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GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

PAPER 62-22

COPPER, LEAD, AND ZINC CONTENT OF STREAM SEDIMENTS IN SOUTHEASTERN NEW BRUNSWICK

(Parts of Westmorland, Albert, Kings, Queens, and Saint John Counties)

(Report, 4 figures, appendix)

A.Y. Smith

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Figure 1. Generalized geological map of part of southeastern New Brunswick showing area covered by geochemical investigation.

Figure 2. Total copper content of stream sediments, southeastern New Brunswick.

Figure 3. Total lead content of stream sediments, southeastern New Brunswick.

Figure 4. Total zinc content of stream sediments, southeastern New Brunswick.

COPPER, LEAD, AND ZINC CONTENT OF STREAM SEDIMENTS IN SOUTHEASTERN NEW BRUNSWICK

INTRODUCTION

This paper reports the results of the final part of a reconnaissance geochemical survey of Nova Scotia and southeastern New Brunswick, begun in Nova Scotia in 1956 by R.W. Boyle (Boyle et al., 1958)[1], continued in 1957 and 1958 by R.H.C. Holman (1958), and extended into New Brunswick in 1959 by the writer (Smith, 1960). Field work for the present project was carried out during the summers of 1960 and 1961.

The amounts of heavy metal (Cu, Pb, Zn) reported (Figures 2, 3, and 4) are the total extractable amounts. All analyses were done in the field, in the Geological Survey's new mobile geochemical laboratory (Smith and Washington, 1962). Analyses were done on dried samples sieved to -80 mesh. Samples were fused with potassium bisulphate, and heavy metals determined separately using dithizone (diphenylthiocarbazone) methods (Gilbert, 1959).

The results of this survey indicate that the amounts of total extractable zinc, lead, and copper in the stream sediments of the area are generally low. As background values used in previous reports may have been too high, new, somewhat lower backgrounds have been calculated. It was found that large areas appear to have higher than average background values, and these may be significant as 'metallized' areas. The geology must, however, be taken into account when considering areas.

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TOPOGRAPHY

The topography of the area is varied. In the south, along the coast of the Bay of Fundy, the land rises steeply, in cliffs,

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[1]Names and/or dates in parentheses refer to publications listed in the References.

many of which are 500 to 600 feet high, to the interior plateau of the Caledonia Complex. Youthful streams have deeply incised the margins of the plateau, and flow precipitously into the Bay of Fundy. The interior of the plateau is gently rolling, rising in places to elevations of 1,200 feet above sea-level. Within the area of the plateau, streams are sluggish and drain swamps or small lakes.

On the north side of the Caledonia Complex, where rocks of Mississippian age underlie the region, the land has been sculptured by glacial stream action. Large ridges remain, with relief of over 750 feet, separated by broad pastoral valleys. In the western part of the area this rolling topography continues northward. In the eastern part, flat-lying Pennsylvanian sediments predominate, and the surface is gently rolling or flat, with little relief.

The quality of the streams for stream-sediment sampling varies throughout the region. In the upland areas in the south, underlain by rocks of the pre-Carboniferous complex, the streams flow rapidly over boulder-strewn beds, and fine material suitable for sediment sampling is sparse. In areas underlain by Mississippian rocks, stream flow is rapid, but fine material is generally available. In areas underlain by flat-lying Pennsylvanian rocks, most of the streams are sluggish and marshy, yielding poor sediment samples highly charged with organic material. In general, the distribution of drainage throughout the area is excellent for sediment sampling.

GENERAL GEOLOGY

The geology of the area is depicted in Figure 1—a generalized map compiled from reports and maps by Gussow (1953), MacKenzie (1951a and b), Kindle (1962), MacKenzie and Alcock (1946), Evans and Alcock (1945), Norman (1941a, b, and c), Stewart (1941a, b, c, and d), and Alcock (1938), and from unpublished maps of the New Brunswick Department of Lands and Mines. Some of the geological boundaries on Figure 1 are arbitrarily placed, particularly between rocks of the Horton Group and those of the Moncton Group. For ease of comparison the base of the Weldon Formation was used as the Horton-Moncton boundary and is not considered a definitive boundary.

Pre-Carboniferous Rocks

The oldest rocks exposed in the area are those of the pre-Carboniferous Caledonia Complex. In the area around Saint John and eastward, Alcock (1938) considered these rocks to be of Precambrian age. Oldest of the Precambrian rocks are those of the Green Head Group, thought by Alcock to be Archaean. They include limestones, dolomites, argillites, slates, and quartzites, all strongly metamorphosed and intruded by basic dykes, granite, and gabbro. Resting unconformably upon the sediments of the Green Head Group are the acid and basic volcanic rocks of the Coldbrook Group, thought to be of Proterozoic age by Alcock. These are the most extensive of the pre-Carboniferous rocks in the area and form the main mass of the Caledonia massif of southeastern New Brunswick. They are intruded by granites, which are also probably of Precambrian age. Lying upon these Precambrian rocks in the Saint John region are the fossiliferous

beds of the Saint John Group, which range in age from Lower Cambrian to Lower Ordovician and are made up of conglomerates, sandstones, shales, and some limestones.

North of Kingston Peninsula the pre-Carboniferous rocks include basic volcanic rocks, slates, and quartzites of the Charlotte Group of Ordovician age. In a few places, as along the north side of Kingston Peninsula, Silurian basic to intermediate volcanic rocks of the Mascarene Group are faulted against Precambrian volcanic rocks of the Coldbrook Group. Granites, syenites, granodiorites, and quartz diorites intruded all the rocks of pre-Carboniferous age during Devonian time. Minor bodies of gabbro or diabase were also intruded at this time as sills or small stocks.

No attempt has been made to indicate the subdivisions of the pre-Carboniferous on Figure 1. These rocks have been generally neglected in the geological mapping of the Maritime Provinces, and in places have yet to be mapped.

Carboniferous Rocks

Throughout the Moncton basin the pre-Carboniferous basement rocks are overlain with great unconformity by mainly terrestrial sediments of Carboniferous age (Figure 1). In this report, the lower Mississippian rocks are divided into three groups: the Horton Group, which includes the Memramcook and Albert Formations; the Moncton Group, which comprises the Weldon and Hillsborough Formations; and the Windsor Group. The three groups recently assumed considerable economic importance as a result of the discovery of barium-lead-silver deposits in Nova Scotia within rocks of similar age and lithology. In the map-area, however, the Moncton Group may include rocks of similar age to some of those in both Horton and Windsor strata, the Weldon Formation may well be the same age as rocks of the upper part of the Horton Group (Cheverie), and the Hillsborough Formation may be the same age as rocks in the lower part of the Windsor Group. Thus the economically significant Horton-Windsor contact may not be as clearly defined in southeastern New Brunswick as it is in parts of Nova Scotia.

Mississippian Formations

The lowermost Carboniferous rocks resting upon the pre-Carboniferous basement belong to the Horton Group, and comprise the Memramcook and Albert Formations. The Memramcook Formation rests upon the pre-Carboniferous basement with profound unconformity. Conglomerate and sandstone grade upward into purple siltstone and shale. The contact of the Memramcook Formation with the overlying Albert Formation is gradational in most places. The Albert Formation consists of predominantly grey sandstones, siltstones, shales, and limestones, some of which are highly bituminous. West of Sussex, however, it consists of conglomerate and arkosic sandstone with lesser amounts of grey siltstone and shale.

The Moncton Group, consisting of the Weldon and Hillsborough Formations, overlies the Horton Group in some parts of

the area, and pre-Carboniferous rocks in others. The Weldon Formation, composed of reddish brown siltstones and mudstones with local basal conglomerates, is generally conformable with the Albert Formation. It is overlain, at least locally with angular unconformity, by conglomerates and sandstones of the Hillsborough Formation. Locally, a rhyolitic ash bed occurs at the base of Hillsborough. This bed may be related to the Mississippian rhyolite flows of Moncton age in the western part of the area.

Near Saint John, Alcock (1938) mapped the Lower Mississippian Kennebecasis Formation, composed of conglomerate, coarse sandstone, and shale. It has been included in the Moncton Group on Figure 1.

Overlying the Moncton Group with apparent conformity are marine sediments of the Windsor Group. These, in their lower members are mainly limestones, containing manganese oxides in places. The upper part of the Windsor Group in the Moncton basin consists of gypsum, anhydrite, and salt with some sandstone and shale. In the Saint John area, the Upham Formation (Bell, 1944) is probably the same age as some strata in the lower part of the Windsor Group.

Overlying the Windsor Group are the red sandstones and siltstones of the Mississippian part of the Hopewell Group. In the Saint John area, Alcock has mapped a sequence of red conglomerates and sandstones—the Hammond River Formation—which is apparently correlative with the Hopewell Group. The Hopewell Group is also represented in this area by the Mispec Group, which Alcock divided into the Balls Lake and West Beach Formations. The relationships of these to the Hammond River Formation are not known.

Two periods of deformation have affected the Mississippian rocks of the region. The first followed deposition of the Weldon Formation, the second took place at the end of the Mississippian Period. One period of volcanism has been recognized, occurring at the time when the Moncton Group was being deposited. Rhyolite flows and tuff beds underlie the Windsor Group in the western part of the area, and near Hillsborough, an ash bed occurs at the base of the Hillsborough Formation, as previously mentioned. This volcanism may be related to the deformation that followed the deposition of the Weldon Formation.

Pennsylvanian Formations

In contrast to the structurally deformed Mississippian rocks, Pennsylvanian rocks are mainly flat lying, but in places low domes, anticlines, and faults reflect structures in the underlying Mississippian. The earliest Pennsylvanian rocks are red sandstones, shales, and conglomerates of the Enrage Formation of the Hopewell Group. These are overlain conformably by the Boss Point Formation of the Riversdale Group. The top of the Boss Point Formation is marked by a disconformity. The Cumberland Group, so prominent in Nova Scotia for its coal measures, is present only in part near Saint John, where a sequence of red and grey sandstones and shales, known as the "Lancaster Formation", has been shown to be the same age as some of the Cumberland strata.

The youngest Pennsylvanian rocks present are those of the Pictou Group. In the northwestern part of the area, north of the pre-Carboniferous rocks, all of these rocks have been shown on Figure 1 as Pictou Group, although some may belong to the Boss Point Formation.

Red sandstones and conglomerates of Triassic age occur in two places along the Bay of Fundy. Near Alma, these rocks are simply classed as Triassic, but in the area around St. Martins, to the west, Alcock has grouped these Triassic rocks into the Quaco Formation. Along the northern coast of the Bay of Fundy these Triassic rocks are in fault contact with older rocks, which no doubt accounts for their preservation.

RESULTS OF THE INVESTIGATION

The results of this investigation are presented in the form of three maps of the area: one for copper, one for lead, and one for zinc (Figures 2, 3, and 4 respectively). Values have been recorded for all stream sediments containing more than 2 ppm copper, 7 ppm lead, and 50 ppm zinc. The 'background' values are somewhat lower than those used in previous reports, but it was considered desirable to indicate as much information as possible, particularly in areas of Horton-Windsor rocks where significant anomalies might be rather small. It is impossible, of course, to assign a single, meaningful background in such a large area of widely diverse rock types.

Attempts were made in the field to keep some record of the organic matter and manganese content of the samples and to relate them to the metal content of the sediment. It was found virtually impossible to collect stream sediment without organic matter. The organic matter may possibly act as an accumulator of heavy metals, but the writer has found that samples containing much organic matter tend to inhibit the action of the flux during analysis, and do not readily yield their metal. The metal values of such samples, therefore, may be too low rather than too high. Similarly, many samples containing manganese oxide have metal values of background or lower. In other words, manganese oxides apparently do not accumulate heavy metals where none are available for accumulation. It is the writer's opinion that sediment values must be regarded on their own merit regardless of whether or not the sample contained organic matter and/or manganese oxides.

Higher-than-background values were found in many areas, and anomalous amounts of the three heavy metals occur together in many places.

Anomalous amounts of zinc are widely distributed throughout the area, as shown on Figure 4; this is partly attributable to the low background of 50 ppm assigned to this metal. Highest values for zinc were obtained in the area around the old Lumsden mine and the Teahan prospect. The single value of 1,500 ppm at the Teahan prospect was in a sample taken directly below the discovery outcrop to test the method, and is not regarded as significant. In the Lumsden area, however, all samples were taken well upstream from any known workings, and would seem to outline a larger mineralized zone than

had previously been recognized. The existence of such a zone is further suggested by anomalous values for lead and copper; a value 122 ppm copper was found in a sample taken well upstream from the known mineralized area.

A broad area of anomalous values was outlined along the western boundary of Fundy National Park. Both within and outside the park, samples collected on Point Wolfe River and its tributaries contained up to 33 ppm copper, and 25 ppm lead. To the west of the park boundary, the Goose Creek and the Quiddy River systems both gave similar anomalous values in copper and lead. Semi-quantitative spectrographic analyses of a group of samples from these three river systems indicated the presence of Ni, Co, and Ag in varying quantities in some of the samples. Apparently, nickel was present in sufficient quantity, in some samples, to interfere with the dithizone test for copper. Known deposits of copper minerals in this area are confined to a belt along the coast approximately a mile wide, so that the present studies appear to have outlined a previously unknown mineralized area.

Other areas underlain by rocks of pre-Carboniferous age gave anomalous results, including the area east of Saint John, and the Kingston Peninsula. Kingston Peninsula is particularly interesting because a significant increase in background, especially the lead background, occurred over the entire peninsula. Within this area several substantial anomalies in lead and copper were found. As no deposits are known in this region, these anomalies would appear to be of significance.

A second group of anomalies was found in areas underlain by Mississippian rocks of the Horton and Windsor Groups. Some of these are along the southeastern margins of the pre-Carboniferous complex, along the northeastern margin of the complex, and in the Carboniferous basin south and east of Sussex. A general increase in the amounts of all three metals was noticed in samples collected along the southeastern and eastern margins of the pre-Carboniferous complex, but it is difficult to know whether this increase is related to the underlying bedrock, or to material transported by the streams from the pre-Carboniferous complex. North of Shepody Mountain a zone of copper anomalies surrounds a ridge underlain by rocks of the Boss Point Formation. Although the Boss Point contains at least one known copper deposit farther east at Dorchester, no such deposits are known in this area. The anomalies may stem from rocks of the Windsor Group, which may underlie this ridge of Boss Point rocks.

Stream samples collected in the belt of Mississippian sediments along the northeastern margin of the pre-Carboniferous complex showed higher than average values for all three metals. In view of the presence of important barium-lead-silver deposits in rocks of similar age and lithology in Nova Scotia, this belt merits further geochemical examination.

Perhaps the most interesting of the areas underlain by rocks of the Horton and Windsor Groups is that lying south and east of Sussex, where a general small increase in the lead background was found. South of Sussex, one stream had a lead value of 100 ppm, and values of 20 ppm were not uncommon. Farther south, along the northern margins of the pre-Carboniferous complex, stream sediments above a band of limestone from the lower part of the Windsor Group yielded slightly increased values in zinc. As the Markhamville manganese

deposit occurs within this limestone band, the increased zinc content of the stream sediments may reflect the presence of similar manganiferous material in the samples. One analysis of manganite from the Markhamville mine gave 6,700 ppm zinc, and 500 ppm lead. This suggests that a possible method of locating other manganese deposits in the area might be developed by analysis of soils and stream sediments for lead and zinc.

In examining and assessing the significance of the results of the present study it is important to bear in mind its preliminary nature. Every possible check was made to insure consistent analytical results, but time did not permit the detailed checking and resampling of anomalies. For this reason, the analytical methods of future investigators should be checked against those used in this survey, and anomalies shown on Figures 2, 3, and 4 should be resampled to verify their existence. The field maps and analytical results are available for inspection to those interested in further geochemical surveys of the area.

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— APPENDIX —

MINERAL OCCURRENCES

Many occurrences of sulphide and manganese minerals occur in the area covered by this investigation. Without exception the sulphide deposits have been small and uneconomic, although small amounts of ore have been shipped from a few of them. Several of the manganese occurrences have been worked on a small scale in the past. Brief descriptions of these occurrences are given below, with references. Their locations, as numbered in the descriptions, are plotted on Figure 1.

Sulphide Deposits

1. Upper New Horton Copper Prospect

Location: N.T.S. 21 H/10E; lat. 45°41.1"N, long. 64°43.8"W.

Reference: Wright (1951).

The copper deposits at Upper New Horton occur in grey arkosic sandstones of the Shepody Formation of Late Mississippian age. The copper minerals chalcocite and malachite are associated with carbonatized plant remains. The deposit is cut by a fault, which strikes northeast and dips northwest at 50 degrees. Small lenses of chalcocite with minor chalcopyrite were found along the fault plane where the fault has intersected the copper-bearing bed. Numerous other occurrences of copper have been observed along the strike of the ore-bearing bed, but none has proved of economic value.

2. Midway Copper Prospect

Location: N.T.S. 21 H/10W; lat. 45°40'N, long. 64°47'W.

Reference: Wright (1951).

This copper-bearing area is some 4,000 feet southwest of the Upper New Horton prospect, between Albert and Waterside. Here, as at New Horton, copper occurs as chalcocite and malachite replacing carbonized plant fragments in grey arkosic sandstones of the Shepody Formation. Copper occurrences have been traced by pits and trenches for a strike length of more than 4 miles, but values are erratic and uneconomic.

3. Lumsden Mine

Location: N.T.S. 21 H/15; lat. 45°47.6'N, long. 65°51'W.

References: Alcock (1930b), Bichan (1947).

The Lumsden mine is on Lumsden Mountain about 6 miles northwest of Albert village, on a road that runs north along Crooked Creek. The sulphides, which include tennantite, chalcopyrite, galena,

sphalerite, and pyrite in a gangue of quartz and calcite, occur in a large northeast-trending shear zone, which cuts basic volcanic rocks of apparently Precambrian age. The host rocks, now grey to green micaceous and chloritic schists, have been intruded by granite, possibly of Devonian age, about 4,000 feet north of the mine. The mineralized zone has been traced by pits for a length of 500 feet with a maximum width of 28 feet. In 1953 the property was prospected by Anthonian Mining Corporation, using geophysical methods and diamond-drilling, with little result.

4. Teahan Prospect

Location: N.T.S. 21 H/10W; lat. 45°43'N, long. 64°59.4'W.

References: Alcock (1930b), Bichan (1947).

The Teahan prospect is at the junction of Kierstead and Bartlet Brooks on the headwaters of Upper Salmon River. Here, as at the Lumsden mine, the ore minerals are pyrite, chalcopyrite, tennantite, sphalerite, and galena with a gangue of quartz, calcite and barite. The ore occurs in a vein striking N55°E and dipping 55°N, cutting schistose acid and basic volcanic rocks. The volcanic rocks are intruded by stocks of sheared quartz diorite and albite granite. The entire assemblage is thought to be Precambrian and has been mapped by Kindle (in press) as belonging to the Coldbrook Group of the Saint John area. The ore-bearing structure has been traced for a strike length of 980 feet with a maximum width of 30 feet. Alcock recorded assays of 14.3% Zn, 1.3% Cu, with 4 oz/ton Ag. However, insufficient ore has been found to make the property economic. In 1953, Anthonian Mining Corporation examined the property by geophysical methods and by diamond-drilling, but without result.

5. Alma Prospect

Location: N.T.S. 21 H/10W; exact location unknown.

Reference: Brumell (1892).

The discovery of large masses of chalcocite in float in the Alma area encouraged prospecting for the source. All that was found, however, were several quartz veins containing small amounts of chalcocite and copper carbonates. These veins occur in diorites, supposedly of Precambrian age. The area is now within Fundy National Park and unavailable for prospecting.

6. Mile Brook Prospect

Location: N.T.S. 21 H/11; lat. 45°32.5'N, long. 65°02.5'W.

Reference: Bichan (1947).

This prospect occurs in a vertical shear zone that cuts diorite, andesite, and schists of the Coldbrook Group. Minerals present include bornite, chalcopyrite, and chalcocite, with specularite,

pyrite, and pyrrhotite in white quartz. The occurrence was prospected early in the century, but it is now within Fundy National Park and unavailable for further prospecting.

7. Elgin Prospect

Location: N.T.S. 21 H/14E; lat. 45°47'N, long. 65°06'W.

Reference: Bichan (1947).

This prospect was found by Bichan in 1947 while working for the New Brunswick Department of Lands and Mines. It is exposed in the east bank of Pollet River, 1 1/4 miles south of Elgin. Sphalerite, chalcopyrite, and pyrite in a quartz gangue occur in a shear zone cutting tuffaceous rock of Precambrian age. No work has been done of the prospect other than that by Bichan.

8. Goshen Copper Prospect

Location: N.T.S. 21 H/14E; lat. 45°46'N, long. 65°12.5'W.

Reference: Hawkins (1958).

Boulder conglomerate of the Moncton Group contains beds of disseminated chalcocite with considerable malachite staining at this locality. Some fragmental plant material is associated with the copper minerals. The conglomerate rests upon pre-Carboniferous basement rocks to the south. Hawkins reported finding sulphide veinlets in the boulders of the conglomerate. He concluded that the deposit was a reworking of sulphide material contained in the conglomerate.

Considerable trenching and drilling has been done, but no deposits of economic proportions have been found. A similar occurrence can be seen in a road-cut 1 mile west of Goshen, where malachite staining is associated with plant fragments in a fine-pebble conglomerate of the Moncton Group.

9. Vernon Mine

Location: N.T.S. 21 H/11; lat. 45°31.5'N, long. 65°07.5'W.

References: McAllister (1958), Bailey (1899).

This prospect was worked around 1865, but was closed because of difficulties in operation. The deposit occurs as veins in rhyolite flows and tuffs of the Precambrian Coldbrook Group. The copper minerals, chalcocite, bornite and chalcopyrite, occur in quartz veins with minor carbonate gangue. The main or "Peacock Vein" strikes N20°E and dips 45°N. MacKenzie in 1945 (McAllister, 1958) noted that most of the vein was unmineralized.

10. Martin Head

Location: N.T.S. 21 H/16; lat. 45°29.5'N, long. 65°12'W.

Reference: Bailey (1899).

Bailey mentioned erubescite (bornite) in rocks of the Coastal Group, but gave no further information. This apparently referred to a small copper occurrence on the west side of Quiddy River at Martin Head, in sediments of the Coldbrook Group. Kindle (1962) showed the location on his map of Point Wolfe map-area. Kindle also showed an occurrence of zinc on Quiddy River, 2 miles upstream from the coast. No further information on this occurrence is available.

11. Little Salmon River

Location: N.T.S. 21 H/16; lat. 45°28.5'N, long. 65°16.5'W.

Reference: Bailey (1899).

Bailey reported: "Little Salmon River (near mouth)—Copper-pyrites in small quantity with much iron-pyrites, in slates." Nothing further is known of this occurrence.

12. Jordan Mountain Copper Prospect

Location: N.T.S. 21 H/14W; lat. 45°50'N, long. 65°29.5'W.

Reference: Brewster (1906).

This deposit occurs in the pre-Carboniferous rocks of Jordan Mountain, a short distance northwest of the manganese deposit (see No. 28 below). The vein cutting green schist was described by Brewster (1906) as consisting of "reddish quartzite carrying chalcocite and malachite disseminated fairly evenly through the vein, both as an encrustation in the seams and in fine particles throughout the rock." The vein, up to 18 feet thick, strikes northeast, dips southeast at 75 degrees, and is reported to contain upwards of 6 per cent copper. Little recent work has been done on this deposit.

13. Gold Mine Gully

Location: N.T.S. 21 H/12E; lat. 45°31'N, long. 65°34'W.

Reference: Bailey (1899).

Bailey mentioned an occurrence of galena and chalcopyrite "Near Wanamaker's Inn in the parish of Upham, King's County." He described the property as follows: "Galena with copper pyrites, in quartz veins penetrating dioritic and petrosiliceous rocks of Huronian age. The veins are small but carry a little silver." The exact location is not known, but is probably in "Gold Mine Gully", a hollow on the south side of Hammond River (shown in the southeast corner of National Topographic Series sheet 21 H/12E).

Local residents speak of a 'gold mine' in the gully some fifty years ago, and samples from this 'gold mine' contain galena and chalcopyrite in quartz. This is probably the deposit referred to by Bailey.

14. Norton (Cochran Mountain)

Location: N.T.S. 21 H/12E; exact location unknown.

Reference: Bailey (1899).

Bailey (p. 36M) described small veins of galena as follows: "The veins are in Lower Carboniferous limestone (Windsor?) resting upon the Huronian rocks of Dickie (Cochran) Mountain. They were observed as early as 1863 but have not been considered sufficiently important to warrant exploration."

Bailey also reported (p. 25M): "On the north side of Dickie (Cochran) Mountain, copper glance (chalcocite) encrusting grey quartzite of Kingston Group and overlain by Lower Carboniferous limestone with galena." The exact location of both these occurrences is not known.

15. Annidale (Dick) Copper Prospect

Location: N.T.S. 21 H/13W; lat. 45°47'N, long. 65°46.5'W.

References: Wilson (1927), Alcock (1930a).

This deposit occurs in altered volcanic rocks of pre-Carboniferous age. These rocks have been fractured along an easterly trending belt several hundred feet wide. Quartz, carbonate, pyrite, and chalcopyrite occur in irregular fractures within this belt. The property was mined intermittently from 1902 to 1922, during which time several car-loads of hand-picked ore averaging more than 10 per cent copper were shipped. Many shafts and pits have been dug on the property, and in 1951 American Metals Company did 3,039 feet of diamond-drilling. The ground was restaked in 1961 by private prospectors.

16. Hampton Uranium Prospect

Location: N.T.S. 21 H/12W; lat. 45°34'N, long. 65°48.5'W.

Reference: Gross (1957).

A major northeasterly striking fault zone passes northeast of Hampton and separates pre-Carboniferous rocks of the Kingston Group from Carboniferous sediments of the Kennebecasis Group. Along the fault zone a deposit of hydrocarbon material was found in 1953 to contain small amounts of uranium. Seven drill-holes were put down, but the highest assays gave only 0.03 per cent U_3O_8, insufficient to be economical.

17. Black River Settlement

Location: N.T.S. 21 H/5W; exact location unknown.

References: Bailey (1899), Alcock (1938).

Bailey reported: "Black River Settlement—Copper pyrites and malachite in hard clay-slate, containing remains of plants; also copper glance (chalcocite) in limestone." Alcock mentioned pyrite and chalcopyrite minerals in quartz veins in volcanic rocks of the West Beach Formation near Black River Settlement. Neither reference gives exact locations.

18. Quispamsis Station

Location: N.T.S. 21 H/5W; lat. 45°26'N, long. 65°57.5'W.

Reference: Alcock (1938).

This deposit occurs in inclusions of limestone of the Green Head Group in massive red granite of possible Devonian age. One limestone mass, some 15 feet wide, contains small amounts of pyrite, sphalerite, and galena. Alcock stated: "The deposit is apparently of contact metamorphic origin. It does not seem to be economically important."

19. Tennant Cove

Location: N.T.S. 21 G/9E; lat. 45°31'W, long. 66°34'N.

Reference: MacKenzie (1951a).

MacKenzie noted, on his map of the Hampstead area, an occurrence of copper and lead minerals on the east shore of Saint John River at Tennant Cove. Nothing further is known of this occurrence.

Bailey (1899) mentioned an occurrence of "copper-pyrite in rusty weathering feldspathic sandstones", at London Settlement, parish of Kars. This is about 6 miles north of Tennant Cove, referred to above. Nothing is known of this occurrence, and MacKenzie did not show it on his map.

20. Goat, Starrs, or Indian Island

Location: N.T.S. 21 G/8E; lat. 45°18'N, long. 66°06'W.

References: Alcock (1930a, 1938).

Chalcocite occurs in altered limestone of the Green Head Group on the north side of the island. Alcock considered it to be of little economic importance.

Manganese Deposits

Numerous manganese deposits are known in the area, some of which may be of economic interest. The descriptions that follow are taken entirely from Sidwell (1952) and Hanson (1932).

21. Shepody Mountain

Location: N.T.S. 21 H/15; lat. 45°48.5'N, long. 64°39'W.

References: Hanson (1932, p. 70), Sidwell (1952, p. 86).

The west side of Shepody Mountain is underlain by chloritic schists of the pre-Carboniferous complex. Resting upon these are thinly laminated limestones of the Windsor Group, overlain by conglomerates of the Hopewell Group. Between the limestone and the conglomerate a thin bed of red clay was found that contained nodular masses of manganese oxides. Manganese oxides also occur in small masses and veinlets in the underlying limestone. The grade and extent of the oxide is not known, but some 500 tons of "good ore" has been shipped. It has been suggested (Hanson, p. 72) that the contact between limestone and conglomerate may be mineralized elsewhere in the area.

22. Memel Mine

Location: N.T.S. 21 H/15; lat. 45°47'N, long. 64°42'W.

Reference: Sidwell (1952, p. 91).

The Memel mine is on the west side of Sawmill Creek, approximately a mile north of Hopewell Hill. There, many years ago, pebbles of manganese oxides were found in conglomerates of the Hopewell Group. The conglomerate is similar to that found at Shepody Mountain, mentioned above. The manganese pebbles have apparently been derived from an occurrence similar to that at Shepody. Exploratory work since 1940 has been disappointing and the deposit appears to have little economic value.

23. Dawson Settlement

Location: N.T.S. 21 H/15; lat. 45°56.5'N, long. 65°45'W.

References: Sidwell (1952, p. 144), Hanson (1932, p. 72).

As early as 1887 the existence of a deposit of bog manganese ore was known near Dawson Settlement. The bogs are on the south side of Hopper Creek, a branch of Weldon Creek. The lower edges of the bogs are about 20 feet above the level of the creek and extend up the slope for 600 feet to the orifices of a series of springs related to the bogs.

The deposits of manganese oxides are thickest—in places more than 8 feet thick—near the mouths of the springs supplying them. They pinch out down slope. The deposits consist of a wet mass of

manganese oxide, bog iron, and peat, lying between an upper layer of grass and plant roots and a hard floor of sand or clay. The bog material consists of 60 to 85 per cent moisture whereas the remaining material contains from 16 to 70 per cent peat. The wet ore contains an average of 6.97 per cent manganese and 4.77 per cent iron.

Early workers treated the ore by simply drying it, but when it was found too difficult to handle in this powdered form, equipment was installed to roast the ore and form it into briquettes suitable for use in a blast furnace. No material of this type has been produced since 1900. A small amount of material was shipped as recently as 1940, but since then the property has been idle.

24. Berryton Prospect

Location: N.T.S. 21 H/15; lat. 45°53'N, long. 64°52.5'W.

References: Hanson (1932, p. 78), Sidwell (1952, p. 109).

This deposit occurs on Berry (Berryton) Brook near its junction with West Turtle Creek. The deposit was known prior to 1912 and was mined sporadically up to 1942.

At Berry Brook, Windsor limestone lies upon conglomerates of the Hillsborough Formation. Overlying the limestone are sandstones and conglomerates of Pennsylvanian age. The manganese minerals, chiefly psilomelane, manganite, and pyrolusite, occur as lenses, nodules, and globular masses. Associated with the manganese oxides are minor amounts of barite and copper carbonate.

The limestone is up to 25 feet thick, and dips north at 10 degrees. The manganese is mainly in the uppermost part of the limestone, parallel to the bedding, and is up to 4 feet thick. The limited extent of the limestone has discouraged further development work.

25. Gowland Mountain

Location: N.T.S. 21 H/14E; lat. 45°49'N, long. 65°2.5'W.

References: Hanson (1932, p. 77), Sidwell (1952, p. 94).

This deposit occurs in an altered granitic rock of Precambrian age on the north side of Gowland Mountain, some 4 miles east of Elgin. It has been known at least since 1885 when exploration was begun. The property has been mined sporadically since that time. The most recent work was done in 1942, at which time the known reserves were exhausted.

The Gowland Mountain vein occurs in a fracture zone in Precambrian granites. The vein strikes northwest and dips steeply west. The thickness of the vein ranges from a few inches to 6 feet, averaging about 3 1/2 feet. In places the ore is composed principally of manganese minerals, including psilomelane, manganite, and pyrolusite with small amounts of barite. However, much of the vein

material consists of angular fragments of country rock, cemented by manganese oxides.

Mining of the vein was carried out by open-cuts and an adit, the workings extending to a depth of 60 feet. Activity ceased in 1942 when the known reserves were exhausted.

26. Glebe Mine

Location: N.T.S. 21 H/11; lat. 45°40'N, long. 65°23'W.

References: Hanson (1932, p. 86), Sidwell (1952, p. 81).

The Glebe mine is 8 miles southeast of Sussex, Kings county. It was operated for a period of 15 years ending in 1882; during that period, 40 tons of manganese ore was produced.

The manganese minerals, manganite and pyrolusite, occur as veinlets and lenses in lower Windsor limestone that lies on conglomerates of the Moncton Group. The ore is generally conformable to the bedding of the limestone. Little recent exploratory work has been done, and the potential of the area is largely unknown.

27. Markhamville Mine

Location: N.T.S. 21 H/11; lat. 45°37'N, long. 65°27'W.

References: Hanson (1932, p. 87), Sidwell (1952, p. 70).

The Markhamville mine was the largest producer of manganese in New Brunswick. From its discovery in 1862 until it closed in 1893, the mine produced more than 23,000 tons of manganese ore.

The deposits occur in a thin band of Windsor limestone that strikes northeast and dips northwesterly. The limestone is underlain by sandstones of the Moncton Group, and overlain by conglomerates of the Hopewell Group. The manganese minerals which include hausmannite, psilomelane, braunite, manganite, and pyrolusite, occur as large lenses, nodules, veins and masses, generally conformable with the bedding of the limestone. They are accompanied by minor amounts of limonite, hematite, and barite.

Initially, manganese production came from clay soil developed by weathering of the limestone. Large masses of manganese ore were found embedded in the clay. In 1941 the Bala Manganese Company explored claims immediately to the south of the Markhamville mine in hopes of finding residual deposits of the same type, but without success. No recent work has been done in the area.

28. Jordan Mountain

Location: N.T.S. 21 H/14W; lat. 45°49.5'N, long. 65°29'W.

References: Hanson (1932, p. 84), Sidwell (1952, p. 57).

The Jordan Mountain mine was first operated in 1882, and up to 1887, more than 400 tons of ore was produced. In 1940 the property was re-examined and attempts were made to revive production. However, operations ceased in 1943 for lack of ore.

The manganese deposits occur as lenses and veins in a shear zone cutting highly metamorphosed pre-Carboniferous sediments and volcanic rocks. The shear zone strikes northeast and dips southeast at more than 70 degrees. The manganese minerals occur in lenses as much as 6 feet thick and the mineralized shear zone has been traced for 2,700 feet to the southwest. Manganese minerals include hausmannite, psilomelane, manganite, and pyrolusite. Barite is apparently the only gangue mineral present.

29. Hammondvale Prospect

Location: N.T.S. 21 H/11; lat. 45°35'N, long. 65°29.5'W.

Reference: Evans and Alcock (1945).

The geological map of the Waterford area (Map 829A) by Evans and Alcock shows an occurrence of manganese at Hammondvale on Hammond River. This prospect was not reported by either Hanson or Sidwell. Its location is shown on this map in the same band of Windsor limestone that contains the Markhamville mine. It is reasonable to assume, in the absence of other information, that the manganese minerals are similar to those at Markhamville.

30. Quaco Head Prospect

Location: N.T.S. 21 H/5E; lat. 45°19'N, long. 65°32'W.

References: Hanson (1932), Sidwell (1952), Alcock (1938).

The manganese deposit at Quaco Head is about 2 miles west of St. Martins, Saint John county. The deposit was mined from 1870 to 1889; reportedly, several hundred tons of ore were shipped during that period.

The deposit is contained in Precambrian volcanic rocks, Carboniferous limestone, sandstone, and shales, and Triassic sandstones and conglomerates. A fault zone at one place brings the limestone member into contact with the overlying conglomerate. The manganese occurs as veinlets and nodular masses in the fault zone, and in both the limestone and conglomerate wall-rocks. Manganese minerals include pyrolusite, psilomelane, and manganite, which are accompanied by minor amounts of barite. The deposit is not considered economic.