1923, this residence was occupied by Mr. Strachan.

At the northwest corner of Hebert and Peter streets, Mr. R. Thomson of the writer's party discovered native silver in a vein one inch wide exposed in an excavation made for the foundation of a house. Animikie iron formation composed of thin layers of chert and iron carbonate are exposed in this vicinity on land rising between Peter and College streets. The rocks dip 20 degrees toward the east-southeast. Veinlets less than 3 inches wide may be seen in nearly all the outcrops. In the vicinity of the discovery there are several ½-inch veinlets spaced at intervals of 4 feet and trending from 20 degrees to 30 degrees east of north. The vein material consists of white quartz, amethyst, pink barite, white calcite, small amounts of sphalerite and chalcopyrite, and locally native silver in leaf form. The mineralization at this locality is not of such character as to warrant mining operations.

It is reported that silver was found in a vein in diabase exposed on the shore of lake Superior, close to the Canadian Pacific railway station. No development work was done and the outcrop is concealed by earth-fillings.

In July 1927, Mr. J. G. Cross of Port Arthur discovered a small amount of native silver in rock excavated for setting a telegraph pole adjacent to the Pagoda in Port Arthur. The rock consisted of sheared diabase traversed by veinlets of pyrite-bearing white quartz.

(56) *Singleton Mine*

In what is now the playgrounds of Prospect school in the city of Port Arthur, at the corner of Prospect and Dawson streets, a pit 30 feet deep was sunk prior to 1887. This was known as the Singleton mine. A vein of quartz here occupies a fault striking north 75 degrees east. The rock on the north side of the fault is shale, and on the south taconite underlain by shale. The latter rocks are well exposed in a cliff 10 feet high about 100 feet west of the pit. Another vein, less than one foot wide, consists of quartz and strikes north. Rich bunches of native silver are said to have been obtained in the workings.

(57) *Shuniah Mine*

The composite vein that has been worked at Shuniah mine strikes east through lots 8 and 9, McIntyre township. It lies in the city of Port Arthur, seven-eighths of a mile south of its north boundary. It may be reached by a road, three-quarters of a mile long, branching north from Lyon boulevard 1,000 feet southwest of the bridge over Current river.

The following notes regarding the mine are drawn largely from Mr. Ingall's report.[1]

"The vein was discovered in 1867 during the summer of that year, and the following winter it was operated under the name Shuniah mine and trenching was done at several places. Two shafts were sunk to depths of 30 and 60 feet respectively, from the bottom of the latter a crosscut was driven across the lode. At first silver was obtained in small bunches in the form of leaves, associated with quartz, calcite, zinc blende, and galena which forms a zone 2 feet wide along the south wall of the vein. The silver-bearing material was followed from the surface to a depth of 18 feet and then lost. It was found again in the middle of the vein in the crosscut at the 60-foot level. Several barrels of ore were taken out, reported to have run from $200 to $300 per ton in silver.

The mine was then closed owing to a disagreement among the owners and the want of funds, which led to a chancery suit, so that altogether including the expenditure thus incurred, some $25,000 to $35,000 were spent.

The mine was opened again in 1870 when it was bought for some $75,000. The main shaft was sunk to a depth of 135 feet, drifts were driven on the lode at the first and the second levels, and crosscuts at several places. One of these latter was driven south for 100 feet, in expectation of cutting another lode. A good many thousands of dollars were spent in tracing the vein on the surface. A barrel or two of very rich ore was removed from the drift. The mine was closed in the middle of the summer of 1873.

In November, 1873, it was again started under the name Duncan mine. The mine continued in operation until 1881, having been worked almost continually for 14 years; the force varying from two to one hundred men. Besides other surface work, a ten-stamp mill with 4 Frue vanners was built at the mine and operated for a couple of months. Acording to Mr. Courtis, the total production of the mine amounted to about $20,000 worth of ore, and the total outlay approximated $500,000."

A plan and section showing the workings were compiled by Mr. E. D. Ingall and shown in Plate V of his report. The following diamond-drill holes are not recorded in the illustration: two horizontally north and south from the 11th level; one west from end of 9th level; and one near shaft No. 2 directed to explore the lode between the 6th and 7th levels. These had a total length of 600 feet; the combined length of all the diamond-drill holes was 4,884 feet.

In 1921 and 1922, eleven crosscut trenches were dug, exposing the surface of the vein for one-quarter of a mile east of the main workings in lot 8. No further discovery of silver is known to have been made and the property has since lain idle.

The geological relations at Shuniah or Duncan mine are illustrated in Ingall's report.[2] The rocks encountered in the lower levels consist of chlorite-hornblende schist permeated and invaded by granite and syenite. These Early Precambrian rocks are overlain by flat-lying Animikie sediments, 515 feet thick, over which there is a sill, 80 feet thick, of diabase dipping about 10 degrees towards the south. A fault with a displacement of about 100 feet relatively downward on the south traverses the entire rock assemblage. The upper members of the succession have been removed by erosion north of the fault. The vein cements the fissures and shatter zone along the fault zone which is 20 feet wide with a general strike east and a dip of 80 degrees toward the south. The principal workings are disposed through a length of approximately one-quarter of a mile in lot 9. Trenches

[1]Ingall, E. D.: Op. cit., pp. 56-63.
[2]Op. cit., Plate VI.

expose the vein on the surface for a further one-quarter of a mile east in lot 8. Numerous caved pits and trenches occur westerly from the main workings in lots 9 and 10; these were probably on its westerly continuation. The total length is approximately 1½ miles. In some parts of the composite vein there are numerous inclusions of country rock in relatively homogeneous vein substance consisting chiefly of white calcite. At other localities there are several veins that form a network; some of these appear to have formed in fractures developed subsequently to earlier veins of a banded type. Hydrocarbon gas under great pressure was encountered in some of the vugs in the old mine workings.

In some veins the vein material, along the walls for widths varying up to 2 inches, consists of intimately associated white quartz, pale pink and white calcite, green fluorite, sphalerite, and galena, whereas the middle parts of such veins are predominantly composed of coarsely crystalline white calcite, white and amethystine quartz, and white fluorite, with small amounts of galena, zinc blende, chalcopyrite, and pyrite. It is reported that cavities in the vein system near the surface were encrusted with black oxide of manganese. The native silver and argentite occurred in leaf form in irregularly spaced, rich bunches associated particularly with those parts of the vein rich in zinc blende. The greater part of the silver ore was found within 70 feet of the surface and none was found in the lower levels of the mine, though the vein with its local concentration of zinc blende continued to the limits of exploration. From the mode of occurrence of the silver it is inferred that the concentrations were of secondary origin.

CURRENT RIVER VEINS

At least twenty veins of the silver-bearing type have been observed in the bed of Current river between the Lyon Boulevard bridge and the forks, 2 miles up stream. These veins strike in various directions. Some are sparingly mineralized with galena, chalcopyrite, and pyrite; none is known to carry silver ore or to be otherwise of commercial interest. On the east bank of the river where a small tributary joins from the east, one-half mile southeast of the forks, old mine workings (58) (shown on Map 198A one mile west of Thunder Bay mine) consisting of pits and trenches are to be seen along a vein through a distance of 100 yards. The rock here consists of flat-lying Animikie shale. The vein occupies a shatter zone, 25 feet wide, which strikes north 8 degrees east and dips vertically. There is 4 feet of solid vein material and beyond this in the shattered rocks are numerous narrow veinlets. The vein material is quartz and amethyst through which galena and chalcopyrite are disseminated.

MACGREGOR TOWNSHIP

(58) *Thunder Bay Mine*

Thunder Bay mine (*See* Map 198A) is in the south part of lot 6, Macgregor township, close to the north boundary of the city of Port Arthur. The vein here was discovered by Mr. Peter McKellar in the autumn of 1866 and its discovery marked the commencement of a second era of mining activity in Thunder Bay region. Work was carried on at the mine until the spring of 1869 by which time 3,294 pounds of ore, worth $2,592, had been produced. The mine was again opened up in 1874 and was in operation on this occasion for six months or more. Mr. McKellar reported that concentrates obtained at this time were rich in native silver; the actual yield was not made known. The composite vein was traced discontinuously, by stripping and test pits one-half mile.

The mine workings consist of four shafts sunk on a composite vein, a crosscut driven northwest at the 60-foot level, and some drifting between the two deepest shafts. No. 1 and No. 2 shafts are each 70 feet deep, No. 2 lying 300 feet northerly from No. 1; 150 feet north of No. 2 is the third shaft, 35 feet deep, and 150 feet north of it is the fourth, 25 feet deep. Ore was mined between the two extreme shafts, a distance of 600 feet. A large calcite vein parallel to the composite silver-bearing vein and some 20 feet south of it, was mined by a crosscut from the foot of No. 2 shaft, during the second period of the mine's activity in 1874.

Besides the erection of necessary buildings, 3 miles of wagon road was constructed to the shore of Thunder bay, where a stamp mill was erected, as well as a dock 200 feet long.

The country rock consists of cherty carbonate of the iron formation and black shales, striking north 34 degrees east and in the vicinity of the vein dipping as high as 22 degrees southeast, but within 100 feet northwest of the mine the sediments are nearly horizontal and are capped by a diabase sill 40 feet thick. There are two parallel veins, 20 feet apart, occupying faults, striking north 34 degrees east. The southeasterly vein is from 6 feet to 12 feet wide and consists chiefly of coarsely crystalline, white calcite. It dips steeply southeast. No silver ore was found in it. The other is a composite vein and consists of numerous veins and veinlets up to one inch in width, ramifying through shale and iron formation in a zone 10 feet wide. Its general dip is 65 degrees northwest. The vein consists of white quartz, accompanied by galena, zinc blende, and pyrite. A small amount of pink and white calcite occupies the central part of the larger veinlets. According to Mr. McKellar native silver and argentite occurred in pockets, 3 to 18 inches thick by 6 to 40 feet in length, the silver being in leaves and grains irregularly distributed among the other vein minerals. When first opened two ore-bodies were found, one next the north or hanging-wall and one in the middle.

(58) *Lot 6*

Approximately one-quarter mile west of shaft No. 1, Thunder Bay mine (*See* Map 198A), a composite vein 2 feet wide has been exposed in a trench and test pit. The country rock is flat-lying, grey, cherty, Animikie iron formation. The vein strikes north 6 degrees east and dips vertically. It consists of white quartz, calcite, purple fluorite, and a small amount of disseminated chalcopyrite.

(59) *Beck or Silver Harbour Mine*

The vein on which this mine was started lies near the east boundary of lot 12Z, Macgregor township, about one-quarter mile north of the shore of lake Superior (*See* Map 214A). It was discovered in the summer of 1870. A 40-foot shaft was sunk and surface explorations were carried on until work ceased in the autumn of 1872.

The country rock is Animikie iron formation. A diabase sill overlies these sediments in a cliff a short distance south of the shaft. The vein was said to have been well mineralized with silver in the upper part of the shaft, but toward the bottom was lean. It is reported[1] that 125 barrels of ore were shipped and that this material assayed $17 to the ton in silver.

Less than one-half mile southwest of the Beck mine, on the east headland of Silver harbour, a network of quartz veinlets in a zone 1 foot wide strikes north 55 degrees east along the faulted contact between Keewatin schist and flat-lying Animikie sediments. On the point and under water immediately off shore there is a network of veins over a width of 30 feet striking north 70 degrees east.

(59) *Algoma Mine*

The vein worked on Algoma mine about 1872 occurs one-quarter mile southeast of Silver Harbour station[2] on the Canadian National railways, in lot 13Z, Macgregor township. It lies at the base of a north-facing cliff 50 feet high, which is capped by a diabase sill. The sill is 25 feet thick and lies on horizontal chert and iron carbonate, a phase of Animikie iron formation. It is reported that a shaft was sunk through 30 feet of unconsolidated material and 20 feet farther into the vein in the consolidated rock, and that to the east a second shaft was sunk on the vein and from it a crosscut was driven southerly through shaly iron formation to a point where diabase was encountered, which was interpreted as a vertical dyke cutting across the sediments. No vein was found at the contact.

The vein material consists of quartz and calcite irregularly mineralized with galena and pyrite. It cements a brecciated shatter zone striking east-northeast. No mineral deposit of commercial importance is known to have been found in this vein. The width of the vein has not been recorded.

Cornish Mine

Mr. Ingall[3] reports that veins were worked during the year 1873, without any satisfactory result, at Cornish mine (60). This is situated in lot 5E, Macgregor township, 1½ miles from Mackenzie station (*See* Map 214A), on the Canadian Pacific railway. The veins are said to be mineralized with zinc blende, galena, and pyrite. They strike east and lie in Keewatin rocks.

[1]Ingall, E. D.: Op. cit., p. 64.
[2]Geol. Surv., Canada, Map 214A. Loon sheet, Thunder Bay district, Ont.
[3]Op. cit., p. 67.

(61) *Three A Mine*

Three A mine is in lot 3A, Macgregor township (*See* Map 214A). It may be reached by a road one-quarter mile long branching northerly from the Nipigon highway at a point 14 chains northwest of mile-post 135 on the Canadian National railways. The vein was discovered in the winter of 1869-70. On the surface the vein was traced across the lot one-half mile in width. During the winter of 1871-72, two miners worked on the lode and took out 22 barrels of silver ore. Shafts were sunk after the autumn of 1872. Operations were discontinued prior to February 1877. A vertical section of the mine showing the workings up to March, 1874, is reproduced in Mr. Ingall's report. The value of the ore obtained has been estimated at about $2,000.

In 1922, Mr. J. Beam of New Bethlehem, Pennsylvania, sank an exploratory shaft to a depth of 44 feet in the vicinity of the old No. 1 shaft. The shaft is vertical for the upper 24 feet; the lower 20 feet is inclined 60 degrees toward the north. This and other exploratory work along the vein failed to reveal silver ore of commercial value.

The country rock is altered Keewatin lavas, part of which is schistose ellipsoidal andesite in which the foliation strikes north 75 degrees east and is vertical. At the No. 2 shaft near the east end of the property, the composite vein is distributed through a shatter zone 2 feet wide and strikes north 60 degrees east. The dip is approximately vertical. Two hundred feet westerly the vein appears to change its direction and strikes north 83 degrees east and dips between 60 degrees and 70 degrees north. The western part of the composite vein is somewhat more widely diffused through the fractured country rock than at shaft No. 2, and some of the veins in the shaft sunk by Mr. Beam pinched out at depth. The vein minerals, in order of relative abundance, are: white, finely crystalline quartz, white calcite, amethyst, and barite, irregularly mineralized with zinc blende, galena, pyrite, marcasite, and chalcopyrite. It is reported that nickel, cobalt, and gold were found by assays. The silver was found both native and combined with sulphur, and was associated with minerals containing cobalt, and this argentiferous material was concentrated in parts of the vein in large and small patches, being comparable in this respect to ore obtained at Silver Islet mine. One sample of the ore is said to have assayed 1·4 per cent cobalt and 25 per cent nickel.

(61) *Lot 1A*

In lot 1A, Macgregor township (*See* Map 214A), a composite vein was worked prior to 1887. The vein crosses the Canadian National railways 9 chains westerly from mile-post 134, and water-filled shafts and caved pits may be seen along its course for a distance of 2,000 feet in a direction north 80 degrees west. The vein continues easterly from the railway to the shore of lake Superior in the south part of lot 12. It occupies a fault. Along the western part of its course granite occurs on the north and Animikie iron formation and shale on the south side. Along the north side of the eastern part, inclusions of Keewatin lavas and ancient sediments lie in granitic intrusives with, on the gently undulating surface of these pre-Animikie rocks, scales up to 4 feet in thickness of Animikie basal conglomerate and the immediately overlying iron formation.

The composite vein consists of a shatter zone 25 feet wide through which there is a network, up to 4 feet in width, of veins, composed of quartz, amethyst, and calcite locally well mineralized with zinc blende, galena, pyrite, and a little chalcopyrite. It is reported by Mr. Ingall[1] that in the vicinity of the Three A mine a 2-foot vein of milky quartz was discovered carrying native bismuth and yielding on assay a little silver. It is possible that this interesting occurrence was found somewhere along the vein system in lot 1A.

Lot 10

Major H. Ruttan of Port Arthur informed the present writer that in 1925 an occurrence of silver was reported to him, in a vein said to have been found on the bank of Mackenzie river in lot 10, Macgregor township. Further particulars regarding this occurrence are not available.

(62) *Mining Location Z 10*

A fault trends northeast along the eastern side of a diabase-capped cliff 35 feet high in mining location Z 10, 1½ miles north of Amethyst harbour (*See* Map 214A). A few small veins filled with calcite, white and amethystine quartz are to be seen in this locality. Extensive mining operations have been carried on in this vicinity, apparently with a view to developing iron ore.. The material in the main part of the fault zone has not been uncovered.

(63) *Buck Island*

Buck island lies east of Conmee point, off shore from Amethyst harbour (*See* Map 214A). On the island, a diabase sill with an exposed thickness of 20 feet dips 6 degrees in a direction south 30 degrees east. A scale of Animikie shale and greywacke lies on its upper surface along the southern shore. Reddish, graphitic granophyre occurs locally along the contact. Chalcopyrite is disseminated through the granophyre.

Two veins are exposed on the island. One vein strikes south 78 degrees, is 6 inches wide, and consists of quartz and calcite locally mineralized with galena. The second is at the south end of the island and is a composite vein distributed through a shatter zone 3 feet or more in width, striking north 80 degrees east. It consists of many tiny veinlets crustified with quartz, calcite, and barite.

(64) *Palette Island*

Palette island is in Amethyst harbour (*See* Map 214A), one-quarter mile west of Lambert island. On the southern half of the island a diabase sill 30 feet thick lies between interbedded Animikie shale and greywacke striking north 50 degrees east and dipping 8 degrees southeast. The northern half of the island shows the upper part of this assemblage apparently

[1]Ingall, E. D.: Op. cit., p. 67.

downfaulted 25 feet. The fault lies in a concealed zone a few feet wide and strikes approximately north 50 degrees east. Contraction cracks are prominently exposed on the upper surface of the diabase sill in an irregular, polygonal pattern resembling mud cracks. Some of the cracks are as much as one-quarter inch wide and are cemented with quartz and green fluorite.

(64) *Lambert Island*

Lambert island, off Amethyst harbour (*See* Map 214A), is underlain by a diabase sill which presumably overlies Animikie sediments. It is reported by Mr. Ingall[1] that approximately $500 were expended in 1884 in testing a vein of rose-coloured quartz and fluorite between 18 inches and 3 feet wide which trends northwest across the island. A pit was sunk on the vein. It did not penetrate through the diabase sill, estimated to be 30 feet thick.

(65) *Perry Point*

Perry point is a projection on the north shore of Thunder bay east of Amethyst harbour (*See* Map 214A). It is underlain by a diabase sill 30 feet thick, the same body that occurs on Lambert island. A vein a few inches wide strikes east through the diabase along the northern side of the cliff about 600 feet north of the southern extremity of the point. Animikie iron formation occurs on the lower land immediately to the north. The vein consists of quartz, amethyst, and calcite. The vein may be a part of a larger vein system in the drift-covered area lying along the northern margin of the diabase. No development work has been done at this locality.

(66) *Lot 13*

On the shore of Thunder bay, on lot 13, Macgregor township, one mile west of Knobel point (*See* Map 214A), two parallel veins occur in small faults traversing Animikie iron formation. They are 15 feet apart and are 2 feet and 3 feet wide, respectively. They strike north 53 degrees east. They consist of white quartz and amethyst, locally well mineralized with finely crystalline galena. The veins are exposed over a length of less than 50 feet.

(67) *Knobel Point*

On Knobel point (*See* Map 214A) near the western boundary of lot 16B, Macgregor township, 400 feet north of the shore of Thunder bay, a vein 3 inches wide occupies a fracture in a diabase sill. It strikes approximately east and is composed of quartz, calcite, and barite, sparingly mineralized with galena. A few yards north of this locality, the diabase sill terminates as a cliff facing northerly toward a drift-covered area. The sill is 20 feet thick and is underlain by black shale. It is possible that a fault and vein may occur along the base of the cliff.

[1] Ingall, E. D.: Op. cit., p. 65.

(68) *Keshkabuon* (*Caribou*) *Island*

This island, formerly known as Caribou island, lies off Perry point, in Thunder bay (*See* Map 214A). Mr. Ingall[1] reports that some surface exploration was done prior to 1887 on veins in the Animikie rocks on the island " but with little or no result." Along the north side of the island an intrusive sheet of diabase up to 100 feet thick lies horizontally upon 100 feet of flat-lying Animikie shales below. To the south the sheet curves abruptly downward and on the southern shore near lake-level layers of shale and greywacke lie above the diabase. Locally a development of granophyre, some 2 feet thick, occurs at the contact between the sediments and the upper surface of the diabase. Numerous small veinlets of quartz, amethyst, and calcite are exposed along the southern shore of the western part of the island. None of these appears to be of economic importance.

Mining operations on the north shore of Caribou island in 1921-22, were for the purpose of obtaining blocks of diabase for the construction of the Port Arthur breakwater.

BLENDE LAKE

A mineralized vein occurs on lot 1Z, McTavish township (69) (*See* Map 214A). It is exposed on the west side of Pass Lake road, 3,700 feet southeast of the Nipigon highway. This vein was discovered in 1867 by Peter McKellar and was explored on both sides of Blende lake through a distance of 1 mile in mining location Z1 and Z4. Two test pits were sunk on the vein within one-quarter mile east of Blende lake. Mr. F. H. Keefer states that no further mining operations have been carried on since he acquired mining location Z1 in 1882. A further examination of the surface, however, has resulted in the discovery of other veins. Three of these lie in the immediate vicinity of the bridge over Blende river on the Pass Lake road (69). The largest of these is exposed 125 feet southwesterly from the bridge. It is in a faulted zone in Animikie greywacke and an overlying sill of diabase. The faulted zone is 70 feet wide, strikes north 20 degrees east, and is cemented with finely crystalline, white quartz. About 60 feet east of the bridge a 6-inch calcite vein in Animikie iron formation strikes north. About 125 feet southeast of the bridge a vein of white quartz and calcite, at least 10 feet wide, is partly exposed striking northeasterly through Animikie iron formation. The veins are exposed for lengths of only a few feet and where visible are devoid of metallic minerals.

The vein discovered in 1867, the Blende Lake vein, cements a fault shatter zone some 20 feet wide striking north 75 degrees east. The rocks on the south of the vein are stratigraphically lower than those on the north, though locally standing at a higher elevation. The greater part of the composite vein is a network of veinlets and veins less than 1 inch in width and composed of fine-grained white quartz. Larger veins up to 2 feet in width trend in an irregular manner through the network and consist of white and amethystine quartz, white calcite, and transparent brown

[1]Ingall, E. D.: Op. cit., p. 65 .

and milky white barite. Galena and zinc blende are locally abundant, but the greater part of the vein as exposed is lacking in metallic minerals. In 1877, Mr. Ingall reported that assays from the Blende Lake vein were said to have yielded $14 to the ton in silver.

LOON LAKE AREA

In 1927, Mr. Tony Oklend, of Loon, discovered mineralized veins within one-quarter mile west of the western boundary of McTavish township (70). They lie 1¼ miles north of Loon lake (*See* Map 214A), close to the portage between Loon and Allan lakes and about one-half mile south of the latter lake. The veins occur in hills underlain by granite and pegmatite with inclusions of chlorite schist. They occupy fracture planes along faults. One vein outcropping east of the portage has an average width of 8 inches, strikes north 55 degrees east, and dips 75 degrees southeast. It has been traced through a distance of 350 feet. In this distance the size and mineral content of the vein change from place to place. The vein consists of white and amethystine quartz, barite, galena, zinc blende, and chalcopyrite. Locally for distances of several feet metallic minerals make up approximately one-quarter of the volume of the vein material.

Another vein is exposed on the south side of a granite knoll one-quarter mile west of the portage (70). Slickensides on the north wall indicate that there has been horizontal movement along the fault. The vein strikes north 45 degrees east and dips 80 degrees southeast. The upper part is 4 inches wide, 15 feet lower it is 7 inches wide. The vein along both walls over a breadth of one inch consists of fine-grained, white quartz mineralized with abundant black sphalerite and galena and a little chalcopyrite. The central part of the vein consists of coarse-grained, platy barite through which transparent orange-brown crystals of barite occur; crystalline aggregates of zinc blende and galena occur sporadically through the barite. The vein has been traced a distance of 60 feet and is naturally exposed on the side of a hill for a vertical distance of 15 feet. About one-fifth of the volume of the vein is made up of zinc blende and galena in approximately equal proportions. Between one-third and one-half of the volume is composed of barite.

MCTAVISH TOWNSHIP

(71) *Silver Lake Veins*

Numerous veins occur in the vicinity of Silver lake, in an area measuring 3½ miles east and west by ½ mile north and south. The position of the known mineralized veins within this area is shown on Map 214A. Veins mineralized with argentiferous galena along the south shore of Silver lake were discovered early in 1866 by Peter McKellar. No merchantable silver ore has been found as yet. In 1926, Mr. H. Dreany commenced the exploration and development of lots 2 and 3, south and east of Silver lake, in a search for lead ore. Mr. Wm. Longworth and associates actively explored their property which includes part of Silver lake and a fringe, 33 feet wide, of the south shore.

The fault system that traverses the above-mentioned area is complex and the rock exposures are not such as will permit deciphering the complexity. In general it appears that a major east-west fault, readily traced west from Silver lake, divides or pursues an irregular course through the eastern part of the area. Numerous minor faults also occur. The mineralized veins are fissure fillings and cemented shatter zones. The shatter zones range in width up to 60 feet and are traceable for hundreds of feet. They are commonly cemented with a ramifying network of tiny quartz and calcite stringers. Galena occurs abundantly in certain of the stringers, particularly at places where several veinlets converge. The various shatter zones occur in line with one another, trend approximately east, and pass along the south shore of the western extremity of Silver lake. The faulting along this zone causes Sibley sandstone to abut against red tuff of a higher stratigraphic horizon, the downthrow being on the north. The shatter zone system has been traced for 4,000 feet easterly and 1½ miles westerly from the west end of Silver lake. Geological mapping reveals the approximate position of a westerly extension of this fault for an additional 5 miles to the vicinity of Beck.

The mineralization in the shatter zones is on the whole widely diffused and sporadic. At the following localities galena appeared to be somewhat more concentrated than elsewhere; 400 feet east of the west end of Silver lake in a cliff rising 40 feet above the lake; 1,000 feet east of the last-mentioned point on the west shore of a bay; across the bay 600 and 1,000 feet, respectively, east of the last-mentioned locality. At all four localities, it is estimated that galena made up 2 per cent of the volume of the rock mass over widths of 4 feet within the shatter zone.

In addition to the broad shatter zones there are simple and composite veins striking in various directions through the area. The simple veins range up to 4 feet in width and galena is known to occur in a number of them. The most richly mineralized vein observed is on the property of Mr. Wm. Longworth and associates on the west side of a peninsula 1,000 feet east of the west end of Silver lake. The vein here is discontinuously exposed along the shore for a length of 150 feet. The southern part of the vein strikes north 25 degrees east; the northern end, 30 feet long, strikes north 52 degrees east. The vein dips about 70 degrees northwest. It is 1 foot wide and consists of white quartz, amethyst, galena, zinc blende, and a little pyrite. The galena locally makes up one-third of the volume of the vein and occurs in cubes measuring up to 2 inches along an edge. The greater part of this vein as exposed is less than 1 foot above lake-level.

The most easterly workings in the Silver Lake area are east of the lake, near the middle of the south boundary of lot 3. A pit 15 deep here shows a fault zone 4 feet wide within which a single vein 1½ feet wide strikes east and dips vertically. It is composed of white quartz, amethyst, calcite, galena, and pale yellow zinc blende. Adjoining the vein there are branch veinlets and mineralized shear zones locally rich in galena.

Numerous workings near the southwestern part of lot 3 are on relatively small veins that strike in various directions and in which there is a considerable proportion of coarsely crystalline barite in addition to the galena-bearing quartz and calcite.

The several workings that occur within 500 feet of the south shore of the lake, between 2,000 and 3,000 feet from its east end, are on a complex system of veins which might be regarded as one composite vein striking south 75 degrees east. One of the workings near the east end of the group is said to be on the original discovery made by Mr. Peter McKellar.

On the north shore of Silver lake, 400 feet east of its west end, a network of tiny quartz veinlets occurs on a low reef composed of Sibley tuff. This is known as the Anderson vein. The network strikes south 72 degrees east, is at least 10 feet wide, and can be traced for 20 feet. In addition to quartz, the following minerals were observed in the veinlets: dark purple fluorite, galena, zinc blende, and pyrite. The vein material makes up approximately one-twentieth of the volume of the rock in the cemented zone, and the metallic constituents make up but a small fraction of the vein material. It is reported that silver values have been obtained here upon assaying. This is the only locality where fluorite was observed near Silver lake.

The numerous occurrences of lead and zinc minerals in the vicinity of Silver lake do not include any one deposit known to be of sufficient size and richness to admit of the profitable extraction of lead and zinc ore.

(72) *Detroit-Algoma Mine*

Detroit-Algoma mine property consists of the southeast quarter of lot 4, con. IV, McTavish tp., 1½ miles northwest of Pearl station on the Canadian Pacific railway (*See* Map 214A).

A mineralized vein was discovered on this property by Duncan McEachern in 1871 and was patented by Thomas H. Wright the same year. In 1882 the title was acquired by A. W. Wright. No work was done on the property until 1906 when a quarter interest was deeded to William H. Morris, and the Detroit-Algoma Mining Company was formed. A small amount of test pitting and stripping was done each year between 1906 and 1909, inclusive. In 1910 a boiler, hoisting engine, compressor, machine drill, and a five-stamp mill were installed, and a 7 by 9-foot shaft was sunk to a depth of 52 feet. Development work continued until 1914, since when the property has lain idle. In 1921, A. W. Wright died and the property was left to his son, A. H. Wright, of Highland Park, Michigan, who now owns it. In 1926 the property was leased to an eastern company. When the property was examined in 1927 it was noted that the above-mentioned mining equipment was still on the premises and apparently could be put in running order with a small amount of repair.

There are two veins on the property. On the southeasterly one, in addition to the 52-foot shaft mentioned above, there are two other shafts measuring 30 feet and 15 feet, respectively, and pits and trenches that expose the vein almost continuously for 400 feet southwesterly from the main shaft. A quarter mile north of the main shaft some stripping has been done on the second vein.

The property is underlain by granite on which irregular-shaped areas of flat-lying Sibley sediments occur with thicknesses up to 30 feet. The surface is hilly with a local relief of 200 feet.

The veins occupy faults that affect both the granite and Sibley sediments. The southeastern fault trends northeast. The rocks on the northwest have moved relatively downward through such a distance that Sibley sediments abut against granite on the opposing wall. At an average distance of a quarter mile northwesterly from the above-mentioned fault, a second fault can be traced along a northeasterly course for a quarter mile. Within this distance its strike changes from north 40 degrees east to north 80 degrees east. The rocks on the southeasterly side of the fault have moved relatively downward.

At the main shaft, vein material cements a brecciated zone having a width of 15 feet. Part of the cemented shatter zone, varying in width between 6 and 8 feet, is relatively free from country rock inclusions and vein material makes up approximately 40 per cent of the total volume. It is in this part of the brecciated zone that the shaft was sunk. The zone dips steeply toward the northwest in the upper 30 feet and steeply toward the southeast in the lower 20 feet.

The vein material consists of white quartz and calcite carrying disseminated galena and zinc blende and pockets of chalcopyrite. Seams and stringers up to 1 inch in width and a few feet in length, richly mineralized with galena and zinc blende, one or other greatly predominating in each individual veinlet, occur irregularly through the cemented zone striking in various directions. There has been a somewhat later development of amethyst and pyrite. A still later 2-inch vein of coarsely crystalline barite cuts the network of veinlets.

Over a width of 8 feet in the vicinity of the main shaft, it is estimated that the metallic constituents, chiefly galena, make up approximately 3 per cent of the volume. The sulphide mineralization is irregularly distributed. It is reported that in the lower 20 feet of the shaft a seam 1 foot wide, richly mineralized with the chalcopyrite, was found. The vein material at all other exposures on the property is of similar character, the mineralization being restricted and of an irregular character.

The following assay results have been supplied by the owner from samples selected from the main vein:

Number	Copper pounds per ton	Silver ounces per ton	Gold ounces per ton	Platinum ounces per ton
1	102	....	0·05	4·1
2	152	170·9	....	....
3	200	....	0·1	0·6
4	210	....	0·1	0·7
5	....	5·5	0·15	0·15
6	35	trace	3·75	2·0
7	30	trace	3·67	2·1

(72) *Mining Claims TB 6359, TB 6360, and TB 6361*

Detroit-Algoma mine veins extend northeasterly into the southwest quarter of lot 4, con. III, McTavish tp. (*See* Map 214A). They were found by J. H. Johnston who, in 1927, staked on them claims TB 6359, TB 6360, and

TB 6361. A trench 15 feet long has been opened across the southern vein which has been traced discontinuously for 1,600 feet on this property. The composite vein as exposed in the trench occupies a fault in grey and pink tuff of the Sibley series. It strikes north 55 degrees east and dips about 80 degrees southeast. The composite vein is distributed over a width of 15 feet and consists of numerous veinlets up to 3½ inches in width with the strike and dip as noted above, and others that ramify irregularly between these. The vein material makes up between 5 and 10 per cent of the volume of the rock in the cemented zone. It consists of colourless and amethystine quartz, barite, galena, sphalerite, and chalcopyrite. Galena is the most abundant of the metallic minerals and makes up between 15 and 20 per cent of the vein material; a few veinlets are composed almost entirely of this mineral.

The northern vein lies at an average distance of 1,000 feet northwest of the southern vein. It is also composite and occupies a fault zone up to 40 feet wide in granite. It strikes north 85 degrees east; the general dip could not be determined. The vein material makes up about 10 per cent of the volume of the cemented fault zone; it consists chiefly of white quartz with a small amount of amethyst and barite; pyrite and galena occur locally in small amounts.

(72) *Mining Claim TB 6576*

A composite vein occurs 1¼ miles north of Pearl station on mining claim TB 6576, one of a group of claims on the east side of Pike lake (*See* Map 214A), staked in 1927, by Mr. Jas. Lawrence and associates of Fort William. No work has been done on this vein. The composite vein as exposed for a length of 10 feet on a granite hillside, is in a shatter zone, 3 feet wide, striking south 55 degrees east with vertical dip. About half of the volume of the shatter zone is white quartz which is the only vein mineral in this exposure.

(73) *Mining Claim TB 6084*

Veins occur on mining claim TB 6084, which lies at the southwest end of Pike lake (*See* Map 214A) between one-quarter and one-half mile northwest of Pearl station on the Canadian Pacific railway. The claim was staked in 1927 by Mr. W. G. Davis of Fort William. The veins have been exposed by pits and trenches as follows. In the southwest corner of the claim a composite vein up to 6 feet wide, and striking north 40 degrees east, has been exposed by trenching for a distance of 450 feet. In a direction north 30 degrees east and 900 feet from the southwest corner of the claim, a trench 12 feet long exposes a vein 2 feet wide dipping 60 degrees north and striking north 87 degrees east. Two hundred feet north 70 degrees east from the last-mentioned trench, a shallow test pit exposes a composite vein 4 feet wide striking north 70 degrees east and dipping vertically; 450 feet easterly along this vein a trench exposes a length of 8 feet. Thirty feet south of the last-mentioned trench a stripping partly exposes a composite vein for a width of 2 feet. It is possible that the various veins lie in two fracture systems.

The veins occur in shattered fault zones in granite containing inclusions of chlorite schist. Chlorite schist on the northwestern side of the first of the above-mentioned composite veins is impregnated with hematite for a width of at least 2 feet. At this locality the composite vein consists of a single vein of quartz 2½ feet wide bordered by a network of branching and interlacing veinlets.

The vein material of the various exposures consists chiefly of white and rust-coloured quartz and amethyst with later veinlets of barite. The veins are locally well mineralized with galena and pyrite, the richest showing being in the 12-foot trench (the second, above mentioned) where half of the 2-foot vein consists of vein material of which between 5 and 10 per cent, by volume, is galena. Mr. Jos. H. Johnston reports that low gold values were found by assay in samples taken from the vein in the southwest corner of the property. Mr. James Lawrence states that in the spring of 1927 he located the continuation of the first-described vein near the eastern shore of Pike lake (50 feet east of the outlet) and exposed the vein by a stripping 10 feet in length. The vein occurs in granite and is said to be 5 feet or more in width. Mr. Lawrence states that the vein carries galena and chalcopyrite.

(73) *Mining Claim TB 6593*

A composite vein is exposed for 15 feet on the south shore of Outlet bay, Grass lake, 1¼ miles northwest from Pearl station, Canadian Pacific railway (*See* Map 214A). It is on mining claim TB 6593, which along with two other claims adjacent on the south was staked by Mr. P. Barr of Pearl in 1927. The vein exposure lies one-quarter mile southwesterly from the southerly vein as exposed on the Detroit-Algoma property and in line with it. The composite vein occupies a shatter zone in granite-gneiss; it is 2 feet wide, strikes north 60 degrees east, and consists of nearly parallel veinlets of quartz making up one-quarter of the volume of the cemented shatter zone. The quartz is locally well mineralized with pyrite. The general appearance of the vein is similar to parts of veins in the general vicinity that are known to be mineralized with lead, zinc, and copper minerals.

(73) *Other Veins near Pearl Station, Canadian Pacific Railway*

Mr. J. H. Johnston, in 1927, discovered two veins on the southeast bank of Pearl creek, 1¾ miles west-northwest of Pearl station, Canadian Pacific railway (*See* Map 214A). The veins cut grey sandstone of the Sibley series. They are parallel, are 60 feet apart, strike northeast, and dip vertically. The northwesterly vein is composite; it is 4 feet wide and is composed of pyrite-bearing quartz veinlets averaging a half inch in width and one barite vein 3 inches wide. The vein material makes up one-quarter of the width of the cemented zone. The southeasterly vein is 14 inches wide and consists of white quartz and amethyst sparingly mineralized with galena and pyrite; a later development of barite occurs in vugs.

In the southeast quarter of lot 5, con. V, McTavish tp., three claims south of the most southerly of the above-mentioned veins, a 6-inch vein of coarsely crystalline pink barite is prominently exposed for 20 feet on the side of a sandstone cliff 10 to 15 feet high. The vein trends northeast and dips 80 degrees southeast.

In the northeast quarter of lot 5, con. V, McTavish tp., 200 feet north of Trout lake, several detached angular boulders cut by mineralized vein material were found by Mr. J. H. Johnston in drift lying on red sandstone of the Sibley series. The boulders range up to 2 feet in diameter and consist of silicified, grey, impure sandstone carrying veinlets and masses of sugary white quartz mineralized with pyrite and galena. Mr. Johnston reports that silver values were found in this material upon assay.

(74) *Enterprise Mine*

The abandoned workings of Enterprise mine are on mining lot C, McTavish township, on the north side of the Canadian National railway about 2½ miles southwest of Ancliff station (*See* Map 214A). A well-mineralized vein was discovered on this property in 1865 by Mr. Peter McKellar. Dr. E. J. Chapman of Toronto in 1868 reported the presence of appreciable quantities of gold and silver associated with the galena and chalcopyrite in parts of the vein. Between 1870 and 1876 two shafts were sunk. No. 1 was sunk to a depth of 180 feet; levels were run easterly 76 feet and westerly 66 feet at a depth of 60 feet; a stope was made in the west drift, and a winze was sunk 14 feet in the east drift about 50 feet from the shaft. A large sump was constructed on the northern wall of the shaft at the 60-foot level to catch surface waters. A crosscut was made from the bottom of the shaft going 15 feet south. Shaft No. 2 was sunk 60 feet at a point about 300 feet west of No. 1.

The total recorded production from the mine was a single shipment made to Swansea, Wales, in 1875. The ore packed in barrels was drawn by ox team over a tram to the loading dock on Black bay about 5 miles east of the mine. The returns were as follows:

142 tons	39·5 per cent lead
15 "	33 per cent lead
10 "	14 per cent lead

No returns were made nor credit given for any gold, silver, or copper in the shipment.

In 1874, Dr. E. J. Chapman reported that a large average sample of the well-mineralized part of the vein near surface gave the following result upon analysis:

Lead	41·84 per cent
Copper	5·40 per cent
Silver	3·2 ounces per ton
Gold	0·33 ounces per ton

He stated that the gold in the ore was contained in the chalcopyrite.

Mining operations ceased in 1876 and a few years later all the buildings and surface works were destroyed by fire. The ownership of the property changed hands, and the new owners dewatered and sampled the workings in 1884. No ore was produced.

In 1926 the property was acquired by Mr. J. A. Jacobs, who sold it to the Power and Mines Corporation, Limited, of which he was then president. Under the management of J. H. Johnston, new buildings were constructed and shaft No. 1 was dewatered. The examination having been completed the operation was suspended in 1927.

Mining lot C is partly underlain by nearly flat-lying sediments of the Sibley series up to more than 40 feet thick, resting on an undulating basement of pink granite. Various members of the sedimentary series, namely, conglomerate, sandstone, finely laminated chert and limestone, and red tuff, successively overlap each other and come in contact with the granite which rises as a hill in the northern part of the lot. A diabase dyke 4 feet wide occupies a fault, striking south 85 degrees east, through the sediments and granite; the dyke is exposed at No. 2 shaft and in the railway cut about 100 feet south of shaft No. 1. Faulting occurred after the diabase intrusion. The cavities and fissures formed during the faulting are cemented with vein material. Several mineralized veins are known to occur on mining lot C; the largest and best mineralized is that which has been mined. This vein has an average width of 4 feet with numerous branches ramifying through a shatter zone for 3 feet on either side. Its length as traced underground is 150 feet. Other veins, which may have some connexion with it, have been found beyond drift-covered area in this vicinity. It is reported that in shaft No. 1, 180 feet deep, the vein pinched out or became very narrow at more than one place and that at the bottom of the shaft it was from 5 to 7 feet wide. The strike of the vein varies between north 65 degrees east and north 70 degrees east; the dip is 75 degrees south in the upper part of shaft No. 1, but more nearly vertical at depth.

The vein consists of calcite and white quartz with local concentrations of intimately associated, fine-grained galena and chalcopyrite, and a later filling of amethyst and pink barite. Gold and silver values were found upon assay. Rich concentrations of metallic minerals were found as discontinuous lodes within the vein at various places throughout the workings. The largest concentration found was that which outcropped at shaft No. 1. With the exception of a small tonnage of rich lead-copper ore near the surface of the vein and on the dump, the greater part of the known richly mineralized material was removed during the early mining operations.

The other veins exposed on mining lot C are less than a foot in width and though of the same character as that at the mine, are either sparsely mineralized or so narrow where well mineralized, that they could not be profitably mined. A further search for lateral extensions of the principal vein along the main fault would be warranted.

(74) *Mining Locations A and B*

Between a quarter and half a mile northeast of Enterprise mine a mineralized composite vein is exposed in the northern part of mining lot B and in the adjoining lot A. It was explored and examined by test pits and stripping over a length of 600 feet by Mr. J. A. Jacobs in 1927.

The composite vein consists of several veins and veinlets cementing a shatter zone in waterlain red tuff of the Sibley series. The general trend is north 60 degrees east. The character of the composite vein varies from place to place; locally there are a few veins one inch wide and branching veinlets ramifying through a zone 5 feet wide, the vein material making up about one-tenth of the volume of the shatter zone. The vein material consists chiefly of fine-grained white quartz through which galena cubes up to one-quarter inch in diameter are abundantly disseminated and, locally, make up one-quarter of the volume of the vein material. Crystals of amethyst occur locally in vugs.

(75) *South of Bowker Station, Canadian Pacific Railway*

A small occurrence of rich hematite iron ore lies 1½ miles south of Bowker station, Canadian Pacific railway, in McTavish township on property owned by J. Welsh. The discovery was made in 1922 by F. Sanderson of Nipigon. In 1923 J. G. Cross of Port Arthur, who held the mineral rights on the property for a time, constructed two trenches, one 20 feet long, the other 50 feet long, revealing the restricted extent of the rich iron ore.

The deposit is poorly exposed on the southern side of a hill of granite which is overlapped around its flank by nearly flat-lying sediments of the Sibley series. A fault shatter zone strikes approximately north 65 degrees east with vertical dip through the hill and is exposed at a point below and 30 feet distant from the contact of the red fragmental rock of the Sibley series against the granite. The shatter zone is cemented with a network of veinlets consisting of white, red, and amethystine quartz sparsely mineralized with chalcopyrite and later veinlets and vug fillings of coarse-grained pink barite.

The red fragmental rock in the shatter zone is permeated with hematite which is concentrated along the walls of the quartz veinlets. The rich hematite-bearing rock does not extend more than a few inches from the walls of the veinlets and passes gradationally into the unmineralized fragmental rock.

The hematite deposit, as exposed in two trenches about 40 feet apart, is of rock richly charged with red hematite in porous, massive, and botryoidal form through a width of 4 feet following the main fault zone. Minor parallel and branching faults and similar mineralization phenomena occur in the vicinity. Trenching operations exposed the deposit to a depth of 3 feet. Insufficient development work has been done to determine whether the hematite persists to much greater depth or whether it is a surface alteration product of some other iron minerals such as iron carbonate or pyrite, which are known to be associated with certain veins elsewhere in this region. The form of the deposit, as a replacement along the walls of a composite vein, indicates that it is probably too small to be of commercial value.

Mr. F. Sanderson reports that samples from the above-mentioned deposit 4 feet wide were analysed, with the following result:

Number	Fe	P	S	SiO_2	Moisture
284117	59·36	0·010	0·260	11·95	1·40
284118	60·28	0·016	1·091	8·83	0·80

(76) *East of Ancliff Station, Canadian National Railways*

Mineralized veins occur on lots 2, 3, 4, 5, and 7, McTavish township, east of Ancliff station (*See* Map 214A) on the Canadian National railway. Two of the veins, one on lot 3 and one on lot 4, were developed subsequent to 1865 at the Caribou and Bain mines, respectively; they were abandoned prior to 1891. There is no record of mineral production from these properties. Since 1926 exploration has been carried on by E. Nurmela and A. Paju of Port Arthur on mining claims that embrace the abandoned properties.

The oldest rock in this area is granite which forms prominent hills extending for 3 miles west of Granite point in Black bay. Nearly flat-lying sediments of the Sibley series occupy the lowlands and are in contact with the granite on the flanks of the hills, showing progressive overlap. A few small diabase dykes cut the granite and sediments and all these rocks have been affected by faults. Mineralized veins occur in the faults; and at two localities adjacent to faults, vein material occurs also in numerous vugs and irregular veinlets in the banded jasper and cherty limestone of the Sibley series.

Near the middle of lot 5, on the side of the hill, the sediments are exposed, lying on the granite basement. The strata have been locally disturbed and irregular veinlets with a maximum width of 2 inches occur through them. The veinlets consist of white and amethystine quartz, galena, and sphalerite. The metallic minerals make up half the volume of the vein matter. The deposit is too small to be of economic interest.

Half a mile east-northeast, in lot 3, banded jasper and cherty limestone with a maximum thickness of 4 feet are exposed over an area measuring 100 feet by 300 feet. They dip 20 degrees southwest and lie on an inclined surface of weathered granite dipping in the same direction and at the same rate. The banded jasper and cherty limestone locally show a remarkable development of "algal" structure. At such places groups of layers rise as domes ranging in diameter from 1 inch to 2 feet, and occurring both as isolated structures and, in some areas, closely crowded. Between the domed structures there is vein material consisting of an intimately associated, fine-grained white quartz, calcite, chalcopyrite, chalcocite, zinc blende, and galena with a somewhat later crusting of amethyst showing crystal terminations projecting into the middle of the cavities. Similar vein material occurs in gash veinlets and vugs irregularly distributed throughout the sediments as far as they are exposed. Malachite and azurite, the weathering products of other copper-bearing minerals, were observed in certain of the little deposits. Mr. E. Nurmela reported that a sample of mineralized material taken in 1927 from a test pit 4 feet deep, yielded upon analysis values in copper, silver, and zinc amounting to $53 to the ton and gold at the rate of 80 cents to the ton. At this locality the visible vein deposits, though richly mineralized, are too small and widely diffused to be of economic value.

The largest of the known veins is near the middle of lot 7 and has been traced discontinuously, along a curving northeasterly course, for 2,000 feet to the northwest corner of mining claim TB 4714 in lot 5. The vein occupies a fault, the northwest wall is of granite, the southeast wall is of red fragmental rock and quartz sandstone of the Sibley series. For distances of several hundreds of feet the vein is naturally exposed on the southwestern side of granite cliffs which rise as much as 50 feet above the rock on the downthrow side of the fault. At several places part widths of 10 feet can be measured across the vein. At one locality the vein is 30 feet wide with branching veins distributed through a further width of 30 feet. The greater part of the vein material is coarsely crystalline, white and pale grey calcite, locally there are bands up to a few feet in width of white, pale green, and amethystine quartz more or less intimately associated with calcite and barite. Near the northeastern end of the vein, as exposed, there are lodes within the wide calcite vein in which the calcite is well mineralized with finely disseminated chalcopyrite for widths up to one foot. Old workings at these localities indicate that the lodes had lengths of about 50 feet or less. Galena and sphalerite are very sparsely disseminated through parts of the main vein, and relatively rich concentrations occur in certain narrow bands in branching veins and veinlets as exposed in one trench extending south from the main vein. A very considerable tonnage of pure, coarsely crystalline calcite is available in this vein; possibly commercially valuable concentrations of metallic constituents may be revealed by further exploration.

In the southwestern quarter of mining claim TB 4714 in lot 5, and in the adjoining claims to the west and south, veins are exposed in six outcrops. The largest of these veins, at a point 300 feet easterly from the northwest corner of claim TB 4722, is 20 feet wide, strikes east, and dips vertically. It occupies a fault; granite overlain by Sibley sediments occurs on the north wall, and Sibley sediments underlie the lower land on the south. The vein consists chiefly of calcite, white quartz, and amethyst, a lode, 8 inches wide, within the vein is mineralized with chalcopyrite and galena. The vein is exposed for a length of 50 feet on the south side of a hill. The other veins in this vicinity are locally well mineralized with intimately associated galena, sphalerite, and chalcopyrite, but all available information indicates that each deposit is either too small to be mined or that further development would be necessary to reveal possible ore-bodies.

At the 65-foot inclined shaft of Caribou mine, on mining claim TB 6592 on lot 3, there is a composite vein of vuggy, lenticular veinlets closely spaced through a width of 5 feet. The vein system occupies a fault shatter zone trending east and dipping between 60 and 70 degrees south. The north wall is of granite; the south is of diabase which occurs as a dyke 6 feet wide occupying an earlier fault with Sibley sediments along its south wall. The veinlets are banded and consist of greenish grey chalcedony, white, finely crystalline quartz, and coarsely crystalline amethyst; chalcopyrite and galena are irregularly disseminated through the white quartz. Very little of the composite vein is to be seen at this locality on account of drift, and the timbering in the shaft. The mineralization in the vein material on the dump is lean. The easterly extension of the vein system is exposed at points 300 feet, 700 feet, 900 feet, 1,100 feet, and 1,400 feet east of the shaft. At each locality there are old pits or trenches exposing a network of small veins of quartz and amethyst in a shatter zone, the veins are irregularly and, in general, sparsely mineralized with galena. At the pit 900 feet east of the shaft, on the east boundary of claim TB 6592, a dyke $2\frac{1}{2}$ feet wide and striking north, has been faulted by the vein; the southern part has moved relatively east. On the whole the Caribou vein is not sufficiently well exposed to permit of an estimate of its ore possibilities.

Between the Caribou vein in mining claim TB 4718 and the southeast corner of TB 6591, which lies to the south 2,000 feet distant on lot 3, four mineralized veins are exposed in small outcrops. The largest of these is the most southerly; it is exposed in a pit 8 feet deep and situated 125 feet northwest of the southeast corner of claim TB 6591. It is 6 inches wide, strikes east, and dips 65 degrees south. It occupies a fault and lies along the northern wall of a diabase dyke, 2 feet wide, that cuts red fragmental rock of the Sibley series. The westerly extension of the vein is exposed on a hill 40 feet high between 100 and 125 feet west of the pit. The vein as exposed consists of quartz and calcite, irregularly mineralized with intimately intergrown galena and chalcopyrite and a later development of pyrite. Galena is the most abundant of the metallic minerals which altogether make up approximately one-quarter of the volume of the vein material.

Four hundred feet westerly from the previously mentioned exposure of the vein on the hill there is a branch vein in granite. It is $1\frac{1}{2}$ feet wide and trends north 65 degrees east. It consists of calcite and white, rose, and amethystine quartz, through which galena is disseminated. The latter makes up one-tenth of the volume of the vein as exposed through a length of 8 feet.

Between the last-mentioned locality and No. 3 post of claim TB 4724, which lies about 2,000 feet distant in a direction south 25 degrees west, Mr. Nurmela reports that a vein system has been discontinuously traced along a fault zone with granite to the west and Sibley sediments to the east. At No. 3 post, which is a few yards east of the inferred position of this fault, there is an exposure of red fragmental rock cut by a vein, 4 inches wide, consisting of quartz and galena.

One thousand feet west-southwest of No. 3 post, in lot 4, the abandoned workings of the Bain mine are to be seen on a mineralized vein. The vein occurs in a shatter zone along the edge of a vertical dyke of diabase, 12 feet wide, striking south 78 degrees east and cutting flat-lying Sibley sediments. The dyke and vein are exposed in an easterly facing cliff 20 feet high. The dyke occupies a fault fissure; a subsequent minor dislocation has opened a channel that has been cemented by vein material distributed around the blocks in the shatter zone and as a network of veinlets through widths of 2 feet and less. In the dump, galena, sphalerite, and small amounts of chalcopyrite and pyrite occur in a gangue of white quartz, amethyst, calcite, and barite.

Near the middle of lot 2, a mineralized veinlet was observed in Sibley sediments within a few yards of a granite exposure. The veinlet is half an inch wide, more than a foot long, and consists of quartz and galena; it strikes northeast.

None of the deposits in the area east of Ancliff, as exposed in 1927, is of sufficient size where well mineralized to be regarded as a commercial ore-body. Further development work may reveal larger concentrations of lead-zinc-copper ore and it is possible that silver values may be found in deposits that have not yet been tested for precious metals.

GRANITE ISLET, BLACK BAY

It is reported[1] that a vein of drusy crystalline quartz cements a fault breccia (1 foot wide) in the granite-gneiss on Granite islet east of Granite point, in Black bay. The vein carries a considerable quantity of galena, but does not appear to contain much silver.

DORION TOWNSHIP

Ogema Mine

Ogema mine, named after the Indian who discovered the mineral occurrence, is 10 miles by road westerly from Dorion station and on old mining locations E 80 and E 157. The deposit was first worked in 1890 by Mr. James Dickenson of Port Arthur. An adit driven 125 feet into the base of a hill reached the vein and here a shaft was sunk 25 feet. Water difficulties caused cessation of development in 1890. The property was sold in 1892 to the Ogema Mining and Smelting Company who put down a 60-foot shaft on the vein above the old workings and made other excavations between 800 feet and half a mile to the northeast. A small button of gold was recovered from vein material treated on the property; it was found, however, that the gold content was too small for profitable extraction. The property lay idle between September, 1892, and January 1, 1927.

In 1926, the North American Lead and Refining Company, Limited, was organized by Robert E. Kemerer, of Montreal, to take over and develop the property, which was then owned by Captain H. E. Knobel. Work was started in January, 1927; camps were erected and a road constructed for 6 miles, partly with Government assistance; a modern mining plant was installed, including a boiler, hoist, and compressor. Development work was continued on the vein from the old adit and the shaft that connected with it; by January, 1928, sinking had reached a depth of 170 feet, and at the 125-foot level drifts had been driven 35 feet each way from the shaft along the vein.

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[1] "Geology of Canada, 1863", pp. 689-690.

The vein system occurs in a fault zone, about 20 feet wide, which lies approximately along the contact between granite on the north and steeply inclined, grey, banded, mica schist on the south, downthrow, side. Its trend varies between north 60 degrees east and north 75 degrees east; it dips steeply south. Within the vein system, individual veins pinch and swell and locally attain widths up to 8 feet, and numerous small veins ramify through the fault zone in an irregular manner. The vein material consists of quartz, calcite, and barite irregularly mineralized with galena, zinc blende, and pyrite. Though the galena and zinc blende are intimately associated, their relative proportions vary considerably from place to place. No information is available of the lead and zinc values of any considerable mass of the vein material. It is possible that further exploration will reveal ore-bodies of commercial value.

Mining Claim TB 6795

The easterly extension of the Ogema mine vein system occurs on mining claim TB 6795 which adjoins the Ogema mine property on the east. A shaft said to be 40 feet deep and pits and trenches were made on this property in 1892, and exploratory work along the surface was performed in 1927 by the owner, E. Nurmela of Port Arthur. The vein system strikes north 60 degrees east and dips between 75 degrees and 85 degrees south. The character and geological relationship of the deposit are similar to those at Ogema mine. Galena and zinc blende are disseminated through the vein, but rich concentrations, in masses sufficiently large to permit of profitable extraction, are not known to be present.

Mining Claims TB 6942, TB 7103, and TB 7104

A mineralized composite vein was discovered in 1927 in lot 6, concession X, west of Goodmorning lake, during the construction of the road to Ogema mine. The following claims were staked on it by the North American Metals Corporation, Limited: TB 6942, 7103, and 7104. The vein was explored during 1927, by pits and strippings, for a length of several hundred yards. It strikes east, dips vertically, and lies in the shatter zone of a fault. The country rock is granite and pegmatite with inclusions of biotite schist. The composite vein consists of numerous veinlets each less than 2 inches wide which ramify through a zone 6 feet wide and make up one-tenth of the volume in this zone. The vein material consists chiefly of quartz with small amounts of calcite and pectolite. Galena and zinc blende are disseminated through the quartz and are richly concentrated in certain veinlets; in exposures observed by the writer these minerals make up about one-tenth of the vein material by volume.

Mining Claims TB 7074, TB 7017, and TB 7020

On mining claims TB 7074, 7017, and 7020, owned by Messrs. Lindburg associated with Messrs. Norrie and Towers of New York, there is a mineralized composite vein. The most westerly exposure is on claim 7020, one-half mile east-northeast from the bridge at the south end of Goodmorning lake, on the road to Ogema mine. The most easterly exposure is one-half mile west from the outlet of Gulch lake. The composite vein is exposed by strippings at these points and in numerous outcrops between them through a length of 2,000 feet.

The composite vein cements a shatter zone in grey and pink sandstone and buff-coloured fragmental rock of the Sibley series, which has a width of 150 feet or more and is bounded by granite on the north. The composite vein strikes north 65 degrees to 70 degrees east and dips about 60 degrees southeast. There is a concentration of vein material in a breccia zone between 6 and 8 feet in width. Numerous veins up to 3 inches in width and intersecting veinlets ramify through the remainder of the cemented shatter zone. About 300 feet north of the most westerly exposure there is a nearly parallel composite vein occupying a fault in a greyish sandstone and an overlying 20-foot sill of diabase, which at this locality has an abundant development of red feldspar. This composite vein has a width of 20 feet and dips nearly vertically. Quartz, calcite, and barite stringers mineralized with galena form a network of cementing material throughout the shatter zone.

In the first-mentioned cemented shatter zone approximately 50 per cent by volume is vein material, consisting chiefly of white and pale amethystine quartz and a little barite. Galena and sphalerite are associated with quartz and locally make up 10 to 15 per cent of the volume of the vein-cemented breccia. Chalcopyrite and pyrite are sparsely disseminated throughout the composite vein.

Mining Claim TB 6006

A composite vein continuing the one exposed on mining claim TB 7074, has been traced in a northeasterly direction across mining claim TB 6006. Surface exploration was made in 1926 by Capt. H. E. Knobel, the owner. The vein system ramifies through a shatter zone ranging in width from 40 to 250 feet wide. Galena and zinc blende are disseminated in varying proportions through a gangue of quartz and calcite and a local concentration was observed in a width of 6 feet where a stripping showed the composite vein to be 40 feet wide. Here the metallic minerals make up between 10 and 15 per cent of the volume of the vein material.

Lot 5, Concession VII

A composite vein was discovered in 1926 on the west half of lot 5, concession VII, on property owned by Mrs. Millar. No development work had been done when the occurrence was examined in August, 1927. The vein occupies a shatter zone 35 feet wide, exposed for a length of 80 feet and striking north 65 degrees east. It lies 1,200 feet north of Crow lake on the eastern side of a drift-filled valley that forms a northerly extension of the depression occupied by the lake. The fault passes east through sandstone and red fragmental rock of the Sibley series. The composite vein is an interlacing network of veins that make up approximately 10 per cent of the volume of the cemented zone. The veins consist chiefly of white quartz; some veins contain coarsely crystalline barite. In the quartz veins galena and sphalerite locally make up from 7 to 10 per cent by volume of the vein material as exposed.

Lots 4, 5, and 6, Concession VII

Mr. D. C. Kemerer reports that in the autumn of 1927 a vein system was found trending north 10 degrees east on the east half of lots 4, 5, and 6, concession VII. The property is controlled by financial interests associated with R. E. Kemerer and H. E. Knobel. The vein has been exposed by trenching for a length of 300 feet and has a width of 5 feet; its extension has been found at several points, indicating a total length of 1,500 feet. The vein, locally, carries galena in large masses. Mineralized vein material has been found in drift adjacent to the vein; certain blocks show barite veins richly mineralized with zinc blende.

Lot 10, Concession VII, and Lots 10 and 11, Concession VI

On lot 10, concession VII, and lots 10 and 11, concession VI, Dorion township, a composite vein trending north 40 degrees east has been discontinuously traced for about 2,000 feet.

The property on which this vein occurs was known as the St. Clair location in 1876 and exploratory work was performed on the vein prior to that date. Subsequently and during different periods the property has been referred to by the names Malotte, Gurd, and Johnson. Mr. E. E. Johnson of Port Arthur was the owner in 1927. The principal workings on the vein are near the outlet of Malotte lake; here the vein has been stripped for over 100 feet and a shaft sunk on it; at intervals of a few hundred feet there are pits and trenches along the extension toward the northeast.

The composite vein occupies a fault zone, in a topographic depression between diabase-capped hills. The rock along the northern side of the fault zone is red diabase, that on the downthrow or southern side is red sediment of the Sibley series. The composite vein consists of numerous veinlets and veins up to a few inches in width which ramify through a zone 100 feet wide, the small veins are closely spaced in a part of the zone locally 12 feet wide. Along the walls of the veins there is a deposit of quartz through which galena is disseminated, the middle of the veins is filled with pink barite. The galena makes up about one-tenth of the volume of the vein material at the localities where the old workings were examined, but the veins are diffused through the shattered rock in such an irregular manner that no precise estimate can be made of the galena content in any large mass. It is possible that lead ore of commercial value occurs in this vein system.

Loose blocks of mineralized vein matter occur in the central part of lot 11, concession VI, Dorion township, on property owned by V. Liberg of Dorion. The blocks consist of Sibley sediment, are angular, and up to 14 inches in diameter; they occur in a drift-filled valley through which an inferred fault passes. The rock is traversed by a ramifying network of quartz veins locally well mineralized with galena.

Lots 11, 12, and 13, Concessions VI and VII

A property owned by C. E. Anderson and E. R. Bingham, of Fort William, and associates, consists of a block of fourteen mining claims, in lots 11, 12, and 13, concessions VI and VII. The property is accessible by road from Dorion station on the Canadian Pacific railway and Canadian National railways. The claims were staked in 1927. On claim TB 6858, a ramifying vein system has been exposed by test pits and trenches for a width of 30 feet and a length of 250 feet. On claim TB 7664, one-half mile east of TB 6858, a vein system has been uncovered over a width of 70 feet and a length of 400 feet. Both vein systems presumably extend beyond the exposure. Small occurrences of galena and chalcopyrite have been reported in veins on the east side of claim TB 6861 and the west side of claim TB 6862, about one-quarter mile northeast of the discovery on claim TB 6858.

The property is underlain by nearly flat-lying Sibley sediments and a basement of older granite and gneiss. The sediments are intruded by sheets of diabase lying at low angles nearly parallel to the bedding. A generalized local geological section is given in the following table:

Formation	Thickness Feet
Grey diabase	125
Quartz sandstone, red fragmental rock, limestone	85
Grey and red diabase	60
Quartz sandstone and red fragmental rock	70
Red diabase	40
Quartz sandstone and conglomerate	20
Basement complex: granite and gneiss.	

The assemblage has been faulted and deeply eroded. Large and small, irregular-shaped mesas, bounded by cliffs and steep slopes, rise to various heights up to 350 feet above a soil-covered lowland. The highest elevation on the property is about 900 feet above lake Superior.

The composite vein exposed on claim 6858 occurs as cement in a shattered fault zone in a notch between diabase-capped hills. The fault zone strikes northeast and dips vertically. Within it there is locally one or more principal veins showing widths up to 8 inches; these are parts of a ramifying network of veinlets that individually in a few feet change in width and trend. The vein minerals are quartz, calcite, barite, galena, and zinc blende. These are intimately associated in greatly varying proportions. In the southwestern part of the exposure, the vein material over a width of 5 feet makes up about one-tenth of the volume of the cemented shatter zone, and galena and zinc blende constitute about half of the vein material by volume. The galena is more uniformly distributed through the veins than the zinc blende. About 250 feet northeast of the southwestern end of the exposure, two veins 10 and 14 inches in width, respectively, are said to be heavily mineralized with zinc blende. Mr. Anderson reports that gold values of $1.20 and $1.80 a ton have been obtained from quartz veins in the composite vein and that silver values have also been found by assay.

The composite vein exposed on the northern part of claim TB 7664 occurs as cement in a shattered fault-zone in a notch between diabase-capped hills. The fault zone strikes northeast and dips vertically. The veins and veinlets display the same mineral associations as occur in the previously mentioned deposit. Galena is widely disseminated in, and zinc blende is richly concentrated in, certain veins and veinlets. Locally, widths up to 3 feet can be found where the vein material makes up half of the volume of the rock. At one locality there is a vein of almost pure sphalerite, 8 inches wide. Insufficient information is at hand to permit estimating the tonnage of either lead or zinc ore in any large mass. Throughout the greater part of the shatter zones the metallic minerals are too widely diffused in the ramifying veinlets to be recovered profitably.

Dorion Lead and Zinc Mines, Limited

The vein system on mining lots L7 and 8 near the northern boundary of Dorion township, on which the Dorion mine was opened prior to 1907, was acquired in 1926 by Dorion Lead and Zinc Mines, Limited, a subsidiary of the North American Metals Corporation, Limited. The property as recently staked is on mining claims TB 5807, 6246, 5808, 7329, 6032, 6247, and 7146. In 1927, under the management of Capt. H. E. Knobel, camps for forty men were built, 3 miles of road constructed, a small mining plant put in, and drifting was continued southwesterly from the end of the old (Sandow) adit near the east boundary of the property. The shaft of Dorion mine 90 feet deep was cleaned out and exploratory work was carried on elsewhere along the vein system.

In the immediate vicinity of the mine, an area of granite is overlain by flat-lying Sibley sediments consisting of conglomerate, sandstone, and red fragmental rock, in all less than 100 feet thick. To the west an inclined diabase sheet more than 100 feet thick is widely displayed. A fault with the downthrow on the southeastern side strikes southwesterly through all these rocks, and throughout the extent of the mine workings its position on the surface is marked by the contact of the Sibley sediments on the south and the granite on the north. The shatter zone along this fault is cemented by a composite vein, from 2 to 20 feet wide, which has been traced for 3,500 feet. The greater part of the vein material as exposed consists of quartz and calcite sparingly mineralized with galena and zinc blende; locally there are veins a few inches in width, richly mineralized with galena and zinc blende. Barite occurs in the middle of certain veins and in distinct veinlets cutting across other parts of the vein system.

It is reported that rich lead and zinc ore was encountered locally at various depths in the 90-foot shaft, and that ore carrying 20 per cent in zinc is exposed across a width of 4 feet in the drift at the east end of the property. In 1927, no large ore-body of commercial value had been proved; it is possible that large concentrations of lead-zinc ore exist.

NORTH OF DORION TOWNSHIP

Thunder Bay Lead and Zinc Mining Company

The northeasterly extension of the composite vein that occurs on the property of Dorion Lead and Zinc Mines, Limited, had been traced discontinuously for over a mile through the block of claims, TB 6684, 6685, 6686, 6687, 6688, 6689, 6690, and 6683, in 1927, by the Thunder Bay Lead and Zinc Mining Company. This property is in the unsubdivided area immediately north of Dorion township.

The composite vein was partly explored by test pits and trenches prior to 1907 by the owners of Dorion mine. No development work was performed between 1907 and 1927. In 1927, camps were built and a mining plant installed in preparation for further exploratory work.

The property is underlain by granite, over which, in the southern part, are flat-lying sediments of the Sibley series. The composite vein occupies a fault zone varying between 3 and 30 feet wide, striking northeasterly through these rocks. The greater part of the vein material consists of quartz and calcite irregularly mineralized with galena and zinc blende, and, more rarely, chalcopyrite. The metallic minerals where richly concentrated are in veinlets or bands within veins and show widths of a few inches and lengths of a few feet. Veins of pure barite occur within the vein system, the largest observed being 18 inches wide and about 250 feet long.

Mining Claims TB 3358 and TB 3461

Claims TB 3358 and TB 3461 lie in unsurveyed territory a short distance north of concession XII, Dorion township. They were staked by the owner, Mr. E. Lebel of Dorion, in 1917. The claims are underlain by fine-grained, interbanded mica schist and gneiss, trending north 65 degrees east, cut by numerous large and small dykes of granite and pegmatite and by pegmatitic quartz veins. A mineralized vein strikes north 35 degrees east. It is a simple vein about 2 inches wide where it crosses granite dykes and a composite vein localized within 12 inches where the country rock is mica schist and gneiss. The surface is gently rolling and mantled with boulder clay; on the low ridge where the vein is exposed, the boulder clay has an average thickness of about 4 feet. Blocks of mineralized material can be seen in the drift along the trend of the vein for a distance of 1,200 feet. The vein has been stripped for 300 feet and two 20-foot pits have been sunk 66 feet apart, one in granite and one in schist. In the granite the vein is sharp-walled and free of inclusions of country rock; it is almost vertical and widens from 2 inches at the surface to 13 inches at a depth of 20 feet. The vein is banded and shows the following succession from the walls to the middle: calcite; a mixture of calcite, galena, and black zinc blende; quartz and yellow zinc blende; barite. The proportions of these minerals vary along the strike, but in general the vein is well mineralized with the metallic species. The composite vein where exposed in the pit in mica schist consists of numerous veinlets localized within 12 inches; they carry a small amount of chalcopyrite as well as the minerals found in the vein in the other pit. On the southwest face of the pit in schist the vein cements a shattered fault zone, the fault plane dips 80 degrees southeast, and the rock on the southeast has moved relatively downward about one foot. The Quebec Government assay office reported the following values in material taken across the sample vein where its width was 10 inches; silver 1·05 ounce a ton; lead 34·22 per cent; zinc 21·23 per cent. An average sample of the mineralized material would show less lead and more zinc.

In 1927, Mr. E. Lebel stated that along the northeast extension of the vein, further discoveries of mineralized veins had been found as far as Wigwam lake 5 miles distant and that vein material rich in galena had been found near the east and west ends of the lake lying west of the middle of Wolf lake.

STIRLING TOWNSHIP

Lot 4, Concession VI

At this locality, four well-defined brecciated zones, from 2 feet to 8 feet wide, and spaced at intervals of about 20 feet, strike parallel to each other north 55 degrees east. The Sibley sandstone, which here forms a thin layer over the granite, has been down-faulted on the southeast side of each fault, the total dislocation being about 5 feet. The brecciated zones are cemented with gash veins and small composite veins of quartz and amethyst carrying small specks of chalcopyrite. No metallic mineral deposit of economic interest is exposed in this locality, though stripping and test pitting have been done in the past.

NIPIGON TOWNSHIP

Several small veins have been found in Nipigon township in a restricted area less than 4 miles southwest of Nipigon village. The discoveries were made by Messrs. M. Lofquist and A. Maata between 1920 and 1923. No considerable development work has been done other than stripping and test pitting.

The oldest rocks are granite and granite-gneiss; they are exposed in hummocky projections on a lowland that is, for the most part, heavily drift covered. Nearly flat-lying Sibley sediments 400 feet thick extend westerly across the area and form the lower part of hills capped by a sill of diabase over 100 feet thick. Diabase dykes more than 50 feet wide occur at the eastern and northwestern extremities of the diabase-capped mesas, and dykes less than 5 feet wide have been exposed in intimate association with veins in granitic rocks at three localities.

The strata of the hills appear to be traversed by faults that follow the drift-filled depressions that extend across the hills; these depressions are indicated by embayments in the outline of the capping diabase. Several faults are known in the area underlain by granite north of the mesas and each of these is occupied by veins of the silver-bearing type or by diabase dykes.

The largest of the known veins is near the northeast corner of lot 9, concession III, Nipigon township. It lies in the area of granitic rocks, is between 1 and 2 feet wide, and has been traced 150 feet. It trends northeast and dips about 80 degrees northwest. The vein minerals and their approximate proportions by volume as estimated in exposures are: pink barite, 90 per cent; galena, 5 per cent; zinc blende, 4 per cent; chalcopyrite, 1 per cent. A sample is reported by Mr. Lofquist to have yielded upon assay silver at the rate of half an ounce to the ton.

Several veins exposed between this occurrence and the foot of the diabase-capped mesas to the west, consist chiefly of barite mineralized with the above-mentioned sulphides.

On the west half of lot 8, concession IV, a vein less than 6 inches wide occurs along the wall of a diabase dyke in a ravine high on a diabase-capped mesa. It consists of prehnite, apophyllite, and white quartz sparingly mineralized with galena.

The deposits in Nipigon township, as known in 1927, are not of commercial value. It is possible that veins wider than those found might be profitably mined for barite; it is also possible that richer concentrations of metallic constituents may be found by further exploration in this area.

MAZOKAMA BAY AREA

Mining Claim TB 6038

Jackfish river discharges into lake Superior at a place about three-quarters mile west of the west point of Mazokama bay, a large indentation in the north shore of Nipigon bay, 9 miles east of Nipigon river. On the east bank of Jackfish river, 1½ miles above the Canadian Pacific railway bridge in the southwest corner of mining claim TB 6038 there is exposed a composite vein. The claim is the property of Mr. William Gordon of Port Arthur who in 1926 staked it and a number of adjoining claims. The workings in 1927 consisted of two trenches across the vein, one on the east river bank and the other 60 feet east from this point. On the west bank a pit 14 feet in depth has been sunk in clay; it has not exposed the vein.

The composite vein cements a shatter zone, from 30 to 40 feet in width, in pegmatitic granite-gneiss. The shatter zone strikes approximately east and dips steeply north. It is naturally exposed for 100 feet or more easterly from the river. The composite vein consists of three nearly parallel calcite veins each varying in width, for the most part, from 10 to 24 inches, and separated by 15 feet or more of country rock traversed by a number of ramifying quartz veinlets up to 2 inches in width. One of the calcite veins reaches a width of 3 feet in the trench at water-level and is reported by Mr. Gordon to have a width of 8 feet, 3 feet below water-level. A barite vein having an average width of 6 inches cuts the network of veinlets. Vein material constitutes approximately 30 per cent by volume of the cemented shatter zone and consists of coarse white calcite (which makes up about 80 per cent by volume of the vein material), coarse white crystalline quartz, amethyst, and barite. The calcite veins are sparingly mineralized locally with galena and sphalerite. Chalcopyrite and pyrite are sparsely disseminated throughout the material. Mr. Gordon states that assays made of this vein show silver values.

Mining Claim TB 4588

A composite vein is exposed on the west side of Mazokama bay at the southeast corner of mining claim TB 4588, about three-quarters of a mile easterly from the Canadian Pacific railway bridge over Jackfish river. In July, 1925, Messrs. James Lawrence and J. P. Mignault sank a test pit 8 feet in depth and dug two trenches on the composite vein about 150 feet from the shore. In 1927 the property was restaked by Mr. G. Harris of Fort William.

A fracture zone about 100 feet wide is naturally exposed along the shore, trending 3 degrees north of west and dipping 70 to 80 degrees south. The fracture zone is in arenaceous tuff. The rock immediately to the south of the shatter zone on the lake shore is a conglomerate consisting of granite boulders up to 20 inches in diameter lying in a tuffaceous matrix. The vein system is a network of quartz and barite veinlets and a cemented brecciated zone having a width of about 10 feet. The vein material is predominantly white crystalline quartz, other gangue minerals are amethyst, white calcite, and rose-coloured barite. Metallic minerals, chiefly of galena and zinc blende, are present to the extent of 3 per cent of the volume. Chalcopyrite and pyrite also occur.

Mr. Lawrence states that this composite vein can be traced westerly through a distance of over 5 miles and outcrops occur a short distance northwesterly from Firehill siding on the Canadian Pacific railway.

Mining Claims TB 3745 and TB 4737

A composite vein crosses mining claims TB 3745 and TB 4737 about one-half mile northerly from Ozone siding on the Canadian Pacific railway. The siding is about one-half mile inland from the head of Mazokama bay. The claims are owned by Mr. James Lawrence of Port Arthur, and associates.

A number of strippings expose the composite vein at intervals through a distance of about 2,000 feet. A shaft, 55 feet deep, was sunk a number of years ago on the most westerly exposure near the western boundary of claim 3745. In 1927, this shaft was filled with water. No recent work has been done on this property.

The composite vein cements a shatter zone 30 feet or more in width in a pegmatitic granite-gneiss. It strikes from 3 degrees to 15 degrees north of west and dips about 70 degrees north. Near the eastern boundary of claim 4737 the composite vein is naturally exposed for a vertical distance of 12 feet in the banks of a stream. This stream flows through a gorge 10 feet wide and 30 feet deep, along a fault which strikes 8 degrees west of north. The vein system as seen on the bank of the creek consists of a cemented brecciated zone 6 to 14 inches in width and a network of ramifying quartz and barite stringers on either side for a distance of 5 feet. Two barite veins 4 inches and 6 inches wide, respectively, occur in the brecciated zone. In the vicinity of the shaft there is a barite vein, varying between 2 and 12 inches in width, and a quartz-barite vein 3 inches wide; these are about 12 feet apart and the rock between is traversed irregularly by several quartz veinlets up to one-half inch in width. On mining claim TB 3727 at a point about one-half mile westerly from the shaft, the probable westerly extension of the composite vein is represented by a barite vein, averaging 2 inches in width, and a number of quartz veinlets. The eastern extension of the composite vein is exposed on a low granite cliff about 1 mile from the above-mentioned creek. In this exposure vein material constitutes approximately 10 to 20 per cent by volume across a width of 30 feet and consists chiefly of interfering barite plates which in places make up about 70 per cent by volume of the vein filling; white crystalline and sugary quartz and amethyst make up the remainder of the gangue. Galena and zinc blende are present and locally make up about 10 per cent by volume of the vein material; galena is the predominant metallic mineral. Chalcopyrite and pyrite are sparsely disseminated throughout. Vein material said to have been taken from the bottom of the shaft is well mineralized with dark-coloured zinc blende, in some specimens constituting about half the volume and averaging approximately 5 per cent of the volume of the vein filling. Mr. Lawrence states that the vein is well mineralized across a width of 9 feet at the bottom of the shaft and yielded 3 ounces silver and $1 in gold a ton on assay.

Mining Location TB 4533

A vein outcrops on the north bank of a creek in the southeast corner of mining claim TB 4533, about 3 miles northeasterly from Ozone siding. This property was taken up about 1882 by W. H. Laird, formerly of Fort William, and was patented as B 84. The property was owned in 1927 by Mr. James Lawrence of Port Arthur, who had staked a group of adjoining claims. No old workings were seen, but a half dozen exploratory strippings have been recently made and two shallow test pits sunk near the above-mentioned creek.

The vein occupies a fault in pink tuff of the Sibley series. It strikes north 87 degrees east and dips 70 degrees to 80 degrees south. In the outcrop on the bank of the creek it is exposed through a height of 15 feet and for a length of 50 feet toward the east. The vein has a width of 6 feet, of which 2½ feet is solid vein material and the remainder cementing a zone of brecciated country rock. The vein material is predominantly coarse, white calcite. Barite, white crystalline quartz, and pale amethyst also occur. Purple fluorite has also been observed in this vein, according to Mr. Lawrence. Black sphalerite makes up about 3 per cent by volume of the vein material and is locally concentrated in masses up to 10 inches in diameter. Galena is sparsely disseminated through the calcite.

About one-quarter mile southwesterly from the above-described outcrop, a composite vein outcrops at the base of a diabase-capped hill. It strikes north 75 degrees west and dips steeply north. It may be traced for a distance of 350 feet westerly. The vein is on property owned by James Lawrence who had dug two trenches on it 30 feet apart at the base of the hill. At the workings the composite vein cements a shatter zone in grey and pink tuff of the Sibley series. At the most westerly exposure the composite vein has a width of 30 feet and traverses a greyish sandstone vertically exposed for 15 feet. The fracture zone is also visible at this point in the underlying pegmatitic granite. The vein material consists of crystalline white quartz, barite, amethyst, and calcite, sparsely mineralized with galena and zinc blende. The vein material constitutes about 5 per cent by volume of the cemented shatter zone; the largest single vein has a width of about 4 inches.

Other Veins Near Ozone Siding

About 2¼ miles north-northeast from Ozone siding, two composite veins about 330 feet apart are exposed in the face of a 50-foot cliff of granite-gneiss. The southern of the two composite veins consists of a number of quartz veinlets in a zone 2 feet wide, and which, collectively, would make up a width of 3 inches of vein material; it strikes about north 80 degrees west and dips vertically. The northern composite vein strikes along the same direction and dips 68 degrees north. It cements a zone 10 feet or more in width and consists in part of a solid barite vein varying in width from 10 inches to 24 inches; quartz veinlets and cemented breccia make up the remainder of the vein system. The vein material is predominantly barite in interfering plates and white, crystalline quartz through which pyrite is sparsely disseminated. No galena or zinc blende was observed in the northern vein. Galena occurs in small amount in the southern vein.

A number of other veins, said to be mineralized with galena and zinc blende, have been reported as occurring near Ozone siding.

ST. IGNACE ISLAND

Veins occur on the shores of St. Ignace bay, St. Ignace island, on Harrison's and St. Ignace locations. An account of them was given by Charles Robb in his report to the Quebec and Lake Superior Mining Association, 1881. The veins are said to vary in width from a few inches to 5 feet in width. The majority of them strike east and west, and are filled with calcite, laumontite, and drusy crystalline quartz. Occurrences of native silver and copper minerals were found in three veins on Harrison's location, and in veins that lie along the north and south walls respectively of a diabase dyke north of Mines cove on St. Ignace location. Mr. Robb reported that he found a few specks of gold in quartz in one of the veins on St. Ignace location. Mr. H. B. Stuart, Toronto, owner of St. Ignace location, stated in 1927 that no development work had been done on these veins since 1882; prior to that date shallow test pits had been sunk. Mr. Robb's opinion was that further development work would be warranted.

NIPIGON STRAIT

In Forrest Shepherd's report to the Montreal Mining Company, 1846, it is stated that veins more than one foot wide occur on both the east and west sides of the northern part of Nipigon strait. Native silver and chalcocite were found in a gangue of calcite. The clear variety of calcite, Iceland spar, was noted in one of the veins. For a distance of between 1 and 2 miles south from pointe à la Gourgane on the west shore, copper-bearing amygdaloidal lava occurs and some of the copper is argentiferous. No deposit of commercial value had been found in this locality by 1927.

FLUOR ISLAND

Forrest Shepherd reported to the Montreal Mining Company in 1846 that large veins containing fluorite and chalcocite occur in the deep gorges that dissect the high diabase hills on Fluor island. He says, " It is believed further judicious exploration will be rewarded with further and more valuable discoveries." So far as known no deposit of economic value had been found on Fluor island up to 1927.

EDWARD ISLAND (*See* Map 203A)[1]

Two nearly parallel veins were explored by shafts prior to 1884, at the south end of Edward island (77). One shaft about 35 feet deep is on the beach, it was dewatered and extended a few feet by D. C. Peacock of Duluth in 1921; the second shaft is inland about 100 feet to the northeast and is deeper than the other. A few hundred pounds of ore rich in native arsenic obtained from shaft No. 1 were disposed of to mineral collectors.

In the vicinity of the mine, basic lavas, locally 30 feet thick, overlie calcareous, quartz sandstone and red fragmental rock of the Osler series dipping at a low angle toward the east. These rocks have been faulted and intruded by a system of diabase dykes trending northeasterly. One of these dykes exposed near the workings is highly feldspathic and along its walls the brecciated sandstone and lava have been metamorphosed and in part assimilated, giving rise to a peculiar grey and red rock. Parts of this peculiar rock consist of granophyre of various textures. Nodules of intimately associated graphite and calcite occur in the grey granophyre and the altered, calcareous, quartz sandstone. West of the mine the granophyre trends south 55 degrees west and can be traced under water several yards offshore. East of the mine granophyre can be traced north 80 degrees east; it continues across an unnamed island onto Porphyry island.

A major fault, possibly striking north 35 degrees east, affects all the above-mentioned rocks and two of the minor faults within it are cemented by the veins that have been developed at the mine. The vein at shaft No. 1 is in grey granophyre; it strikes north and varies in width up to 1 foot with numerous branches and parallel veinlets ramifying through a width of 2 feet on either side. It is of the banded type with fine-grained calcite, zinc blende, and native arsenic in reniform masses along the walls, and in the middle part calcite, chalcopyrite, galena, and, locally, argentite and native silver. It is reported by Capt. Cross that ore from this vein assayed 80 ounces of silver to the ton. Work ceased on this deposit where the vein narrowed to a few inches; during storms the waves of lake Superior dash over the collar of this shaft. In shaft No. 2 the vein is of the composite type, is several feet wide, and consists of calcite sparsely mineralized locally with galena, zinc blende, and chalcopyrite. It strikes approximately north 10 degrees east. No mineral deposit of value was found in it.

Further prospecting work is, perhaps, warranted in this locality in an endeavour to find other bodies of arsenic-silver ore. Surface trenching east and west from shaft No. 2 would cross the fault zone presumably lying

[1] Geol. Surv., Canada, Map 203A. Thunder Cape sheet, Thunder Bay district, Ont.

below the drift. Possibly mineralized veins cross the granophyre rock east of the mine. Veinlets of pink calcite and barite mineralized with chalcopyrite were seen on Porphyry island to cut the granophyre on the east shore and inland from this point 450 feet.

PORPHYRY ISLAND

On the east shore of Porphyry island (*See* Map 203A) near its northern extremity, a composite vein (78) lies in a fracture zone in basic lava. It strikes north 68 degrees east parallel to a diabase dyke which lies adjacent on the north. The vein can be seen under water for 100 yards offshore, and for a few feet onshore. It is made up of small veins averaging 3 inches in width; the total width of vein material in the 20-foot fracture zone was estimated at 3 feet. The vein material consists chiefly of calcite (in part colourless Iceland spar) with a small amount of pink laumontite and disseminated chalcocite and chalcopyrite. One of the veinlets is richly mineralized with copper minerals.

ISLANDS AND MAINLAND FROM PIE ISLAND SOUTHWESTWARD

(79) *Pie Island*

Pie island consists of Animikie sediments traversed in a northeasterly direction by dykes of diabase and capped in part by a diabase sill.

Between 1875 and 1877, one of a series of veins on the western shore of the island was developed to a depth of 200 feet and through a length of 170 feet, by two shafts, a winze, three levels, and three crosscuts, as shown in a figure in Ingall's report.[1]

"The underground developments have been made in the vein where it cuts a trap dyke, which intersects the argillites of the vicinity, or immediately adjacent to it. The width of the vein is from 3 to 4 feet and it is filled with a breccia of fragments of the country rock cemented together by crystallized quartz which is mostly colourless but sometimes amethystine, and is accompanied by a little calcite, which occurs mostly crystallized in scalenohedra in the vugs. The great feature of this vein, as shown by an inspection of the dumps, consists in the large amount of metallic minerals it carries. These are zinc blende, galena, and iron pyrites, mentioned here in the order of their preponderance, and all occurring for the most part well crystallized, especially in the case of the galena, of which small but very perfect crystals of a combination of ∞ P ∞ with O may be found. This latter also occurs sometimes as thin seams in the joints of the argillite, which, on account of their dark, lustreless appearance, might possible be mistaken for argentite by the inexperienced, especially where the films are thin. An assay of such a piece showed it to carry neither gold nor silver (*See* Report of Prog. 1885, pt. R, Assay 28). That these metallic minerals, although they are occasionally found to do so, as a rule carry either none of the precious metals or a very small proportion, is shown by the other assays given in the same place. Assay 25 of a specimen selected as carrying a good proportion of galena, free from other metallic minerals, gave: gold, none; silver, 0·175 of an ounce to the ton. The other numbers: 26 carrying a good proportion of zinc blende mixed with a little galena and 27 consisting nearly altogether of pyrites, gave neither gold nor silver.

Some development work has also been done on a large vein on 13 B mining location, about a mile east-southeast from the last mentioned. It strikes in from the

[1] Ingall, E. D.: Geol. and Nat. Hist. Surv. of Canada, 1887, pt. H.

shore with a course north 75 degrees west magnetic and dips to the north. It is about 12 feet thick, is enclosed in the argillites of the district, and intersects two trap dykes which cut through them. A shaft has been sunk on it, the depth of which was not ascertainable, however, as it was full of water. In mineral contents it is very similar to the first mentioned, except that the quartz is accompanied by a good proportion of pink spar, probably dolomite.

One assay made of some specimens selected as carrying some galena and a little blende gave neither gold nor silver; whilst another sample, broken from an outcrop about half a mile from the latter point and about on the run of this vein, which carried some galena accompanied by a little pyrites, yielded on assay: gold, none; silver, 0·467 of an ounce per 2,000 pound ton (*See* Report of Prog. 1886, pt. T, Assays 29 and 30). Little or no work has been done on the rest of Pie island."

(80) *Angus Islands*

These islands lie off the east side of Pie island. About 1877 " a vertical shaft is said to have been sunk on one of the islands, and a drift run out from it to intersect the vein which could be seen 'outcropping' under water near the shore. No success seems to have attended this effort."

(81) *McKellar Island*

This island is south of Pie island. A vein on it was discovered in 1869 by the Messrs. McKellar Brothers, and some years afterwards test work was done. A figure by Ingall[1] shows a shaft, 130 feet deep; an adit, 150 feet long; and a crosscut 60 feet long. The vein

" is very large, consisting of coarsely crystalline calcite and barite, occurring in separate ribs for the most part, although they are mixed in parts of the vein. With these preponderating minerals there is a smaller proportion of quartz, generally colourless. The metallic minerals consist of zinc blende with a little galena and pyrite which are for the most part concentrated in dark-coloured bands in the main vein, of which bands there are two on the north side and one on the south side of the island. A sample of one of these streaks assayed—gold, none; silver, about ¼ ounce; whilst another from a different place in the same gave neither gold nor silver, showing that the dark coloration was not due to finely disseminated argentite or argentiferous blende (*See* Geol. Surv., Canada, Rept. of Prog. 1886, pt. T, Assays 33 and 34).

Besides this main vein which is composed of solid spar, and is about 60 feet wide on the south side of the island there are numerous side stringers intersecting the country rock of the west wall of the vein, and on these the developments have been mostly made.

The enclosing rock is a dark green, coarse-grained trap. This composes the whole island which is only some 500 or 600 feet in diameter, and is evidently part of the outcrop of a dyke which appears farther west in Thompson island. A little altered argillite appears on the south side of the island still clinging to the dyke.

According to Mr. P. McKellar, argentiferous blende was the chief silver-bearing ore of the vein. The developments done so far have evidently not opened up any very large body of ore.

During the summer of 1886, the barite rib on the east side of the vein has been worked down from surface, some thirty men being employed at this work, and the product, after hand-picking to extract as much of the calcite and quartz as possible, was being shipped to the United States, the buying firm giving $5 per ton over the rail at the island for the best quality."

[1] Ingall, E. D.: Op. cit., Pl. II, fig. 2.

(82) *Thompson Island*

"This island consists for the most part of trap in the form of dykes running lengthways through it with a small development of the argillites between the two forming the two points at its western extremity. The backbone of the island is constituted by the dyke which forms its eastern extremity, and which is evidently the same as that forming McKellar island, which it resembles in appearance, being a dark green trappean rock of rather coarse texture.

It was located in 1853 by Mr. T. Macfarlane for the Montreal Mining Company. A small amount of exploration was done in 1873 and in the winter of 1873-4, when some development work was done to test a vein crossing the island at its eastern extremity in a northwesterly direction. It consisted, as far as I was able to see, of an adit level run in on the vein, where it shows in the face of the cliff forming the north shore of the island, for a distance of about 25 feet, from the end of which a 9-foot winze has been sunk on the vein, which here consists of an aggregate of stringers and branches of various sizes, covering a width of about 4 feet. The gangue consists mostly of barite with some calcite and white and amethystine quartz. It carries a small amount of the usual metallic minerals, viz., blende, galena, and pyrites. Other veins occur, crossing the island in a northwesterly direction, of a very similar nature to the last, and where seen are all enclosed in trap."

(83) *Spar Island*

"This island is part of the old Prince location, and was one of the first worked properties on the lake, operations having been carried on there in the years 1846 and 1849.

It consists, like the others, of a group of trap dykes with argillites between, which latter rocks attain their largest development at the east end of the island, where they are to be seen forming a cliff about 200 feet in height, and are capped with a thin sheet of columnar trap. They are cut at this place by several dykes running lengthways of the island. Passing along the south shore of the island the same geologic conditions are observable, except that for some distance the argillites are seen to be associated with intrusive sheets of trap. This is visible for some distance along the south shore at one place where in cliffs some 30 to 40 feet high are to be seen three such sheets. That they are intrusive sheets is shown by the fact that they are frequently lenticular and curve up the beds above them out of their plane of bedding, the under side of the trap sheet lying flat on the beds below it. At one place this was found to be the cause of a very sudden change of dip of the argillites from a flat angle to the eastwards to a dip of about 45 degrees westwards. Again, where the covering argillite has been recently denuded away, the remarkably smooth upper surface of the trap sheet further attests to the correctness of this view, these surfaces in no way resembling those polished and grooved by ice, which also occur in this region.

A plan, etc., of the western point of the island where the developments have been made is given in Plate III [of Ingall's report]. Here there are shown two dykes of trap separated by argillaceous beds and accompanied by an intrusive sheet of trap, on which is left a slight thickness of the argillite originally covering it. The main dyke consists of a medium-grained trap whose colour is lightened by the presence of white feldspar occurring radiately crystallized, the interspaces being filled out with a dark green mineral, probably hornblende. The smaller dyke "B" is a dark green crystalline trap carrying a quantity of pyrites much more compact than the other, and weathering with a comparatively smooth reddish brown surface in contrast with the grey aspect of the weathered surfaces of the main dyke, which can be seen to be due to the kaolinization of the feldspar. The trap sheet in general appearance and fracture closely resembles dyke "B", and also carries pyrites.

The argillites are of a dark grey colour and lie nearly flat. They turn upwards as they approach the main dyke and are much altered. When within about 20 feet of it their bedding becomes obliterated and they take on a confused structure like false bedding, whilst on the fracture they resemble a fine-grained red trap. A similar altered argillite is described later as occurring at Jarvis island.

There are several veins visible on the shores of the island running across it in about a northwesterly direction. They show occasionally a little of the usual metallic minerals, zinc blende and galena in a gangue of barite, calcite, and quartz. The vein at the western end of the island shown in Plate III [of Ingall's report] is the only one on which any work has been done. The main vein with which are associated a few sides branches is large and filled with a solid gangue of coarsely crystallized barite and calcite, the metallic minerals being represented by copper glance, copper pyrites, zinc blende, and a little argentite, which occur for the most part disseminated through about 6 inches of gangue along either side of a 6-inch rib of pink barite occurring in the middle of the vein. This fissure has faulted the enclosing rocks about 65 feet horizontally. In the 'Geology of Canada, 1863,' page 708, it is stated that the two shafts (shown on Plate III) are respectively 24 and 47 feet deep, so that the developments made have apparently not been extensive. It is said that besides the copper minerals found here some rich specimens of silver ore were obtained."

(84) *Jarvis Island*

A vein on this island . . . . .

" was discovered in 1868. It runs across the island in a northwesterly direction and dips northeast at 50 degrees to 55 degrees contrasting thus with the nearly vertical dips of the veins of the other islands. In the summer of 1869 Mr. Macfarlane sunk a 12-foot shaft on the vein, in accomplishing which work the following ore was produced:

79 lbs.	first quality ore containing 3·45 per cent of silver=39·70 ozs. at $1.25	$ 49 62
2,483 lbs.	second quality ore containing 0·15 per cent of silver=54·18 ozs. at $1.25	$ 67 72
	Total	$117 34

In 1870 this shaft was sunk 20 feet deeper. In 1871 the Ontario Mineral Lands Company had a small party working on the lode during the months of June and July, when they sold it for $150,000 to an English company, under whose regime quite a considerable amount of work was prosecuted in the way of drifting, sinking winzes, etc. Three shafts were also sunk, of the respective depths of 160, 31, and 78 feet, and some stoping done. Besides this, the necessary surface work, erection of houses, etc., was accomplished, and considerable explorations made on the mainland portion of the property, which latter did not, however, lead to any results. These operations were conducted during the years of 1871-2, and were suspended late in the latter year owing to unforeseen financial troubles. In the spring of 1886 the company which had prosecuted this work again commenced operations, and continued working in 1887. Their operations were chiefly confined to sinking the main shaft and drifting from it.

The distribution of the enclosing rocks is shown in Plate IV [of Ingall's report.] Here, as at Spar island, the vein crosses two trap dykes with argillites in between, which lie nearly flat, but turn down and become much altered on approaching the more northerly dyke, as they do under similar conditions mentioned in speaking of Spar island. Near the southern dyke the argillites are turned upwards, but there is little or no alteration. The most northerly dyke shows two varieties, the one a rather coarse-grained rock, in which the hornblendic mineral, being mixed with white feldspar, gives it a greenish grey appearance; whilst the feldspar of the other, being red, gives a redder colour to the rock. The vein on which this work has been done is somewhat similar to the two last described, the gangue being made up of the same minerals. It is from 10 to 15 feet thick, and the different minerals are arranged in bands more or less parallel with the strike of the vein. I notice the following succession at one point on the outcrop of the vein, in going from west to east across it:

1st. About 4 feet of largely crystallized calcite, with thin seamings of quartz throughout, occurring mostly between the crystals and along their cleavage planes.

2nd. A 2-foot band in which the calcite still preponderates, but with a large admixture of barite and a small percentage of quartz seams as before.

3rd. About 6 feet consisting almost entirely of barite, with only a few inclusions of calcite.

The same banded structure is visible in the main shaft, where there is, however, a good deal of decomposed rock enclosed, and slickensided walls would indicate fissuring and movement subsequent to filling. Although silver ore has been found from time to time in the vein, the bodies have apparently been so far of limited extent.

The other metallic minerals, as elsewhere, occur concentrated in spots in the vein, and occasionally carry a little silver, as evidenced in the assay of a specimen which came from the lower drift whilst I was there. (*See* Rept. of Prog. 1887, pt. T, Assay 34). It contained about 2 per cent of blende and galena, with a little pyrrhotite, and gave: gold, none; silver, 0·35 of an ounce to the ton of 2,000 pounds. An assay of some of the pyrites from this vein showed it to contain neither gold nor silver (*See* Report of Prog. 1886, pt. T, Assay 20). This vein is somewhat analogous to the Silver Islet vein in carrying carbonaceous matter, which shows as a black seam on the hanging-wall."

In 1927, Jarvis island was acquired by Sudbury Basin Mines Company.

(85) and (86) *Victoria Island and McKellar Point*

"Passing westwards along the band of dykes forming the 'Macfarlane Belt,' we come to Victoria island. This is similar to the rest, having several dykes of trap running through its length, with intermediate argillites, which latter, however, here compose a much larger proportion of the island than is the case with those just mentioned. The developments made are situated at its western extremity where a vein of the usual type, of barite and calcite, running in a northwesterly direction, has been tested by surface work and by two test pits to a depth of 30 feet. Some tunnelling was also done on another vein. It is said that about $5,000 were expended on this island.

At this end of the island there is a large development of a red, syenitic rock. Whether this is a product of the alteration of the argillites by the intrusive rocks of the dykes, or what is the precise nature of the causes which originated this rock, must be left in abeyance for closer study, both on the ground and with the aid of the microscope.

On the further extension westward of this belt, at the extremity of McKellar point, very similar conditions are found. Here also there is a large development of the red syenitic rock in connexion with trap dykes of the usual basic nature and dark appearance. The syenitic rock varies in different places from a highly crystallized, rather coarse-grained red rock, showing distinctly to the eye the red feldspar associated with the green, apparently hornblendic, mineral, whereas in other places, whilst presenting the same general colour and appearance as the typical syenite, it is much finer grained, and has more the appearance of a clastic rock which has been somewhat metamorphosed. Here also nothing can be definitely said of the origin of these rocks without further work being done. This syenitic rock has a distinctly bedded appearance at this point, showing a dip to the east at about 15 degrees. Another curious feature here presented, and which is noticeable also in the rock at the west end of Victoria island, consists in the occurrence of inclusions, which have the appearance of bent and twisted pieces of argillite which have been metamorphosed.

These rocks only occur at the extremity of the point, the rest of which consists of a regular tangle of dykes of trap of the ordinary nature, with argillites included between them, the whole forming a prominent rocky ridge running back towards the mainland. Numerous veins of the usual nature cross the point in a more or less northwesterly direction. They carry a little of the ordinary metallic minerals of the district in a gangue of barite and calcite, with some colourless and amethystine quartz. A little work has been done on some of them, notably on one on the north side of the point, on which an 80-foot tunnel has been run in and a shaft about 30 feet deep sunk."

(87) *Stewart's Location (Near Pigeon River)*

"This is one of the tracts of land originally taken up by the Montreal Mining Company in 1846, and in 1887 it was owned by the Ontario Mineral Lands Company. In 1868 a small party of men explored there for about a month without result. Later on the Silver Islet Company had a party working for about a year on several north and south veins carrying copper glance."

(88) *Pine Bay*

" A little has been done here on a north-northwest vein carrying argentiferous galena, but the proportion of silver was not large."

(89) *Big Trout Bay*

" Near the inner end of this bay some test work has been done on a vein running in a northwesterly direction and dipping to the northeast at an angle of 70 degrees to 75 degrees. It is about 12 inches thick, and has definite walls where seen in the workings. It cuts a hill about 300 feet high of argillites, capped, as usual, with trap, and intersected by dykes of the same rock. The work done is near the top of the hill, and shows a vein which, in the usual gangue of coarsely crystallized calcite and barite with a little amethystine quartz, carries iron pyrites and shows indications of copper in the shape of occasional malachite stains. Around the workings the country rock is entirely trap, which carries a large percentage of pyrites adjacent to the vein. A piece of this was selected for assay to see whether the pyrites carried the precious metals, which proved not to be the case (*See* Geol. Surv., Canada, Ann. Rept. 1886, Part I, Assay 17).

The work done consists of some stripping on the back of the vein, and two tunnels, each about 50 feet in length, one 30 feet below the other, run on the course of the vein. It was done in the years 1882-83, and some $1,500 were spent on these developments."

(90) *Cloud Lake*

" Here argentite and native silver are said to occur in a vein with blende and galena in quartz. An adit 200 to 300 feet long was driven into the side of the hill to crosscut the vein, but did not succeed in finding it, as it had apparently split up. The surface explorations traced the vein for about a quarter of a mile, in which a good show of silver is said to have been seen. The expenditure on this work probably amounted to about $25,000. This vein was supposed to be the continuation of the last-mentioned one, but as the distance between the two points is about 5 miles, this is rather a gratuitous assumption."

(91) *Lot 5, Concession II, Crooks Township*

The following information is from Mr. F. S. Wiley, Port Arthur.

A vein was discovered in 1895, near Cloud lake, in the northwest quarter of lot 5, Crooks tp., and traced southeast through a distance of about 1,500 feet, into the northeast quarter of the same lot. The vein was stripped and tested on the side of a cliff 20 feet high, close to the lake. In 1907 a shaft was sunk to a depth of 45 feet near the western boundary of the northeast quarter of lot 5. The property was in litigation for several years.

The vein cements a fracture zone about 4 or 5 feet wide striking northwest and passing vertically through a diabase sill 5 feet thick and flat-lying Animikie shales below. The vein consists of quartz and calcite mineralized with argentite. It was estimated that the material removed from the shaft had a silver content averaging 20 ounces to the ton. The outcrop on the cliff near the lake carried more spectacular values.

(92) *Caldwell Island*

Ingall says,

" This island is composed almost entirely of trap, intersected by numerous dykes of the same. A shaft was here sunk to the depth of 60 feet on a vein, without much result."

(93) *Mink Island*

"A wide vein, carrying indications of copper in a gangue of calcite and barite, crosses the dyke forming this island. In 1872-3 a slight amount of work was done here, and some development work was accomplished on the mainland opposite which showed a promising looking vein. The expenditure amounted to about $1,000."

(94) *Sturgeon Bay (K 13)*

"Some capitalists of London, Ontario, did some work here. Two large veins occurring in the argillites near a dyke were seen intersecting under water near the shore. A shaft was sunk close to the water's edge, on the north shore of the mouth of the bay, and a drift run out to cut the veins at their junction. A shaft was also sunk some 300 feet farther inland."

(95) *K 17 Location*

"Some test work has been done on a brecciated vein consisting of the argillite country rock cemented together by quartz. It runs north 60 degrees to 70 degrees east (magnetic) and dips to the south 80 degrees. It is said a strong force of men worked here for nearly a year about 1878 or 1879, and that the expenditure at this time amounted to some $5,000."

(96) *Prince's Mine*

"This is the oldest mine on the Canadian shores of the lake, having been worked in 1846 or 1847, when it appears to have been regarded more in the light of a copper than of a silver-bearing vein. It strikes north 30 degrees to 40 degrees west (magnetic), and where it shows on the shore is split into two branches, with argillite between and trap forming the outer walls—that on the eastern side appearing to be a dyke cut transversely by the vein. Regarding the trap on the western wall, it is not very apparent whether it is a large dyke also traversed by the vein, but it shows as a 40-foot cliff rising out of the water, running south from the vein exposure mentioned for a distance of 1,000 feet, whilst inland it shows a similar wall running about parallel to the vein and dipping about 80 degrees to the southwest, up against which almost horizontal argillites are seen to abut. About 60 yards in from the shore, at a point where the two before-mentioned branches would seem to come together, a 65-foot crosscut tunnel has been run through the argillites in a westerly direction towards this cliff, the inner end of which tunnel intersects numerous branches for a distance of about 25 feet. The vein next shows about 250 yards farther inland where it outcrops on a hill, at which place two shafts have been sunk on it and a tunnel has been driven in on it towards the shafts about 50 feet lower than the mouth of the higher shaft. The vein down to this level occurs in trap, but whether this is the bed (sill) which caps the argillites in the neighbourhood, or whether it is the extension of one of the dykes that are seen on the coast farther north, running in this direction, it would be impossible to ascertain without making a much closer examination than I found it possible to do with the time at my disposal. The drift being blocked up with debris, it was impossible to enter; but it is said that a winze was sunk some 50 to 60 feet below this, and whether the vein was thus followed down into the argillites, or what was the effect of this change of the "country" rock, it would be interesting to know, but it is now impossible to find out after this lapse of time. According to the "Geology of Canada, 1863," this tunnel was driven for a distance of 163 feet, and one of the shafts was 90 feet deep, in sinking which a bunch of ore was obtained weighing several hundredweight and containing 3 per cent of silver, which in two assays yielded respectively one part of gold in 7,000 of silver, and eight parts to 1,000 of silver. This bunch contained native silver disseminated in thin laminæ through the calcareous spar and blende...... Crystallized sulphuret of silver was also found in this vein, and the calcareous spar was stained with blue and green carbonates of copper and with red arsenate of cobalt.

Between these workings and the shore exposure the vein must intersect several trap dykes which are to be seen along the coast to the north, striking in such a direction as to there run athwart it.

The two branches on the shore are respectively 5 and 6 feet thick, whilst at the inland workings, where it exists as one vein, it is much thicker. It here shows a central rib of coarsely crystallized calcite with some barite, with a large proportion of largely crystallized, mostly amethystine, quartz on either side. Judging from the loose ore on the dump, blende seems to have been the most plentiful metallic mineral in the vein at this place.

On the shore exposure the vein presents very similar characteristics, except that the metallic minerals do not seem to have been so plentiful and that some of the branches consist almost entirely of quartz, whilst in others calcite and barite mixed constitute the greater part of the vein stone.

Assays made of specimens selected on account of the metallic minerals present in them, proved these to carry neither gold nor silver (*See* Geol. Surv., Canada, Report of Prog. 1886, pt. T, Assays 21 and 22)."

(97) *Loch Lomond*

An occurrence of argentite was discovered by the writer in 1923 on a point on the east shore of loch Lomond (*See* Map 198A), 3,300 feet southwest of Outlet bay. The top of a diabase sill is here exposed in nearly horizontal attitude 4 feet above lake-level. The exposed surface measures approximately 100 square yards and is divided into irregular polygonal blocks by a contraction-crack structure, which resembles mud-crack structure. The polygons are from 3 to 6 inches in diameter; the contraction cracks are $\frac{1}{4}$ inch to $\frac{1}{2}$ inch in width and are cemented by white crystalline quartz, crustified on the walls, producing a comb structure. Along the median part of one such veinlet, $\frac{1}{2}$ inch in width, argenite was found through a distance of 3 inches.

(98) *Loch Lomond Tunnel*

Water from loch Lomond is conducted into the water main which supplies the city of Fort William, through a tunnel under the high hill at the northeast end of the lake (*See* Map 198A). The tunnel is seven-eighths of a mile long and trends north 52 degrees east. Through the courtesy of Mr. Cyril Symes, city engineer, the writer was given an opportunity to inspect the tunnel in 1923. Several veins and a few faults are clearly exposed, the positions of the larger features of this character, however, have been coated with concrete to seal the tunnel. There is a north-trending fault with relative downthrow on the east, at a point between 1,040 feet and 1,060 feet from the northeast end of the tunnel. The fault which is probably occupied by a vein is concealed by concrete. The rock to the east of the fault is diabase and that to the west is grey shale. At 3,000 feet southwest of the northeast end of the tunnel, a 2-inch veinlet of quartz and calcite contains a small amount of native gold in wire form.

COPPER

In Fort William and Port Arthur, and Thunder Cape map-areas, copper-bearing minerals occur in veins of the silver-bearing type and in drusy granophyre on Tee point and Pyritic island. Known occurrences of this type have been described in the preceding section of this report.

Copper-bearing minerals occur in amygdules in basic lava on Porphyry island, Edward island, and the peninsula east of Black bay. Prospecting operations on the copper-bearing amygdaloidal lavas have been confined, so far as known, to examinations of outcrop. It is reported that many small occurrences have been found at various localities. The writer has observed native copper in amygdaloidal lava on the shore north of George point; in Miles bay; near the north end of Edward island; and at several places along the west shore of Porphyry island. It is not known whether the several observed occurrences are in a single or many lava flows; the vertical limits of the copper mineralization in the vicinity of the occurrences have not been determined. No body of copper ore is known.

The native copper occurs as tiny nuggets up to one-tenth inch in diameter along with zeolites, chlorite, agate, and calcite as amygdule-filling. At each locality where copper was observed, the little nuggets are separated from one another by distances varying from a few inches to several inches and on the whole are sparsely distributed. The copper-bearing amygdules occur in dark greenish grey, or minutely mottled greenish grey and red, lava, which is not highly vesicular. No copper has been observed in the red, highly vesicular upper parts of lava flows.

To the northeast, beyond the limits of the map-areas, amygdaloidal basic lavas occur in a crescent-shaped area 70 miles long and with a maximum width of about 12 miles. This area includes a large peninsula southeast of Black bay, St. Ignace island, and many other islands as far east as and including Turtle island. Many occurrences of native copper have been reported from this area; but no copper ore has been produced and no record is available regarding the size and grade of any mineralized mass.

It is recorded[1] that, in 1900, the Pritchard Harbour Copper Mining and Development Company, Limited, had constructed two tunnels 20 and 22 feet long, respectively, and a shaft 31 feet deep at Pritchard harbour (recently called Louise bay), on the south shore of Black bay. Specimens of amygdaloidal lava containing " a considerable percentage of native copper " are said to have come from this mine. Operations at this mine were discontinued some time prior to 1910, according to residents of the district.

Copper-bearing amygdaloidal lava, possibly of Animikie age, has been observed west of Thunder bay at the following localities: lot 4, concession II, Crooks township; lot 8, concession VI, Blake township; and lot 12, con-

[1]Bow, James A.: "Mines of Northwestern Ontario"; Rept. Ont. Bureau of Mines, vol. IX, p. 86 (1900).

cession III, Oliver township. Available information[1] regarding these occurrences indicates that further development would be necessary in order to determine whether the deposits are of commercial value.

Copper ore-bodies have been mined for many years on Isle Royale and Keweenaw point, Michigan, in amygdaloidal lavas which closely resemble the copper-bearing lavas on the north shore of lake Superior. It is possible that future exploration will reveal ore-bodies in the latter district.

IRON

Iron ore has not been found in Fort William and Port Arthur, and Thunder Cape map-areas, though it may be present in the Gunflint formation, the equivalent of the Biwabik formation of Mesabi district, Minnesota. In Mesabi district, bodies of iron ore have developed in the Biwabik formation where it forms the bedrock surface and, so far as known, do not occur where it is overlain by the Virginia Slate formation, which is the equivalent of the Rove formation. Presumably, therefore, the possibilities of iron ore occurring in the map-areas are greater in the Animikie area north of Kaministikwia river, in Fort William and Port Arthur map-area, than elsewhere, for throughout the greater part of the area north of the river the Gunflint formation probably occurs at the solid rock surface, whereas to the southwest it is confined to a comparatively narrow strip along the edge of overlying strata. Outcrops of the Gunflint formation in the area north of Kaministikwia river are, on the whole, small and not numerous; descriptions of them are given in a foregoing section of this report. Excavations have been made in the formation at several silver mines and prospects, and examinations of the dumps have failed to reveal iron ore at these localities.

An exploration for iron ore by diamond drilling was made, in 1924, by Andrew Johnson of Duluth, and associates, in lot D, McIntyre township, along a creek crossing Oliver road north of Alba station. Eight vertical holes were bored at irregular intervals over a total distance of 2,800 feet along a nearly straight north-south line. The most northerly hole was 800 feet north of Oliver road. The holes ranged in depth between 55 and 160 feet and a total of 572 feet was bored. Mr. Johnson reported that no iron ore was found.

Westerly beyond Fort William and Port Arthur map-area for a distance of 60 miles to the vicinity of Gunflint lake, the Gunflint formation presumably occurs at the solid rock surface along the northern margin of Animikie area in a zone ranging in width between about 1 and 10 miles. This zone is, for the most part, drift covered. Small areas, in which outcrops are relatively numerous and large, occur near North lake, Bishop lake,

[1] Lawson, A. C.: Am. Geol., vol. V, Jan.-June, 1890, pp. 174-178.
Coleman, A. P.: Rept. Ont. Bureau of Mines, vol. IX, pp. 145-148.
Tanton, T. L.: Geol. Surv., Canada, Sum. Rept. 1924, pt. C, p. 27.

Little Gull lake, and Silver mountain. A description of the outcrops in these areas and a discussion regarding possible iron ore deposits in and near these areas, by Gill,[1] has been published.

"No single bed or group of beds has been found which is sufficiently rich in iron to be utilized as an ore without preliminary concentration. The beds of several horizons are locally rich enough in magnetite to produce a concentrate containing 60 per cent Fe with reasonably fine grinding and a concentration ratio of 2 or 3 to 1."

Some horizons relatively rich in magnetite appear to maintain this characteristic over extensive areas. It is possible that magnetite ores may occur in these horizons. In Mr. Gill's opinion, hematite-limonite ore-bodies may be present in the vicinity of Little Gull lake and farther east in the general vicinity of Silver mountain. Areas underlain by the Gunflint formation and devoid of diabase sills are regarded as favourable for the possible occurrence of hematite-limonite ore.

Near the southeast corner of lot 9, concession II, O'Connor township (*See* Map 213A), on property owned by Mr. A. L. Parker of Hymers, there is an outcrop of iron formation. A group of beds about 40 feet thick consists of beds, ranging from an inch to a few inches in thickness, and alternately highly siliceous and rich in hematite. In 1926, three diamond-drill holes were sunk on the south half of lot 8 to explore the drift-covered iron formation adjacent on the east to the above-mentioned outcrop. Mr. F. H. Keefer reported that no iron ore was found in the iron formation penetrated by these bore-holes.

Concentrations of hematite occur in the Gunflint formation near Loon lake. The positions of the largest known concentrations are shown on Map 214A. Descriptions of the deposits and records of the results of exploratory work in publications[2] indicate that the known concentrations are not sufficiently large to be of commercial value.

On mining location No. 5, Macgregor township (*See* Map 214A), Beulah mine was operated in 1909 by the Dominion Bessemer Ore Company. It is reported[3] that an ore-loading dock on Thunder bay was built and a tramway constructed from the dock to the ore-body about one mile inland. "Two cargoes of ore were shipped but operations ceased at the end of 1909." By 1927, the dock had been destroyed and the tramway was no longer serviceable.

At Beulah mine there is an exposure of iron formation dipping about 10 degrees south-southeast. The iron formation consists of layers, ranging in thickness from 2 inches to 6 inches, and rich in greenalite granules, with

[1] Gill, J. E.: Geol. Surv., Canada, Sum. Rept. 1924, pt. C, pp. 28-88.

[2] Smith, W. N.: "Loon Lake Iron-bearing District"; Ont. Bureau of Mines, vol. XIV, pt. 1, pp. 254-260 (1905).

Silver, L. P.: "The Animikie Iron Range"; Ont. Bureau of Mines, vol. XV, pt. 1, pp. 156-172 (1906).

Hille, F.: "Report on the Examination of Some Iron Ore Deposits in the Districts of Thunder Bay and Rainy River, Province of Ontario"; Mines Branch, Dept. of Mines, Canada, Pub. No. 22 (1908).

Lindeman, E., and Bolton, L. L.: "Iron Ore Occurrences in Canada"; Mines Branch, Dept. of Mines, Canada, Pub. No. 217, vol. II (1917).

[3] Corkill, E. T.: Ont. Bureau of Mines, vol. XIX, pt. 1, p. 81 (1910).

Lindeman, E., and Bolton, L. L.: "Iron Ore Occurrences in Canada"; Mines Branch, Dept. of Mines, Canada, Pub. No. 217, vol. 2, p. 63.

siderite, as cement around the granules, alternating with layers ranging in thickness from 2 inches to 10 inches and consisting of granules of greenalite, hematite, and siderite in a cement of chert, which makes up the greater part of these layers. Layers corresponding to the greenalite siderite layers occurring at the surface and at various depths to between 2 and 5 feet consist largely of a limonitic, alteration product. Corkill[1] reports that in mining, the ore was separated into two grades, one grade running over 55 per cent iron, the other below. Both grades carry a rather high percentage of manganese and no appreciable sulphur and phosphorus. Presumably the higher grade of iron ore was obtained by sorting the thin, highly ferruginous layers from the intercalated, thin, highly siliceous layers. No body of natural iron ore has been revealed.

MOLYBDENITE

Molybdenite has been found in four pegmatite quartz veins distributed over a distance of a mile along the contact of the tongue of granitic rock which, in lots A and B, concessions II and III, Conmee township (*See* Map 213A), extends north from the batholith.

The largest of these veins is on the north side of the road in the southern part of lot B, concession III, on property owned by Messrs. S. Young and Wm. Welsh of Fort William. The vein consists of fine-grained, translucent, white quartz in which occurs amorphous molybdenite, in thin streaks and platy segregations, lying parallel to the walls and irregularly spaced through the vein. Small amounts of disseminated chalcopyrite and pyrite are present. The country rock is a pyritiferous, chlorite syenite. The major part of this siliceous deposit is a vein 20 feet wide, with few inclusions, and strikes approximately north 50 degrees east and dips 80 degrees southeast. A part of the vein material occurs as small lenses whose contacts with the adjacent silicified rock are not sharply defined; there is also a zone about 10 feet wide in which there is an intimate intermixture of vein material and abundant, indefinitely bounded horses of country rock. The complete width of the deposit, including the small, lenticular veins adjacent to the main vein, has not been determined, and on account of drift covering its length has not been proved beyond 30 feet. A shaft measuring 4 by 8 feet has been sunk to a depth of 47 feet, entirely in vein material. A vein a few inches wide cuts the molybdenite-bearing vein; it consists of coarsely crystalline white quartz, amethyst, and calcite with small amounts of disseminated galena and chalcopyrite.

A sample weighing 270 pounds, said to represent the run-of-mine from this deposit was tested at the Mines Branch, Ottawa, in 1918.[2] The material contained 1·29 per cent of molybdenite and by crushing to 80-mesh it was found possible to recover 80 per cent of the molybdenite values by flotation.

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1 Corkill, E. T.: Op. cit., p. 81.
2 Mines Branch, Dept. of Mines, Canada, Sum. Rept. 1918, p. 111.

On a trail along the east side of Anderson lake, in lot 5, concession VIII, McTavish township, molybdenite occurs in flakes averaging about one-quarter inch in diameter as an accessory constituent of pegmatite made up chiefly of coarsely crystalline quartz and red feldspar. The molybdenite is irregularly distributed in the pegmatite; no concentration of probable commercial value is known to occur at this locality.

BUILDING STONE

Sandstone suitable for building material occurs in the Sibley series in Thunder Cape map-area. A pale grey, impure, quartz sandstone has been produced from a quarry about a mile northerly from George point on the east shore of Black bay. There has been no production in recent years.

It is reported that the greater part of the eastern shore of Thunder bay was taken up, many years ago, as quarry locations. White quartz sandstone is there prominently exposed in cliffs about 200 feet high. A small amount of this material was produced from a quarry on the shore east of Keshkabuon (Caribou) island, at a place about 2 miles north of the limit of Thunder Cape map-area, on mining location V 18, Sibley.

The principal production of sandstone from the Sibley series has come from quarries north and northeast of Thunder Cape map-area at the following localities: Simpson island and isle Verte in Nipigon bay; and lot 2, concession VI, Stirling township. The last-mentioned quarry has been worked in recent years; it is owned by Messrs. W. A. Dowler and M. Watty, Hurkett, Ontario; from it is produced an impure quartz sandstone, almost white and with a delicate pinkish tint.

Limestone of the Sibley series suitable for ornamental building stone, has been found near the mouth of Nipigon river. The limestone there is thinly interlaminated with red, purple, and green shaly material. In a zone, about 20 feet wide, adjacent to a wide diabase dyke, the rock has been slightly recrystallized and indurated. Prior to 1919, an ornamental building stone, known as Nipigon marble, was produced from a quarry on the east shore.

Blocks of diabase, commonly known as trap rock, occur in the talus at the foot of cliffs on diabase-capped mesas. The material has been used in the construction of breakwaters and is suitable for any purpose that requires a massive rock resistant to erosion. The natural jointing in the rock results in the formation of roughly cubical or equidimensional polygonal blocks, usually a yard or more in diameter. Localities in Thunder bay where material of this character may be loaded directly from the talus on to scows are on the shore of Thunder bay west of Flatland island and along the north shores of Keshkabuon and Lambert islands. Of these localities the last affords the best shelter for boats, and the diabase sill that caps the island could be readily quarried.

A gravel composed of irregular-shaped pebbles of red quartz porphyry, ranging from 1 to 4 inches in diameter, occurs extensively off the east shore of Bowman island, which is about 30 miles northeast of Thunder Cape map-area. Considerable quantities of this gravel have been dredged and used in concrete structures around the harbours of Fort William and Port Arthur.

ROAD METAL

The region in the vicinity of Fort William and Port Arthur and along the north shore of lake Superior is well supplied with gravel, which occurs in beach and fluvioglacial deposits. Crushed diabase is produced for road metal at the Fort William plant at the base of mount McKay and at Stewart and Hewitson quarries, Port Arthur. At the latter plant the indurated shale lying within 10 feet below the base of an intrusive diabase sill has been used, after crushing and screening, for a surface material on roads. In 1926 the Quinn Stone and Ore Company commenced the production of crushed stone obtained from an elevated beach, consisting of water-worn talus near the base of mount McKay. The rocks in the deposit are diabase and Animikie greywacke and shale. After crushing, the slime is removed by washing.

BRICK-CLAY AND SHALE

There is an abundance of stoneless clay along the lower reaches of Kaministikwia river suitable for the manufacture of brick and tile, in fact there is no other point in Ontario, except Toronto, so well supplied with a convenient brick material. Details regarding the brick-clays in this locality, in Port Arthur and in Dorion township, are given in a report by Keele.[1]

Animikie shale suitable for brickmaking has been used from the Alsip quarry near Sawyer bay[2]. For a time a brickmaking plant was operated at the base of mount McKay, using for its materials Animikie shales and greywackes in the talus near by. Operations at both of these localities were suspended in 1919.

NATURAL GAS AND MINERAL FUELS

Inflammable gas was encountered at depth in Silver Islet mine and Silver Mountain mine. There is no record regarding the composition of the gas and it is possible that it may have been hydrogen sulphide or a hydrocarbon. It is reported that hydrocarbon gas was encountered in Shuniah mine. An ebullition of natural gas in the harbour of Port Arthur is said to have been used to light a navigation signal for a considerable period of time, several years ago.

In 1923, a bore-hole was sunk to a depth of 1,300 feet on the north side of Squaw bay, near Fort William, by Messrs. J. Beam and A. E. Annis. It was noted by Mr. Annis during the final 200 feet of boring that natural gas, in small amount, came from the hole, and each time that the bailer was raised, after a period of drilling, it could be halted within a few feet of the top of the hole and the gas above it ignited. On one occasion, when the writer was present, the gas burned for 10 seconds. There did not appear to be a steady ebullition of sufficient quantity to be ignited under ordinary circumstances.

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[1] Keele, J.: "Preliminary Report on the Clay and Shale Deposits of Ontario"; Geol. Surv. Canada, Mem. 142, pp. 125-129 (1924).

[2] Keele, J.: Mines Branch, Dept. of Mines, Canada, Sum. Rept. 1919, pp. 106-107.

The deep bore-hole at Squaw bay and two shallow bore-holes located about 1½ miles south of the mouth of Slate river were sunk during 1922 and 1923 in search of oil. The results were negative.

Anthraxolite, a mineral substance somewhat resembling anthracite, occurs in narrow veins at a few places in Port Arthur and environs. The largest known deposit is half a mile east of the Golf Club, southwest of Port Arthur, where in the central part of a banded vein of the silver-bearing type, anthraxolite occurs through an exposed length of 30 feet with an average width of 6 inches.

Beyond the limits of Fort William and Port Arthur map-area many occurrences of anthraxolite are known in veins cutting the Gunflint formation. None of the occurrences is of sufficient size to be of commercial value as fuel.

PEAT

The peat in three bogs near the cities of Fort William and Port Arthur could be utilized for the manufacture of peat fuel. Details regarding the quantity and quality of the peat are given in a report by A. Anrep.[1]

MARL

A lake with an area of about 12 acres occurs in McIntyre township, 1⅓ miles south-southeast of Intola post office. A deposit, locally 2 feet thick, consisting chiefly of calcareous shells of small organisms, is exposed along the shore around the western part of the lake. The deposit probably extends over a large part of the lake bottom.

SOILS

By soil is meant the uppermost stratum, commonly about 6 inches thick, of unconsolidated rock which, owing to weathering, the incorporation of organic material, and micro-organisms has been rendered suitable for supporting plant life.

The soils in Fort William and Port Arthur map-area have been developed in Pleistocene and Recent deposits and Map 197A shows the distribution of the various classes. On the whole, the texture of the soils is somewhat finer than that of the immediately underlying subsoil. No physical analyses were made by the writer and, therefore, in the following account the terms descriptive of textures may not have their standardized meanings. Much of this information, including physical analyses of some of the soils, and statements regarding their economic value, has been drawn from an unpublished manuscript by Mr. R. A. Brink of Ontario Agricultural College, who in 1919 studied the soils in a part of Fort William and Port Arthur map-area. The following notes on climatic conditions are also taken from Mr. Brink's report.

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[1] Anrep, A.: "Investigation of Peat Bogs in Ontario"; Geol. Surv., Canada, Sum. Rept. 1921, pt. D, pp. 7-9.

The highest temperature recorded at Port Arthur is 96 degrees and the lowest —40. The length of the period free from killing frosts averages 107 days, which compares favourably with that of the southern portions of the Prairie Provinces and is sufficient for most of the stable farm crops adapted to the temperate zone.

The annual precipitation is greater than over the Prairie Provinces, but less than found in southeastern Ontario. Of the 23·22 inches of precipitation falling annually, on the average 50 per cent comes during the crop season and is usually well distributed. The level of the groundwater is quite high in most localities, aiding considerably in maintaining a sufficient supply of moisture at the surface. A heavy formation of dew during the cool summer nights augments considerably the moisture supply.

MUCK AND PEAT SOILS

The muck and peat soils consist largely of organic material in various stages of decomposition; the muck differs from the peat in that it contains a greater amount of mineral soil and its organic material is more decomposed.

Peat forms by the gradual accumulation of vegetable matter in ponds, muskegs, and swamps, and its preservation is due to the presence of groundwater near the surface. It forms the surface soil over the greater part of the muck and peat areas shown on Map 197A. Where the peat is thick it is of low agricultural value. It is generally acid, lacks some of the mineral elements necessary to plant life, and though it usually contains a large amount of nitrogen, this is largely in a form not available to plants. Drainage, by the lowering of the groundwater-level, brings about oxidation and decomposition of the peat and tends to produce a mucky soil. In areas covered by 1 to 3 feet of peat it has been found that after drainage and cultivation, the peat largely disappears, for the bulk of the peat is greatly reduced by oxidation and what remains when mixed with the undersoil forms a rich mucky soil.

Most of the swamp areas are so situated that artificial drainage is possible. The large swamp areas are underlain by reddish sand intermixed with clay. The surface of this material is usually white, due to the decomposition of the dark silicates and the removal of ferric hydrate by acids of the humus.

DUNE SAND SOILS

Dune sand occurs in a strip about ¼ mile wide and 1½ miles long, extending west from a point about ½ mile northwest of the village of Rosslyn. The dune sand soil is of little agricultural value chiefly because, when cultivated, the sand is likely to drift. At the time of examination, the area was covered with small jackpine trees and these effectually check the drifting of the sand. No area of valuable agricultural land occurs close to the east of the dune sand area, that is, in the direction towards which it is probably tending to migrate.

ALLUVIUM OF PRESENT STREAMS

Silt and fine sand form the soil on the lowlands along Kaministikwia River valley and on the delta near the mouths of this stream. The soil usually consists of reddish brown, fine sand, which is well leached and oxidized but contains in most places considerable organic material. The subsoil for the most part is fine sand, but, in places, it is reddish lacustrine clay.

The areas have been subject to overflow by the river during stages of high water in Recent geological time. The low relief of the surface and its closeness to groundwater-level tend to maintain excessive moisture in the soil and to prevent aeration. Forest trees on this soil are chiefly balsam, poplar, and balm of Gilead. These soils are of agricultural value; the excessive moisture locally encountered may be corrected by underdrainage.

GRAVELLY SAND

The soil on the lake beaches consists, for the most part, of reddish brown, coarse sand with gravel and, in places, a large proportion of coarse gravel or boulders. The soil in most places contains a low percentage of organic material.

The beach soils occupy irregular-shaped areas of considerable size near lake Superior, and several relatively small, narrow areas in the lowlands west of the twin cities. Because of the loose porous character of the soil the natural drainage is usually excessive.

SOILS ON DELTA, TERRACE, AND LAKE-BED DEPOSITS OF GLACIAL LAKE ALGONQUIN

Stony Sand

This soil consists of reddish brown or yellowish sand containing stones and boulders. The subsoil consists of yellowish sand with stones and boulders. In places the soil is very stony and contains such a small amount of fine material that it is of little agricultural value. Even where there is a high percentage of fine material the natural drainage is excessive and the soil is easily affected by drought.

These soils are developed on ancient river gravels and occur only in small areas. Two such areas large enough to be represented on the map lie, respectively, about 2 miles southwesterly from Rosslyn village and in the vicinity of Rosslyn bridge. The ancient river gravels are for the most part concealed by overlying finer river deposits. Where exposed the surface is nearly level.

Fine Sand

Extensive areas of fine sand border Kaministikwia river and stretch northeast to Current river. The soil is light brown and of very uniform composition. The subsoil contains a larger proportion of very fine sand and silt. The following table gives the results of mechanical analyses made by R. A. Brink, of typical samples of the soil and subsoil.

—	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Surface soil...........	2·7	6·5	7·7	39·5	25·3	15·3	3·0
Subsoil...............	0·0	0·0	1·2	23·6	52·1	18·8	4·3

In past years this soil was forested with white and red pine, but, as a result of lumbering and forest fires, trees of this type are now scarce and the second growth is of Banksian pine. Wild vetches and wild peas grow in profusion on this soil. The surface is normally covered with a tough turf a few inches deep which upon cultivation tends to disappear and the sandy soil shifts with the wind. The light nature of the soil and the open subsoil cause it to be readily affected by drought. The surface of the areas occupied by this soil is characterized by gentle slopes. This soil is not suited to general farming but proves of great value for potato growing.

Fine Sandy Loam

This soil consists for the most part of reddish brown, fine, sandy loam, generally free from stones and boulders. It usually becomes progressively finer downwards. The subsoil is a reddish loam in which tiny flakes of mica occur. The following table gives the results of mechanical analyses of typical samples, made by R. A. Brink, of the soil and subsoil.

—	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Surface soil...........	0·0	1·2	2·5	25·2	54·8	7·1	9·2
Subsoil...............	0·0	0·0	0·0	4·9	44·3	33·9	16·9

This type of soil occupies long strips and irregular areas bordering the fine sand area through which Kaministikwia river flows. The surface is nearly level or gently sloping, but the natural drainage is generally adequate. In places where the under drainage is deficient, on account of the heavy subsoil and the lack of slope, tile drainage would materially improve the physical properties of this soil.

The content of organic matter is generally higher and is more easily maintained than in the sandier soils, and the soil is one of the most extensively cultivated and most highly productive in the district. It is especially suitable for potato and vegetable culture.

Clay Loam and Clay

This soil is a reddish brown to dark brown clay loam or clay in which small stones occur locally. The subsoil is of red or bluish grey clay, which is very sticky when wet and highly retentive of moisture.

These soils are most extensively developed on the southern part of the plain lying between Kaministikwia river and the high rocky hills to the south. The surface is nearly level or gently sloping, except where trenched by gullies and stream valleys. In general the under drainage is somewhat deficient.

The clay loam and clay soils are well adapted for mixed farming. The principal crops that have been grown with success are oats, timothy, alsike, and red clover. Spring wheat is also grown. These soils are naturally more highly productive than the lighter soils, but are more difficult to work and can be worked with best results only within limited periods of time when the clay is neither so wet as to puddle nor so dry as to bake. The physical conditions and working qualities of the heavy soils are improved by under drainage, and by liming and increasing the organic matter content, which tend to promote granulation of the soil.

Stony Sand and Clay

The small areas over which this soil occurs are characterized by a heterogeneous assemblage of materials believed to have been dropped by melting ice floes. Small stones and boulders make up more than 10 per cent of the soil. The agricultural uses to which this soil may be put are conditioned by the size and abundance of the stony constituents. No sharp boundary can be recognized in the field between this soil and the stony parts of the clay loam.

STONY CLAY AND STONY LOAM

A glacial till deposit of variable thickness forms the surface material over more than half of those parts of the map-area that lie more than 850 feet above sea-level. In the high, hilly districts the soil is usually too thin and stony to be of value for agricultural purposes, but in large parts of the townships of Oliver and McIntyre, where the rolling land slopes gently toward the south, the till, in general, contains less and less stony and bouldery material as it is traced southerly. The silty material that forms the finer part of the soil is brown or rust coloured and contains a considerable amount of iron oxide. Parts of this area, where the surface is fairly level, are being successfully farmed. The natural drainage is as a rule sufficient. Good crops of hay and grain are produced.

GRAVELLY SAND AND SANDY LOAM

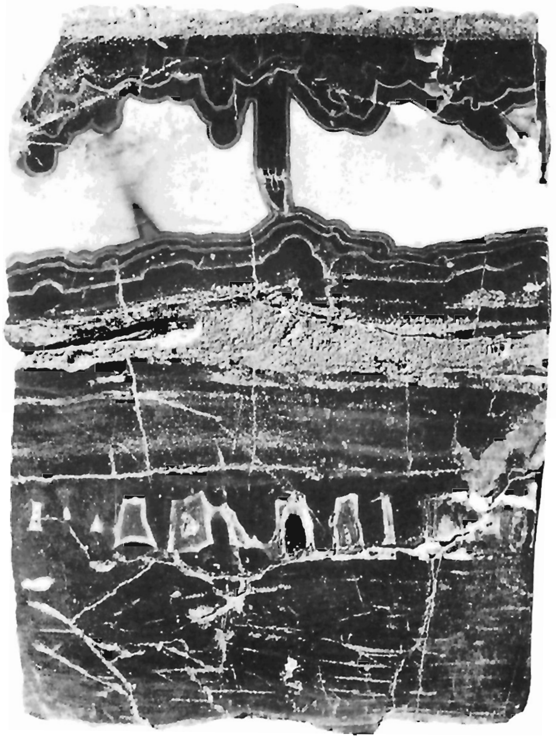
Fluvioglacial deposits are irregularly distributed over that part of the district having an altitude of more than 850 feet above sea-level. These deposits occupy a considerable part of the townships of McIntyre and Oliver, and in these townships finer materials such as sands predominate over gravelly deposits. Coarse gravelly materials are characteristic of the fluvioglacial deposits in the higher and more hilly parts of the map-area. The gravelly, sandy loam soil in McIntyre and Oliver townships is variable in composition. It is reddish brown or rust- coloured, due to presence of iron oxide. The surface is rolling, uneven, and naturally well drained. In general, the properties of the soil are suitable for the growth of crops.

PLATE II

View of port, Port Arthur, Ontario.

Contact between Animikie and overlying Sibley, in cliff south of Surprise lake. The contact lies a few inches below the hammer head, conglomerate is absent and there is no discordance.

Plate IV



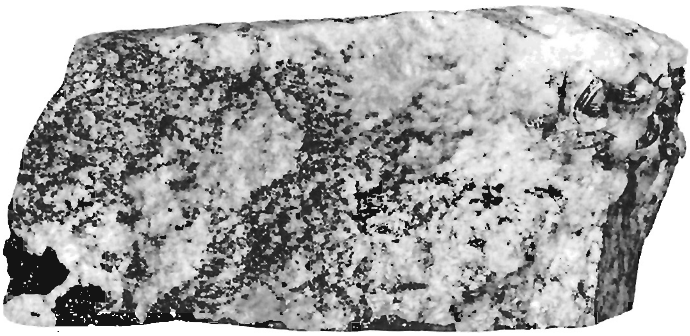
A. Specimen of Animikie iron formation, showing internal structure of some layers. Maximum length of specimen is $3\frac{3}{4}$ inches.

B. Cast in Animikie shale of mud flow structure, Pie island. Maximum length of specimen is $4\frac{1}{4}$ inches.

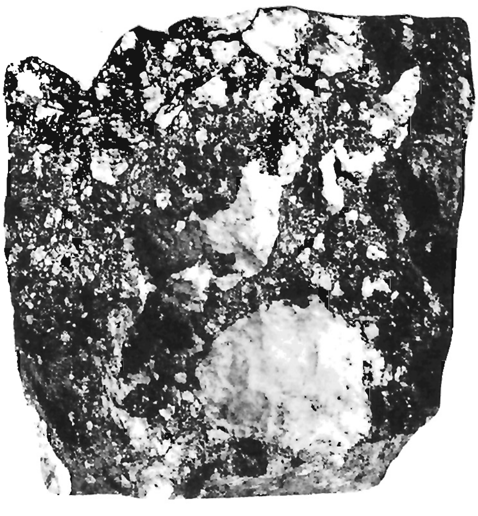
A. Thinly bedded, grey chert and limestone of D member, Sibley series. Maximum length of specimen is 5 inches.

B. Photomicrograph of red fragmental rock of E member, Sibley series. Ordinary light. × 20.

A. Silver Islet mine, as it appeared in 1921. Thunder cape, 6 miles distant, is in the background.



B. Silver Islet ore (maximum width of specimen, 4 inches). Wire silver is visible, occurring in vugs in white calcite; silver with other metallic minerals form tiny aggregates in pink dolomite.



C. Pink carbonate and quartz in irregular-shaped nodules in gouge, Silver Islet mine (maximum width of specimen, 3 inches).

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