RADIOACTIVE MINERALS AT OTTER RAPIDS, ONTARIO

by

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of the requirements for the degree
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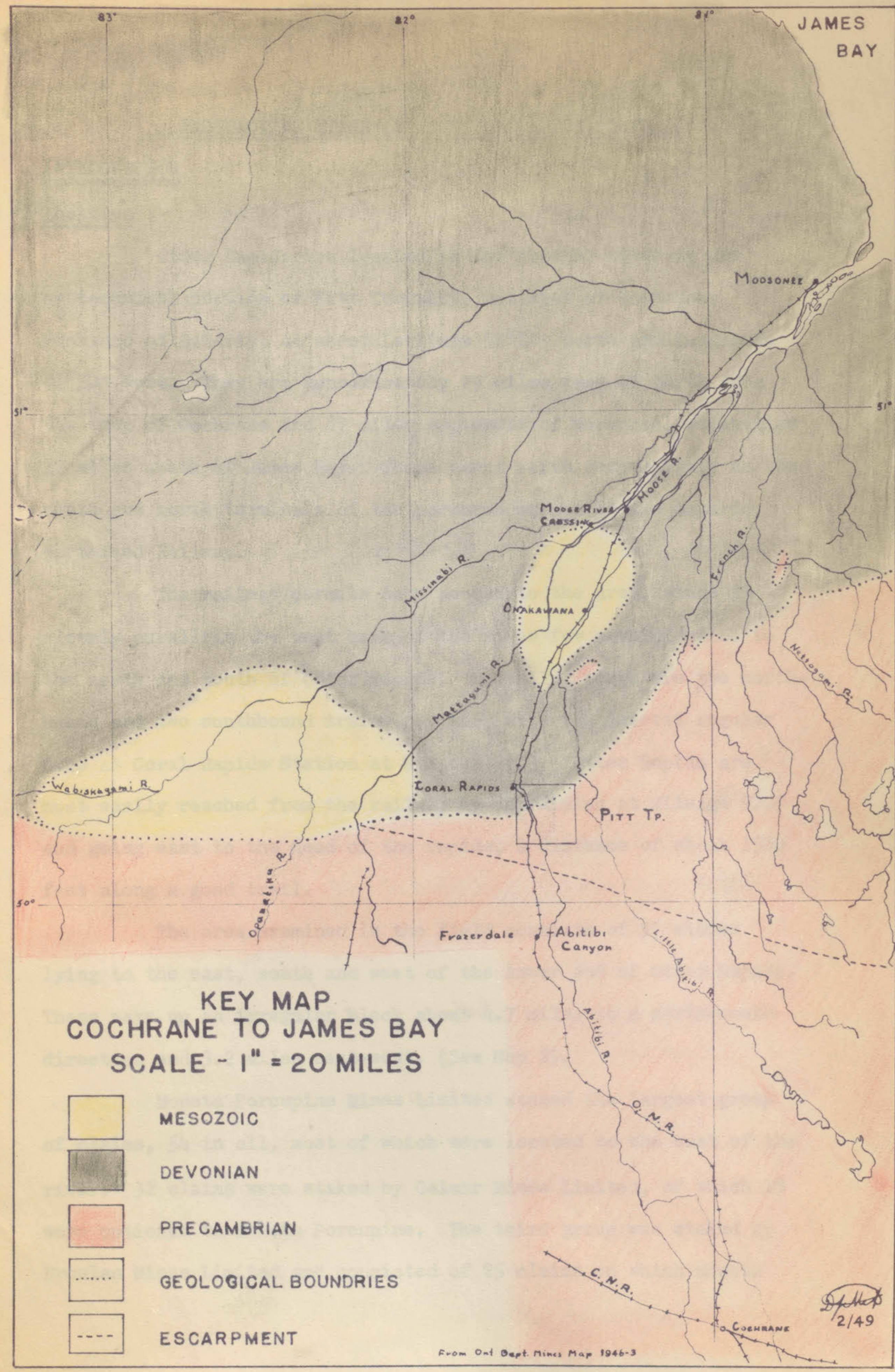
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INTRODUCTION

Location

Otter Rapids are located on the Abitibi River in the west-central portion of Pitt Township, District of Cochrane, Province of Ontario, at about Latitude 51°10' North and Longitude 81°30' West. They are approximately 79 miles west of north from the town of Cochrane and 87 miles southwest of Moosonee, which lies 12 miles south of James Bay. These towns serve respectively as the south and north terminals of the northern branch of the Ontario Northland Railway.

The railway permits easy access to the area, since it closely parallels the west bank of the river for several miles to the north and south of Otter Rapids. Normally, there are two north-bound and two southbound trains per week with the nearest regular stop at Coral Rapids Station at Mileage 96.3. Otter Rapids are most easily reached from the railway by detraining at Mileage 91.7 and going east to the head of the rapids, a distance of about 1500 feet along a good trail.

The area examined in the field consists of 97 claims lying to the east, south and west of the lower end of Otter Rapids. These make up an irregular block about 4.7 miles in a north-south direction and 3.2 miles east-west. (See Map 2).

Moneta Porcupine Mines Limited staked the largest group of claims, 54 in all, most of which were located to the east of the river. 32 claims were staked by Calmar Mines Limited, of which 18 were optioned to Moneta Porcupine. The third group was staked by Broulan Mines Limited and consisted of 25 claims on which Moneta

Porcupine obtained a working option. With the exception of a portion of the Broulan claims, all the above groups were examined by the writer. In addition to the examination of the claims, several exploratory traverses were made to the north, south and west.

In considering the regional features, a much larger area has been referred to, based mainly on previous reports on the area, or on information obtained from maps and aerial photographs.

History of Geological Examination

Prior to 1947 the Otter Rapids area was chiefly notable as the most northerly spot at which Precambrian rocks were to be found along the Abitibi River. The limited geological work done in the region may be divided into three phases: The early period consisted of reconnaissance surveys by E.B. Borron, whose earliest report was published in 1880 (1), W.A. Parks in 1899 (2), W.J. Wilson in 1902 (3), and J.M. Bell in 1904 (5), all of whom noted with varying degrees of emphasis the gneisses and igneous intrusives of the immediate area. The second period was one in which the possibly economic deposits of lignite, fire clay, gypsum and limestone and possibilities of petroleum in the Mesozoic-Paleozoic rocks of the Hudson Bay Lowland drew most attention. Much of this work was done in connection with the building of the railroad from Cochrane to Coral Rapids and later to Moosonee. J.G. Cross, M.Y. Williams and Joseph Keele reported respectively on the Precambrian, the Paleozoic, and the Clay and Shale deposits in 1920 (7). W.S. Dyer, in his generally comprehensive report published in 1928 (12), referred only very briefly to the Precambrian, being concerned chiefly with the younger sedimentary rocks. Later, in 1931 (13), he reviewed the stratigraphy and structure on the basis of a deep drill hole at Onakawana. The third phase started in 1947 with the discovery of a radioactive vein by Alex Mosher.

Otter Rapids

R.C.A.F. Photograph A4346-39

In connection with the staking done by Moneta Porcupine Mines Limited, P.H. Taylor mapped the Mosher vein and reported generally on the area in November 1947 (20). In June, 1948, a study was made of the area immediately surrounding the vein by N. Hogg, of the Ontario Department of Mines (22), and a more general geological and Geiger counter survey of the large group of claims noted above was made by the writer (25).

In addition to these surveys, a brief reconnaissance survey was made of the Otter Rapids area by Eldorado Mines Limited and the writer has been informed of another reconnaissance survey for radioactive minerals, made along portions of the Mattagami River at about the same time.

Purpose and Method of Investigation

The field work in which the writer was engaged during the summer of 1948 had as its purpose the discovery of radioactive deposits, similar to the Mosher vein. This objective was not achieved but several small areas of strongly radioactive pegmatite were discovered. The most outstanding of these pegmatites was carefully examined in the field and samples from it were later the subject of laboratory examination.

The field work consisted essentially of running east-west traverses over the claims examined, spaced at intervals of about 300 feet, or less when outcrop was encountered. A Geiger counter was operated on all traverses and whenever the instrument showed increase of radioactivity above the normal, more careful investigations were made to delimit the area and to obtain an approximation of the intensity of radiation. In only a few cases were these areas of sufficient interest to be worthy of further examination and only two showed enough marked radiation over a sufficiently large area to merit careful investigation.

The laboratory investigation had as its main purpose the identification of the minerals causing the radioactivity, in particular those from the body of pegmatite which showed the most outstanding radioactivity. For additional information on these investigations and a description of the methods employed see under "Laboratory Investigation" Page 44.

Acknowledgements

The writer is indebted to Dr. A.W. Jolliffe, who acted as his director of research and first suggested the method of approaching the subject; to other members of the Departments of Geology and Mining staffs; to Dr. F.A. Burton of Moneta Porcupine Mines Limited for permission to use all maps, notes, etc. which were made while the writer was in the employ of that company during the summer of 1948; to Nelson Hogg of the Ontario Department of Mines whose advice in the field and loan of thin sections of material from the Mosher vein and other rocks of the area, and a suite of rock specimens from the same area, were of great help; and to C.S. Parsons of the Department of Mines and Resources who supplied the writer with samples from the area which had been previously sent to his Department for assay.

Summary and Conclusions

The area is largely overlain by a thick sheet of till which slopes gently to the north with very little relief. The drainage is generally poor and most of the area away from the river is muskeg or swamp. Rock exposures are rare except along the rapids.

The Precambrian-Paleozoic contact of the Hudson Bay lowlands is located just to the north of the area. The Paleozoic rocks consist of several sedimentary formations of Devonian age cut by a few basic dykes, whereas the Precambrian rocks are composed of a group of gneisses intruded by syenite, granite, pegmatite, diabase and lamprophyre. The restricted geological work done over a wider area indicates that similar conditions are present for some distance to the east and west, the only exception being the limited areas of Mesozoic lignite, sand and clay deposits which are found overlying the Paleozoic rocks.

Structural information is meager due to the drift cover. In the younger rocks north of the contact there are two structural basins in which the Mesozoic rocks are confined, and several folds. In the Precambrian area, the foliation of the gneisses strikes generally east and one or more fault scarps have been postulated on physiographic grounds. In the immediate vicinity of Otter Rapids, there is pronounced jointing and sheeting, two sets of minor faults, and (on physiographic evidence only) one or more major faults. Available information on the structure has led the writer to suggest certain additions and modifications to the hypotheses concerning the broader structural features of both the Precambrian and Paleozoic rocks. In brief, it is suggested that there is a wide band of parallel faulting in the Precambrian area and that movements along these faults produced some of the warping in the Paleozoic rocks.

The radioactive occurrences include a carbonate vein and certain pegmatites. The carbonate vein is in a zone of sheeting cutting most of the local Precambrian formations. It consists dominantly of dolomite, with feldspar, a little quartz and muscovite, several sulphide minerals, magnetite, hematite and a few unidentified opaque minerals. Efforts to locate the source of the radioactivity were unsuccessful, but it is apparently associated with the hematite. Pegmatite dykes are found cutting all rocks of the area except the diabase, lamprophyre and the carbonate vein; only some of them have radioactivity above normal. The minerals composing the radioactive pegmatites are mainly albite, biotite and quartz, with some microcline, zircon, monazite and a few rarely-occurring unidentified non-opaque and opaque minerals. In the field, the feldspars of these pegmatites are bright salmon pink in colour, surrounded by concentrations of small crystals of zircon and monazite. The radioactivity is due to the monazite.

Other minerals in the pegmatites are ilmenite and what is thought to be either specularite or a columbate mineral. In some places, concentrations of these are found near, but not in, strongly radioactive areas.

Economically, the deposits are of little value, since the highest "U_3O_8 equivalent" obtained from samples submitted for analysis was 0.12% for the vein material and 0.139% for the pegmatite, and, in both cases, thorium is the chief radioactive element present.

The laboratory investigation involved the separation of various mineral fractions followed by optical and chemical examinations.

PHYSIOGRAPHY

Topography

The area is characterized by almost monotonously low relief. Except for the steep-walled valley of Abitibi River, the gulches cut in these walls by short streams tributary to the river, and the drop over the low escarpment from the Precambrian to the Paleozoic rocks, there is no place where the local relief exceeds about 30 feet. Local elevations consist mainly of sand or gravel ridges of glacial origin and a few areas of outcrop.

Keele (7, p.32) has stated that, assuming a uniform slope, the following grades hold between Cochrane and James Bay:-

		Elevation	Gradient
Precambrian area:	Cochrane to Otter Rapids	911 to 425 ft.	$5\frac{1}{2}$ ft./mile
Escarpment:	Otter Rapids to Coral Rapids	425 to 305 ft.	30 ft./mile
Paleozoic area:	Coral Rapids to tide water	305 to 0 ft.	4 ft./mile

Kindle (11) gives the following additional data:-

		Distance	Drop	Gradient
Precambrian area:	Mouth of Fredrickhouse River to head of Lobstick Rapids	37 miles		2 ft./mile
	Lobstick Rapids to foot of Abitibi Canyon	$6\frac{1}{2}$ miles	234 ft.	36 ft./mile
Precambrian and Paleozoic:	Foot of Abitibi Canyon to James Bay	120 miles	406 ft.	3.4 ft./mile
	Otter Rapids (18 miles north of Canyon)		86 ft.	
Paleozoic area:	Foot of Otter Rapids to sea			2 ft./mile

He also states that on the Mattagami River at Long Rapids, the drop over the escarpment from the Precambrian to the Paleozoic totals 209 feet in a distance of approximately 15 miles. In several more recent publications some of these figures have been slightly altered.

"Barchans" southwest of Otter Rapids

R.C.A.F. Photograph A4352-49

North from the Canadian National Railways transcontinental line, Abitibi River flows almost magnetic north across the Precambrian area, but a few miles north of the contact, it veers to the east and continues in a nearly straight line to its junction with Moose River. Throughout most of this distance, the river maintains about the same width, contracting only at rapids. At the head of Otter Rapids (see Map 2), it is nearly one-eighth of a mile wide, then narrows abruptly to approximately 100 feet. A third of the way down it broadens out for a short distance and then again becomes narrow until the foot of the rapids is reached. From this point it regains its original breadth. The total drop is 87 feet in 1.8 miles and there is a potential horse-power of 42,530, exceeded in this respect only by Abitibi Canyon. For some distance above and below the rapids the banks rise steeply to heights of 60 to 75 feet and in some places they may be as much as 120 feet above the river.

An item of physiographic interest is the presence of a series of low, curved sand ridges southwest of the rapids, which, on examination of aerial photographs, strongly suggest somewhat eroded barchans, "frozen" by the growth of vegetation (see Plate II). The points of the crescents are generally to the southwest, whereas the presently prevailing winds seem to be largely from the northwest. This would suggest that at the time of their formation (possibly coinciding with the retreat of glacial Lake Barlow-Ojibway or the post-glacial marine invasion of the Hudson Bay Lowlands), some factor existed which exerted a strong control over the prevailing wind direction. This may have been the presence of a large body of water much nearer than any at present, or the front of the retreating ice sheet.

The low rock ridges east and west of the river usually trend about north. Other than the "barchans", the low ridges of sand and gravel do not show any particular orientation. Presumably, they are all of glacial origin.

The drainage of the area is generally poor. Large areas consist of flat or nearly flat muskeg or cedar and alder swamp, underlain by Pleistocene clay and till. The surface water cannot easily penetrate this layer, and the nature of the terrain has prevented, to date, the formation of a good drainage system. Only a few well-developed streams extend back into the muskeg area and reach the river at grade. Numerous gulleys have been cut into the banks of the river by short streams which drain the edges of the marshy areas, but only a few of these continue to run during dry periods in the summer.

A few marshy lakes are scattered through the muskeg region, but almost all are small. In the rare cases where a definite inlet or outlet can be determined from aerial photographs, these streams usually end in areas of swamp. Most of the lakes show a rude lineal arrangement that may reflect bedrock features since they lie about parallel to some of the more pronounced known or assumed structural features.

Vegetation

The vegetation of the area consists of three major groups. Along the river banks are spruce and poplar with some cedar and birch. On inland ridges the trees are largely jack-pine, with some poplar. In the muskeg dwarf black spruce, alders and swamp cedar, with small tamarac occur in the more open areas; the ground is covered with sphagnum moss, with clumps of Labrador Tea in some places.

Rock Exposures

In the Precambrian area rock exposures are rare, except for a strip 100 to 150 feet on each side of the more precipitous parts of Otter Rapids. Some small exposures occur along the river banks above the rapids and several areas more or less covered with overburden are to be found away from the river. Of the latter, the larger number are located between 3000 and 6000 feet east, with one area about 11,000 feet east of the river. All rise somewhat above the general level of the terrain but none forms a conspicuous landmark.

The Paleozoic rocks close to the contact are fairly continuously exposed along the river from Sextant Rapids to at least as far north as near Coral Rapids Station, but, to the writer's knowledge, no outcrops exist away from the river, (see Map 2).

DESCRIPTION OF FORMATIONS

General Statement

The rocks of the region range in age from Precambrian (Archean?) to Pleistocene. The area is probably best known for its deposits of gypsum and lignite of, respectively, Devonian and Lower Cretaceous (or Upper Jurassic) age.

A low escarpment trending east or northeast marks the boundary between the younger rocks (on the north) from the Precambrian rocks to the south. Only a few inliers of gneiss are found to the north of it.

A generalized geological column for the whole region, extending as far south as Abitibi Canyon and as far north as Moose River Crossing is given below. It is based mainly on the work of Dyer (12) but includes additional data from other sources.

Cenozoic	Pleistocene		Marine clays, glacial till, interglacial clay, and peat.
	---- Unconformity ----		
Mesozoic	Lower Cretaceous or Upper Jurassic	Mattagami	Fire clay, sand, and lignite
	---- Unconformity ----		
Paleozoic	Upper Devonian	Long Rapids	Petroliferous black and grey shales
		Williams Island	Limestone and calcareous shale.
	Post Middle Devonian		Lamprophyre dykes, augite peridotite dykes
	---- Igneous Contact ----		
	Middle Devonian	Abitibi River	Grey fossiliferous limestone
	Middle or Lower Devonian	Moose River	Limestone and gypsum
	Lower Devonian	Sextant	Arkose, clay, etc.

---- Unconformity ----

Precambrian	Keweenawan (?)	Diabase dykes
	Archean (?)	Granite pegmatite, Biotite augite granite, Syenite, gabbro and anorthosite.
		Granite gneiss, biotite and hornblende granite gneiss, biotite syenite gneiss, biotite garnet gneiss, pyroxenite gneiss.

Regional Geology

Cenozoic

Keele's study of the unconsolidated deposits of the area (7) led him to state that the area is almost entirely covered with a glacial till sheet, the materials of which were derived from the Hudson Bay Lowlands. This sheet slopes gently to the north with small local depressions in which deposits of peat have accumulated. There is no definite evidence of multiple glaciation but there are indications of minor retreats and advances of the ice as shown in some localities by stratified sands with till above and below. Clay beds which have been called interglacial by previous workers, Keele states to be pre-glacial in age.

The most widespread member of the glacial deposits is boulder clay and till;many of the pebbles and boulders in the till are limestone similar to that underlying the lowlands. Glacial sands and gravels break the continuity of the till in places; one deposit of these is located between Otter and Sextant Rapids. Several gravel pits, from which railway ballast has been obtained, are located south of the station of Coral Rapids (See Plate I). Other small deposits composed of stone-less glacial clays, swamp clays and flood plain silts are locally present.

Mesozoic and Paleozoic

The Mesozoic rocks are concentrated in two known basins, one between the Mattagami and Missinabi Rivers near the Precambrian escarpment and the other on the Abitibi River centering about Onakawana. The deposits consist of lignite, fire clay and silica sands.

Briefly considered, the Paleozoic rocks are almost exclusively sedimentary, consisting of limestones, both fossiliferous and non-fossiliferous; dolomitic limestones; grey, greenish, black and red shales and clays, some containing plant fragments; green, grey, yellowish brown and gypsiferous sandstones; and green, grey, buff, white and red arkoses of highly variable grain size. (12). In the region under consideration they are all of Devonian age, but to the west and northwest rocks of Ordovician and Silurian age occur.

Very complete descriptions of the Mesozoic and Paleozoic sediments are contained in Dyer's 1928 report (12), but, since the present work is concerned principally with the Precambrian rocks of a small portion of the region, no valuable purpose would be served by reproducing any of his statements, beyond the outline given above and the previously noted geological column.

No areas of younger rocks are known south of the escarpment. However, on the large island at the south end of Otter Rapids, the writer found a lenticular mass of fine-grained, cream-coloured limestone about five feet in diameter, and possibly eight inches thick, which shows numerous fractures and the remnants of what may have been a gastropod shell. The limestone is located in a slight hollow in the gneiss at the crest of the island and may possibly be in place.

The Post-Middle Devonian dykes in the Paleozoic area closely resemble certain dykes cutting Precambrian rocks to the south. Thus, this is one of the relatively few places in the Canadian Shield where intrusions younger than Precambrian are found (22). A specimen taken by W.J. Wilson from one such dyke at Sextant Rapids was described by O.E. LeRoy (3, p.235) as follows:

" The hand specimens represent a very dark, almost black augite lamprophyre of a type closely allied to the monchiquites. The section consists of aggregates of calcite and serpentine as pseudomorphs after olivine; and pale brown and pink ideomorphic augites in a ground mass of augite, shreds of biotite, calcite, chlorite, magnetite and fibrous zeolite."

The zeolite was later examined by N.L. Bowen (8) and found to be a new species which he named "Echellite", and suggested that it was the alteration product of zoisite. However, in 1933, he stated that his findings were based on an incorrect analysis and that the mineral was thomsonite (16).

Hogg (22) found what he describes as an augite peridotite dyke cutting Precambrian syenite, that closely resembles the Sextant Rapids dyke and is in turn cut by a narrow lamprophyre dyke, very similar to narrow lamprophyres cutting the Sextant dyke.

Precambrian

The predominant rocks of the region are a series of gneisses cut by various intrusions. Descriptions of gneisses from widely separated areas would appear to indicate that there are several types more or less widely distributed throughout the region.

Wilson (3) briefly notes reddish granitoid gneiss and micaceous rusty gneiss at the north end of Otter Rapids Portage and garnetiferous gneiss at the south end. He gives more detailed descriptions of a well-foliated rusty gneiss between Rocky and Lobstick Portages and a garnetiferous biotite syenite gneiss south of Lobstick Portage.

J.M. Bell (5) describes thin sections of specimens from two widely separated areas; a well-foliated acidic gneiss relatively low in ferromagnesium minerals and a basic gneiss from the Wabiskagami River, and more siliceous, massive basic and acid gneisses from the Nettagami River (See Map 1). He believes the gneisses of both areas to represent altered acidic and basic igneous rocks. The acid phase is apparently a coarse-grained biotite gneiss, probably originally a granite. He also mentions that garnetiferous and hornblende gneisses are very common, the latter grading into the basic variety.

Cross (7) mentions basic gneisses near Lobstick Portage on the Abitibi River, which consist of biotite and garnetiferous biotite gneisses "with occasional small segregations of pyroxenite". Parks (2) had previously called these "augite syenite". They grade into a gneissic phase of the Abitibi Canyon gabbro. Below the canyon, biotite syenite gneiss is noted in isolated outcrops as far as the foot of Otter Rapids. On the Mattagami River, the gneisses are hornblende and biotite granite gneiss as far north as the junction with the Kapuskasing River, then become more basic with hornblende replacing the biotite. From the foot of Little Long Rapids to the northernmost Precambrian exposure the gneiss is highly garnetiferous. Hogg (22) mentions a gradation from biotite syenite gneiss to biotite garnet gneiss at Otter Rapids.

Other rock types of the region are found in an intrusive mass which includes gradations through augite gabbro, hypersthene gabbro to anorthosite at Abitibi Canyon (Wilson (3) and Bell (5)), granite between this point and Otter Rapids (Wilson (3)), and granite and syenite at Otter Rapids (Hogg (22)).

Pegmatites are noted by Wilson (3) at the north end of Otter Portage and between Otter Rapids and Long Portage. Bell (5) believes them due to the refusion or recrystallization of the gneisses. Cross (7) states that pegmatite dykes are very abundant in the biotite and garnetiferous biotite gneisses, syenites and granites. Dyer (12) notes pegmatite dykes to be plentiful, particularly so on Mattagami River.

The more basic dyke rocks have been divided into two major types by Bell (5), a "diabase-dolerite" and a "diabase-porphyrite" both from the Nettagami River near the north boundary of the Precambrian.

Wilson (3) notes diorite dykes at the south end of Otter Portage. Cross (7) notes "quartz-diabase, olivine-diabase and more basic varieties with magnetite and probably containing ilmenite" as well as the augite peridotite dykes mentioned above. Lamprophyres have been reported only from the vicinity of Otter Rapids (22, p. 4).

Local Geology

Gneisses

For the purpose of field classification the gneisses were grouped into the following four main types, depending on the most conspicuous minerals present.

Garnet-biotite gneiss
Biotite granite gneiss
Biotite syenite gneiss
Pyroxenite gneiss.

Examples of the second and fourth types are relatively rare.

Clear cut contacts between the various kinds of gneisses are very rare. An outcrop may consist of (a) a single type, (b) two types grading almost imperceptibly into each other, or (c) two types of markedly dissimilar mineral composition separated by a pegmatite body. One of the very rare cases where one type is in sharp contact with another is on a small island in the rapids. Here a garnetiferous gneiss and a micaceous gneiss are separated by a narrow, lenticular mass of pyroxenite gneiss about three feet long and one inch wide. This narrow lens is parallel to the general strike of the foliation and is cut off at either end by pegmatite.

In a few places, particularly along the upper part of the rapids, narrow bands of biotite schist up to four inches wide were found cutting the gneisses, commonly about parallel to the foliation but in places crossing it at a small angle.

Due to the scattered nature of the outcrops (see Map 2) and to the erratic distribution of the various types of gneisses it was difficult to determine their areal distribution. However, the garnetiferous gneiss appears to be somewhat more prevalent along the banks of Otter Rapids than inland to the east. Throughout most of the area the gneisses were not subdivided during mapping and are shown on Map 2 as "undifferentiated".

The following are generalized descriptions of the various types and indicate the gradation between them. The minerals were determined megascopically.

The garnet-biotite gneiss usually shows a grey weathered surface, occasionally stained with yellow or rusty brown, and is mottled with red garnets. The fresh surface is a darker grey. The grains of the groundmass range in size from about $\frac{1}{2}$ to 2 mm, the larger being the more common. The garnet porphryblasts are generally about 2 to 3 mm in diameter, although they are found up to a centimeter across. The texture of the groundmass is normally xenoblastic, whereas the garnet is always idioblastic. The foliation is gneissic in form and usually can be clearly seen on the weathered surface, but in places it may be so fine as to be nearly schistose. In the hand specimens, the minerals composing this type of gneiss are garnet (45%-20%), biotite (30%-10%) and feldspar (50%-20%). Quartz is found in some specimens and pyroxenes or amphiboles in others, but rarely amounting to more than 5% in either case.

The biotite granite gneisses are characterized by appreciable amounts of visible quartz. On the weathered surface they are a rusty or yellow brown, whereas the fresh surface is grey or brownish grey, occasionally mottled by small red garnets. The grain size of the groundmass is relatively fine, ranging between $\frac{1}{2}$ and 1 mm and the garnets, when present, are up to 2 to 3 mm. The texture of the groundmass is xenoblastic and the garnets are idioblastic in form. The structure is decidedly gneissic and shows compositional banding. The minerals present are quartz (40%-30%), feldspar (30%-20%), biotite (35%-25%) and garnet (15%-5%).

In contrast to the above, the biotite syenite gneisses contain no visible quartz, but have considerable amounts of feldspar. Weathered surfaces are yellow brown, rusty brown, dull grey or grey black, in places with rust stains. Fresh surfaces are yellow brown, greyish brown, light grey or grey black. The grain size ranges between $\frac{1}{2}$ and 2 mm with the larger sizes being rare. The texture is xenoblastic, and the gneissic structure is in places almost lacking. Minerals recognized in hand specimens are feldspars (70%-30%), biotite (40%-10%) and garnet (20%-0%). Other minerals believed to be present are chlorite, magnetite and pyroxene or amphibole.

The fourth, rarely-occurring type of gneiss is greyish black on the weathered surface and black on the fresh surface. The grains are usually fine (1 mm), xenoblastic, and finely foliated. Minerals present are biotite (50%), feldspar (20%), pyroxene (30%) and a small quantity of what may be magnetite. This closely resembles the pyroxenite gneiss described by Cross (7) and for that reason has been tentatively named "pyroxenite gneiss".

Syenite and Granite

Apparently cutting the gneisses are various phases of syenite and granite. These are found to the north of the Mosher vein, on either side of the rapids and in one outcrop about 8000 feet to the east. In some places these rocks are quite fresh in appearance, while in others they show some foliation, about parallel to that of the gneisses.

In the field the syenite has a pinkish grey weathered surface, whereas the fresh surface is a medium grey showing a salmon pink mottling. The rock is medium-grained, the crystals being about 2 to 3 mm in diameter with a tendency towards a porphyritic texture. Feldspar is the predominant mineral with about 35% of the rock being a greenish white variety and another 25% consisting of pink crystals. Other minerals present are biotite (30%) and a ferromagnesium mineral (10%) which resembles augite.

The granite is greenish grey on the weathered surface and brownish grey on the fresh surface. The grain size is medium (2 to 3 mm) but feldspar phenocrysts up to 8 mm across in places give the rock a porphyritic texture. The minerals are quartz (35%), pink and white feldspars (50%) and biotite (15%). An outcrop of gneissic granite on one of the islands in the rapids shows a rude "augen" structure, with quartz "eyes" measuring about 8 mm by 2 mm.

Pegmatites

The garnet-biotite gneiss, the biotite syenite gneiss, the granite and syenite are cut by pegmatite dykes of irregular shape and size, ranging from narrow stringers to large irregular masses as much as 150 feet long by 50 feet wide. They form two major sets nearly at right angles to each other, striking approximately northeast and northwest respectively. In some areas lit-par-lit injections of the pegmatite into the gneisses were observed and associated with these injections are small stringers of yellowish or bluish quartz. Most of the pegmatites are composed of large crystals of pale pink feldspar with relatively little quartz and scattered books of biotite up to three inches in diameter.

At various places, pegmatites of a different type were found. These are the pegmatites which show radioactivity above the normal. Their most pronounced characteristic is the bright salmon pink colour of the feldspars. The occurrence and mineralogy of such pegmatites is described in more detail on pages 37 to 40.

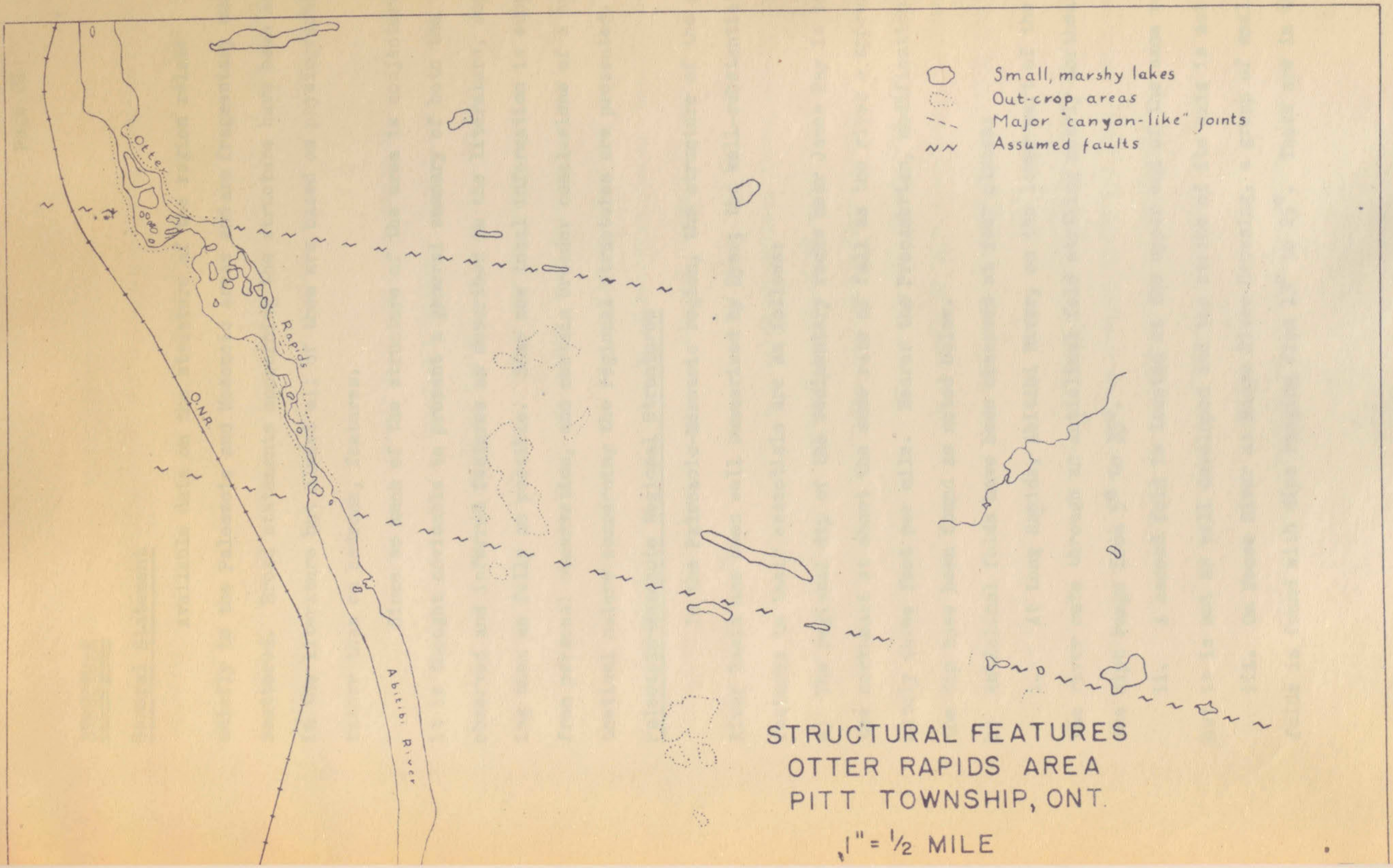
Diabase dykes

Younger than the pegmatites and other previously mentioned rocks of the region are a group of diabase dykes. These occur at several places along the banks of Otter Rapids and strike east or north. In many places they form the floors of steep-walled gullies, due probably to more rapid erosion, and this is believed to be one reason why none were encountered more than a few hundred feet away from the river.

A common outstanding characteristic of the wider dykes is their porphyritic appearance, due to large greenish crystals of feldspar. Mr. Hogg reports that a thin section of the diabase showed neither quartz nor olivine.

Lamprophyre dykes

Narrow, fine-grained lamprophyre dykes are the latest rocks of the area and have been called Post Middle Devonian because some cut augite peridotite dykes of this age. It has also been suggested that there is a close relationship between the lamprophyres and the radio-active vein (22).



STRUCTURAL FEATURES
OTTER RAPIDS AREA
PITT TOWNSHIP, ONT.

MAP 3

STRUCTURE

General Statement

Available data on the structure of the region relate chiefly to the Paleozoic and Mesozoic areas and are fragmentary and scattered. Broad statements concerning the structure have been made in the literature but almost all of them are based on physiographic, rather than on bedrock, features.

Since so much of the structure of the area is conjectural, it is thought advisable to present a general summary of both the observed and inferred features as described in the literature, separating them as fully as possible. Some new local information is supplied from personal observation, and certain broader conclusions of a hypothetical nature concerning the regional structures are presented.

Paleozoic-Mesozoic Regional Structures

In the Paleozoic-Mesozoic region, the structure of the Moose River Basin has been well summarized by Dyer; the well-substantiated features in their essentials are as follows:

a) The regional dip of the sedimentary rocks near James Bay is to the northeast at about the same rate of fall as the river - approximately three feet per mile. Nearer the Precambrian, modifications in the dip have been found as noted below.

b) Anticlinal folds have been observed at four places:

i. At Long Rapids, Abitibi River, on the lower part of the rapids, the river cuts through an anticlinal fold striking nearly northeast. The dips range from 5^{o} to 35^{o}.

ii. A second fold is located at the upper end of the same rapids, but it is not as well developed and the strike of its axis is not known.

iii. On Moose River at Moose River Crossing, a group of small folds is found with dips ranging from 13^{o} to 25^{o}. These are in the vicinity of the Moose River gypsum deposits.

iv. At Grand Rapids on the Mattagami River a broad fold occurs of which little seems to be known, except that dips are to the north and south.

c) Two structural basins, to which the preservation of the Mesozoic lignite deposits are ascribed, are located near the southern boundary of the sedimentary rocks.

i. The largest lies north of the Precambrian-Mesozoic contact between the Mattagami and Missinabi Rivers. On Mattagami River, Mesozoic rocks are present at the foot of the Precambrian escarpment and as far to the northeast as Grand Rapids, where Paleozoic sediments dip south and do not reappear. Very recently, a deep diamond drill hole in Sanborn Township, located in the northeastern portion of this basin (see Map 4) has cut 300 feet of Devonian rocks. The 700 feet of overlying unconsolidated material was not recognized as being of Mesozoic age (26).

ii. The second basin is located on Abitibi River, centering about Onakawana. It has a north-south width of 35 miles from the foot of Long Rapids to Moose River Crossing, and unknown east-west dimensions. A deep drill hole in this area (13, p. 86) which went into highly weathered Precambrian rock at a depth of 1027 feet, plus the known dips of the Paleozoic rocks to the north, south, and west, supply the main evidence for this basin.

d) Faulting: No definite faults are known but brecciation of the sediments has been reported from several areas (5) (12). This may be of only a minor nature and not due to major faulting.

Inferred structural features presented in various reports include:

Folds, comparable to those that are known, may exist beneath the overburden (13). The northeast strike of the axis of a fold at the foot of Long Rapids on Abitibi River is in direct line with an inlier of Precambrian gneiss on Little Abitibi River which is overlain by arkose and Devonian sediments. The fold is presumed to continue at least to this point (12).

Three possibilities are suggested by Dyer (12) for the continuity and extent of the structural basins.

i. The Onakawana basin is a northeast extension of the Mattagami basin.

ii. The Grand Rapids-Mattagami River anticlinal fold may form a division between the two basins.

iii. The extension of the Mattagami basin west to the Missinabi River is suggested by the apparent continuity of Mesozoic sediments and lack of Paleozoic sediments in that direction.

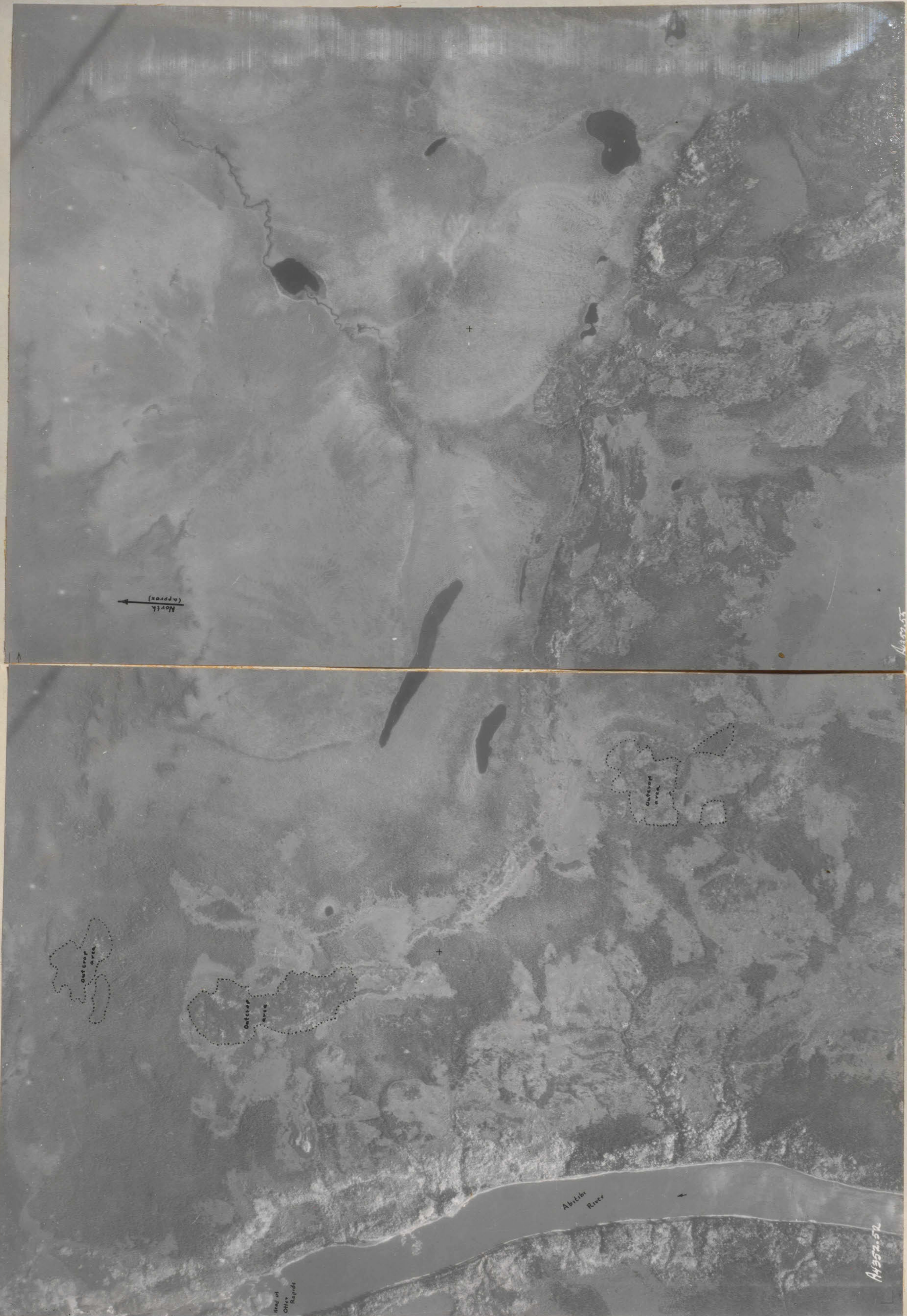
A fault having "a few hundred feet of throw" is believed to exist at the contact of the Precambrian with Mesozoic rocks on the Mattagami River (11). Here the Precambrian rocks rise in an escarpment 100 feet above the river, whereas a drill hole a few hundred feet to the north was still in Mesozoic sediments at a depth of 128 feet. Another fault, possibly a continuation of the first, is believed to exist between the Precambrian and Mesozoic rocks on the Opazatika River (11).

Age of the folding and faulting

Based on the conformable relationship of the Cretaceous and Devonian rocks, it is thought by Dyer (12) that the main folding and inferred faulting is Cretaceous or Post-Cretaceous in age. Pre-Cretaceous folding on a smaller scale is thought to have resulted from the intrusion of dykes at Coral and Sextant Rapids on the Abitibi River. (13). The small folds at Moose River Crossing are considered the

Area southeast of Otter Rapids
showing string of marshy lakes
extending approximately S75°E
from the head of Otter Rapids.

R.C.A.F. Photographs A4352-52 and A4352-55


North (approx)
Outcrop area
Outcrop area
Outcrop area
Abitibi River
Head of Otter Rapids
A4352.55
A4352.52

result of either the transformation of anhydrite to gypsum or the intrusion of dykes.

Precambrian Structures

The only observable regional structure in the Precambrian rocks is the general easterly strike of the gneissic foliation. The dip of the foliation is very erratic. All other structures have been inferred from the physiography.

By inference, major structures have been suggested by Kindle (11) and Dyer (12) (13); and the writer offers additional regional interpretations based on the study of aerial photographs and maps. (see Structural Hypothesis).

Aerial observations made by the Ontario Department of Lands and Forests (9) and data on elevations along the Abitibi River from the preliminary survey for the Ontario Northland Railway, led Kindle (11) to believe that there are one or two scarp-like slopes facing the Paleozoic rocks. The major scarp is believed by him to run in a southeasterly direction from the point where the Mattagami River leaves the Precambrian rocks, through Abitibi Canyon and thence towards the Quebec boundary. A secondary scarp of lesser magnitude is suggested to follow the contact between the Precambrian and younger rocks, at least between the Mattagami and Abitibi Rivers and probably farther to the east and west. These scarps are compared to the fault line scarp north of the Ottawa and St. Lawrence Rivers as postulated by Kindle and Burling (6). Dyer (12) (13) subscribes to the idea of a belt of faulting which corresponds to Kindle's major escarpment, whereas Keele (7) had thought earlier that a scarp exists at or near the contact.

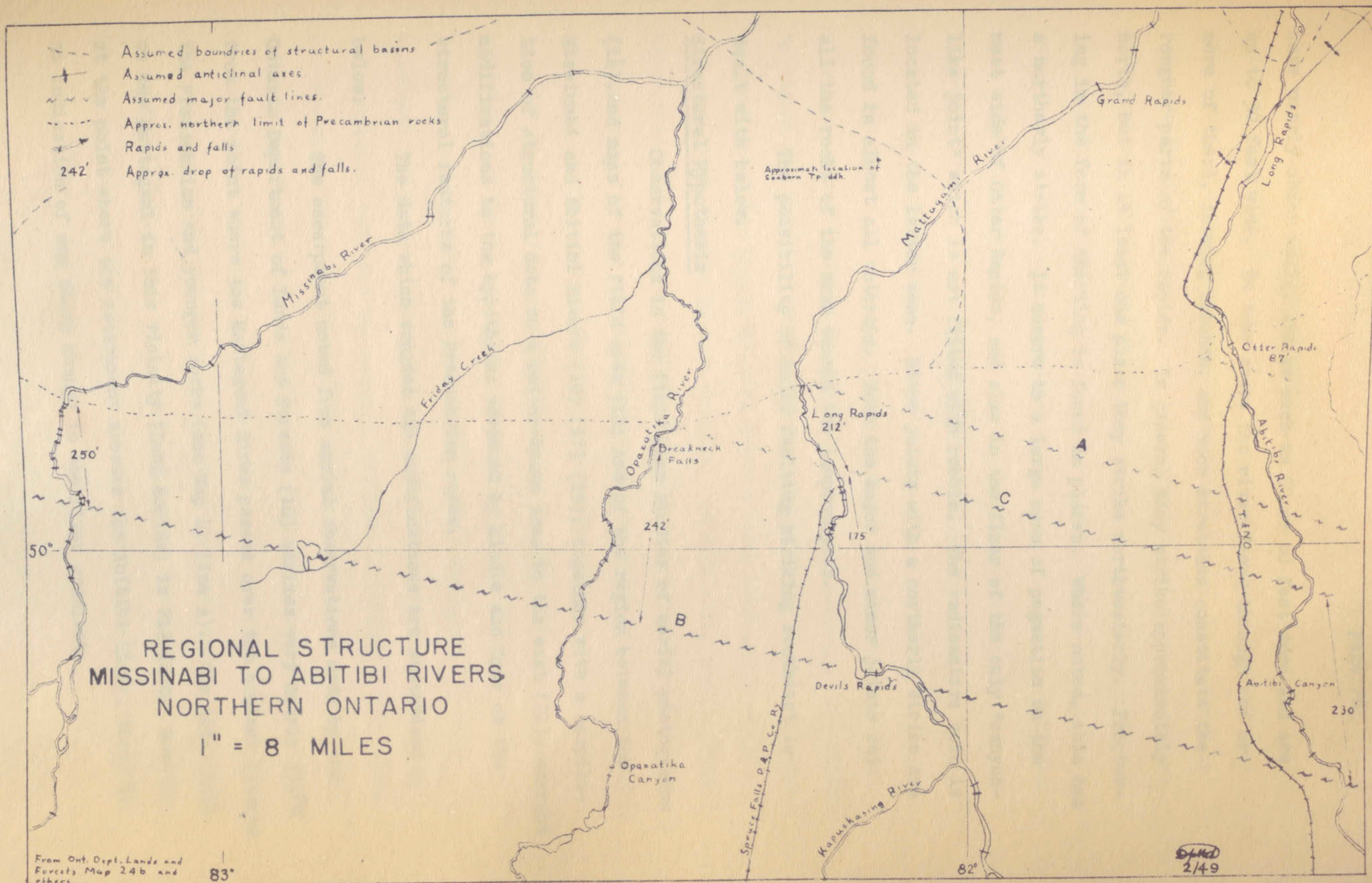
In contrast to these hypotheses, A.W.G. Wilson (4) had suggested at an earlier date that the Precambrian Shield surface consists of a series of "faceted" erosion surfaces. These facets represent erosion surface remnants including: (1) Precambrian peneplains which underlie the Paleozoic rocks and are exposed at the Shield boundaries; (2) Paleozoic peneplains which bevel both the Paleozoic and Precambrian rocks; (3) still younger peneplains developed on the Shield area alone. According to this hypothesis the inclination of the surfaces increases as the boundaries of the Shield are approached, with the older having the greatest gradient. However, his data were obtained in areas north of Lake Ontario and in the vicinity of Lake Winnipeg, where the structural relationship between Precambrian and Paleozoic rocks differs quite markedly from that north of the Ottawa-St.Lawrence valleys or south of James Bay.

In the vicinity of Otter Rapids, the prevailing strike of the foliation of the gneisses is, as elsewhere, approximately east, but it varies locally as much as 90°. In some cases this aberrant strike can be traced into areas where it becomes more nearly normal. The dips are highly variable, ranging from nearly vertical to nearly horizontal and suggest considerable folding. In one case, tight folding can be seen in a steep wall on an island in Otter Rapids.

Very minor faulting was noted in several areas, usually with a measurable strike or dip separation of only a few inches. Such faults strike either about N20°-30°E or about N75°-80°W. In the second case, the fracturing usually cuts across the foliation at a small angle. Both these sets of fractures are known to cut the gneisses, syenite and pegmatites of the area but no evidence of their cutting the diabase and lamprophyre dykes is known. On the other hand, there is no evidence to show that these intrusions are post-faulting.

One of the most prominent features of the Otter Rapids area are numerous "canyon-like joints" (22) (see Plate IV), apparently formed by erosion along zones of weakness caused by sheeting. These

MAP 4



Assumed boundries of structural basins
Assumed anticlinal axes
Assumed major fault lines.
Approx. northern limit of Precambrian rocks
Rapids and falls
242' Approx. drop of rapids and falls.
REGIONAL STRUCTURE
MISSINABI TO ABITIBI RIVERS
NORTHERN ONTARIO
1" = 8 MILES
Missinabi River
Friday Creek
Opazatika River
Mattagami River
Abitibi River
Kapuskasing River
Grand Rapids
Long Rapids
Otter Rapids
87'
Long Rapids
212'
Breakneck Falls
242'
175'
250'
230'
Devils Rapids
Abitibi Canyon
Opazatika Canyon
Approximate location of Sanborn Tp ddh.
T&NO
Spruce Falls P&P Co Ry
A
B
C
50°
83°
82°
From Ont. Dept. Lands and Forests Map 24b and others
2/49

have nearly sheer walls, are as much as 50 or 60 feet deep and are up to 30 feet wide. In some cases the river flows through one or more of these, forming islands, and such stretches constitute the rougher parts of the rapids. In general they strike approximately north, but in at least one place they strike northwesterly. Fracturing in the form of sheeting is found in places. Where noted, this has a northerly strike. It occurs in a large mass of pegmatite on the west side of Otter Rapids, and also in the floor of the only "canyon-like joint" which is not filled with rubble. The radioactive vein is located in the latter zone. Minor joints with a northerly strike are found in almost all outcrops. Both the major and minor joints cut all the rocks of the area except the lamprophyres.

The possibility of major faulting striking southeast is dealt with below.

Structural Hypothesis

Observations in the field plus studies of aerial photographs (14), and maps of the field area (18) and of the region between the Missinabi and Abitibi Rivers (10) (17) (19), together with a compilation of structural data on a better-known area to the east (21), warrant modifications to the hypotheses advanced by Kindle and Dyer on the structural features of the Precambrian rocks.

The data which suggest the modifications are summarized below:

The escarpment noted from aerial observations made by the Ontario Department of Lands and Forests (10) strikes very nearly S75°E from the point where the Mattagami River passes over the contact between the Precambrian and younger rocks (see Map 4, line A). The total fall on the Mattagami in this vicinity (Long Rapids) is 212 feet. However, at the point where the escarpment crosses the Abitibi River, there is no indication of any sharp change in the river gradient.

In the vicinity of Otter Rapids (see Map 3 and Plate III) a string of elongated marshy lakes extends approximately S75°E from the head of the rapids. Northerly-trending outcrop ridges occur on either side of this line but the chief group to the south lies about 4000 feet east of those to the north. Farther north, the rapids widen abruptly for a short distance at the north end of which the river swings sharply to the west. A line striking approximately S80°E from this deflection passes near two small lakes that are elongated along the same strike. Other less well defined lineaments with similar strikes may be found on the aerial photographs.

Examination of regional maps of the area between the Missinabi and Abitibi Rivers discloses certain relationships. The Abitibi, Mattagami and Missinabi Rivers all flow nearly north towards the edge of the Precambrian Shield but each makes a sharp bend to the west, after which they again swing northwards. In each case, from near the point where the river swings west there are a series of rapids and falls extending to the edge of the Shield area. The bends lie on a straight line that strikes about S75°E (Map 4, line B). If another parallel line (C) is drawn from Breakneck Falls on the Opazatika River, the total drop of the rapids and falls between the two lines (B) and (C) is of the order of 200 feet (Abitibi 230 feet; Mattagami 175 feet; Missinabi 250 feet). Somewhat similar conditions are to be found on the Opazatika, but here the swing to the west is farther to the south and the river does not parallel the other major rivers. However, the drop of rapids and falls north from the previously mentioned line (B) to the foot of Breakneck Falls totals 242 feet. It should be noted that the drop shown for the Mattagami River does not include the final drop of Long Rapids, and on the Missinabi River the drop represents only the distance between lines (B) and (C) which lies within the Shield area. Further, since the only available figures were for the drop of the rapids and falls alone, the total figures do not represent the total fall of the rivers.

On the basis of information gained from the Sanborn Township drill hole and the earlier Onakawana drill hole it has been possible to obtain the elevation of the Abitibi River formation at these points. These are, respectively, approximately 400 feet and 680 feet below sea level. The gradients of this formation from Grand Rapids on the Mattagami River to the Sanborn drill hole, north from Long Rapids on the Abitibi River, and south from Moose River Crossing to the Onakawana drill hole, are very close to 50 feet per mile in all three cases.

The Kapuskasing River and several smaller streams, as well as portions of the main rivers of the region flow approximately northeast.

From the above somewhat fragmentary data, and assuming that the major rivers draining into the Moose River are influenced by bedrock features rather than the overlying drift cover, the following interpretation of the regional structure has been made.

Instead of two fault line scarps trending southeast as described by Kindle, there is probably a wide band of parallel or subparallel faults along each of which the northern block has moved relatively westwards and, possibly, downwards at the western end. The blocks are cut by two sets of transverse fractures striking about north and northeast.

Movement along these assumed faults has probably been recurrent, and, at one stage, may have produced some of the folding in the Paleozoic rocks and possibly played some part in the formation of the "structural basins".

This interpretation is based on the following:

a) At Otter Rapids there may be assumed at least one, and possibly two or more faults or fault zones striking about S75°E, on which the northern block appears to have moved in a westerly direction, as indicated by the alignment of the lakes and displacement of the outcrop areas and the river. It seems probable that other similar fractures are present, forming a series of slices.

b) Between the Missinabi and Abitibi Rivers there are apparently two or more major fault zones which have the same strike as those above, and along which there has been the same relative horizontal movement with the northern block moving to the west, as indicated by the rivers following portions of the assumed fracture zones.

c) The limited data on the stream gradients might be taken to indicate rotational movement, with the western end of each slice being moved down relative to the adjacent block to the south.

d) The uniform northeasterly trend of the Kapuskasing river and portions of other rivers and streams, and the northerly trend of the Missinabi, Mattagami and Abitibi Rivers, may indicate a structural control. Locally at Otter Rapids a similar pattern of northeasterly striking faults and northerly striking zones of sheeting are present.

e) The fold at Long Rapids on the Abitibi River, which has its axis very nearly at right angles to the strike of the major faults could have formed either by compression due to the westerly movement of the Precambrian rocks, or by uplift of the basement rock. The occurrence of the Little Abitibi River Precambrian inlier in direct line with the strike of the axis of the fold, would seem to indicate that the second possibility is more nearly true. Either or both of these possible causes may explain some of the other folds of the area.

f) The slight gradient of the limbs of the structural basins indicates that they are due to either the initial dip of the sedimentary rocks or to gentle warping. The postulated down warping of the western ends of the fault blocks may have aided in the development of these basins.

Some of the above conclusions on the regional structure resemble in considerable detail the structure of a better-known area in Quebec, lying between latitude 50° and latitude 49°, the Ontario boundary on the west and the Grenville gneisses to the east and south-east. Claveau (21) has summarized the literature of this area, particularly as it concerns the structure, and finds two general types of faults and fault zones. These are "strike faults" which are about parallel to the greenstone belts (west to northwest) and "cross faults" striking variously northeast, north and northwest. The former are considered to be pre-Huronian in age and the latter post-Huronian. The assumed faulting of the region between the Missinabi and Abitibi Rivers which strikes S75°E may correspond to these "strike faults", while the northerly trend of the Missinabi, Mattagami and Abitibi Rivers, the northeasterly trend of the Kapuskasing and portions of other rivers, and local fracturing at Otter Rapids may correspond to the "cross faults".

If these assumed fractures are comparable with those to the east, it seems likely that movement has been recurrent along them. The "strike faults" to the east in Quebec are called pre-Huronian and their possible equivalents in Ontario may be the cause of Devonian or post-Devonian folding. The time of the formation of the structural basins is probably Cretaceous or post-Cretaceous, and may represent the most recent adjustment along the assumed fractures.

RADIOACTIVE OCCURRENCES AND MINERALOGY

Radioactive occurrences of possible economic value in the Otter Rapids area include a radioactive carbonate vein (the Mosher vein) and radioactive pegmatites. These deposits were investigated in the field by standard geological methods as well as by Geiger-Mueller counter traverses. Later some of the radioactive and associated minerals were studied in the laboratory by optical and chemical methods. Tests for radioactivity were made in order to isolate the source of the radioactivity.

The portable Geiger-Mueller counters used in the field were of two types, both of which are manufactured by Electronic Associates Limited of Toronto.

The larger, known as the EA-130, has three Geiger-Mueller tubes with a total cathode projected area of about 18 square inches (24). It is powered by an "A" and a "B" battery of the portable radio type and has two electronic circuits, one of which serves to step up the voltage across the Geiger tubes to approximately 1000 volts, the other being an amplifying circuit. Changes in radioactivity are noted audibly by the increase or decrease in clicks heard through the ear-phones with which the instrument is equipped, and visually by means of a micro-ammeter dial. Three ranges of sensitivity are possible, the 2M, the 10M and the 50M scale, each one-fifth as sensitive as the previous one. The instrument weighs 12 pounds and is carried over the shoulder in a haversack-type bag.

The smaller instrument, the EA-100, or prospector model, is similar in most respects except that it has only one Geiger tube with an effective projected cathode area of 2.2 square inches, there is no micro-ammeter, and the sensitivity is fixed. The weight of this instrument is $6\frac{1}{2}$ pounds.

The sensitivity of the device is indicated by the fact that the background count in the Otter Rapids area ranged from about three micro-amperes to about ten micro-amperes on the 2M scale of the EA-130 instrument, with a normal of about eight micro-amperes. Over pegmatites the background was usually appreciably higher varying from 15 to 30 micro-amperes on the 2M scale.

The EA-100 instrument is somewhat less sensitive than the larger model, but the experienced operator could generally detect increases which were approximately equivalent to 10 to 15 micro-amperes on the 2M scale of the larger model.

In their report on Cardiff and Monmouth Townships, Wolfe and Hogg (23) give the following information on the sensitivity of the EA-130 type counter:

> "In theory the 10M scale gives readings a fifth as great as those on the 2M scale, and the 50M scale gives readings a twenty-fifth as great as on the 2M scale or one-fifth as great as those on the 10M scale. In practice, however, it was found that this is not the case and that scale readings are not directly comparable."

Also, based on experience gained in the field, it seems probable that direct comparisons of readings from this type of counter should not be made except as a general indication of the relative radioactivity, since the sensitivity of the instrument depends a great deal upon the so-called "plateau" of the Geiger-Mueller tubes, which falls off somewhat with usage, particularly so if the tubes have been exposed to intense radiation. For the same reason, comparison of readings between two instruments may show considerable variation.

By employing a formula using the meter reading, scale factor, distance (squared) and a constant, a rough quantitative expression of the "radium equivalent" may be obtained with the EA-130. A more exact "radium equivalent" is possible by calibrating the instrument with a 50 milligram radium equivalent constant supplied by the company (24).

It would appear that, for a direct comparison of the radioactivity, the "radium equivalent" obtained by the second method is the most reliable.

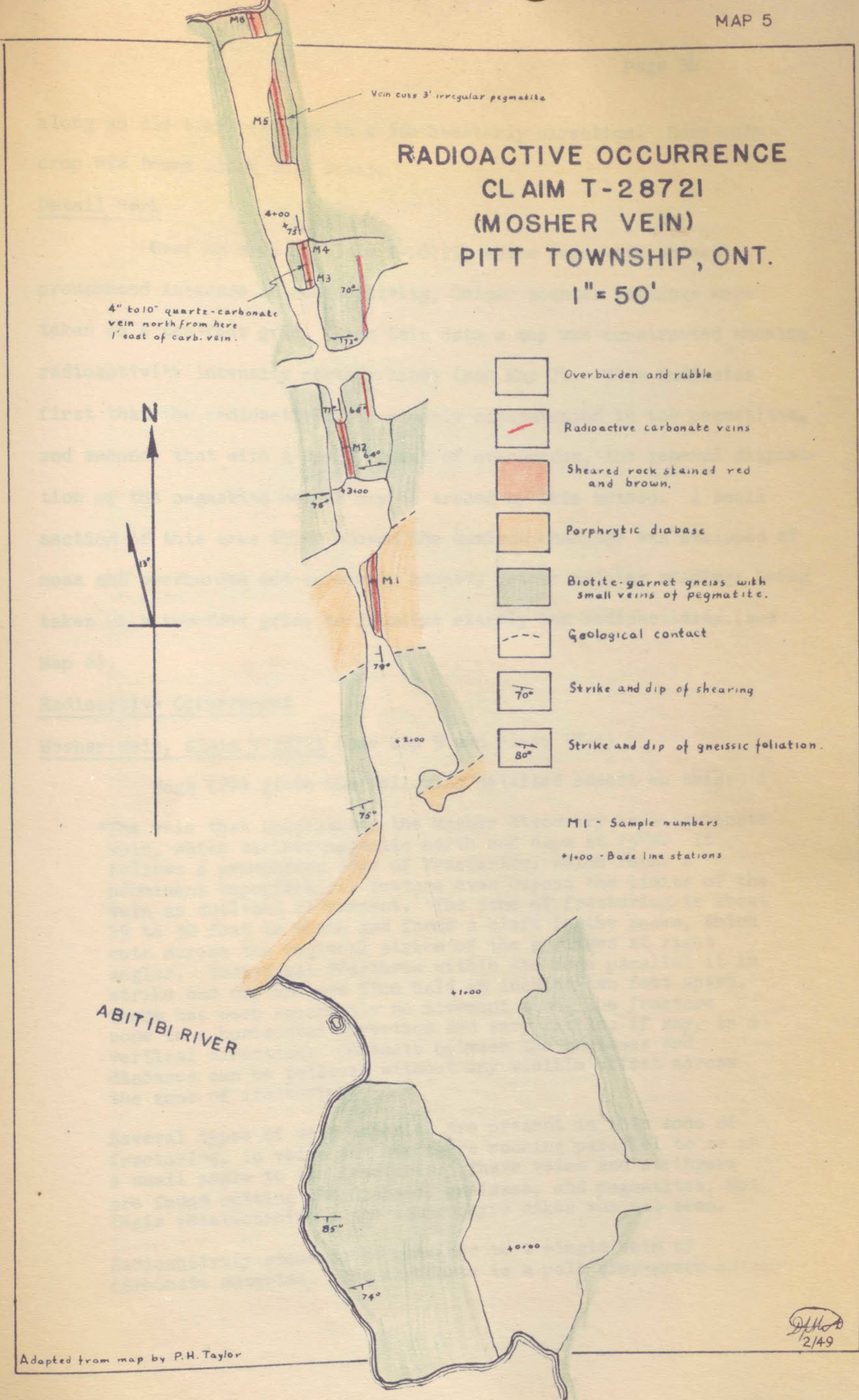
On the accompanying maps and plans, EA-130 Geiger counter readings are indicated symbolically thus - 20/2, 10/10, 14/50, etc. The first figure indicates the reading on the micro-ammeter scale, and the second indicates the sensitivity setting. For example, 20/2 indicates a reading of 20 micro-amperes with the instrument set at 2M.

General Procedure of Geiger Traverses

The general plan of work was to run systematic east-west traverses over all the claims at intervals of 300 to 400 feet, with more detailed work on all outcrop areas. Large outcrops were traversed at intervals of 150 feet, 100 feet, or less, depending on conditions. Areas which were considered to be of especial promise, such as gullies with a north-south strike, any carbonate veins, prominent joints, and areas of pegmatite which showed a bright pink coloration, were gone over with care. The shoreline of the Abitibi River, the railroad line and all trails or portages were traversed. In general, any areas which gave a reading of 40 micro-amperes or higher on the 2M scale of the EA-130 counter were carefully investigated.

Exploratory traverses outside of the claims were made north from Otter Rapids on the west side of the river as far as Coral Rapids station, on the east side of the river for about two miles north of the foot of the rapids, and south by canoe for about eight miles from the head of the rapids, investigating all the scattered outcrop areas along the river.

To the east of the claims, three traverses were made of one quarter of a mile, one mile and about three miles in length. The first two of these were entirely through swamp while the last was


RADIOACTIVE OCCURRENCE
CLAIM T-28721
(MOSHER VEIN)
PITT TOWNSHIP, ONT.
1" = 50'
Overburden and rubble
Radioactive carbonate veins
Sheared rock stained red and brown.
Porphrytic diabase
Biotite-garnet gneiss with small veins of pegmatite.
Geological contact
Strike and dip of shearing
Strike and dip of gneissic foliation.
M1 - Sample numbers
+1+00 - Base line stations
Vein cuts 3' irregular pegmatite
4" to 10" quartz-carbonate vein north from here 1' east of carb. vein.
M6
M5
M4
M3
M2
M1
4+00
3+00
2+00
1+00
0+00
N
13°
ABITIBI RIVER
Adapted from map by P.H. Taylor
2/49

along an old trail running in a southeasterly direction. Some outcrop was found along this trail.

Detail Work

Over an area in claim T-28799, where pegmatite showed a pronounced increase in radioactivity, Geiger counter readings were taken on a ten-foot grid. From this data a map was constructed showing radioactivity intensity contour lines (see Map 7). This indicates first that the radioactivity is clearly concentrated in the pegmatites, and second, that with a small amount of overburden, the general disposition of the pegmatite masses may be traced by this method. A small section of this area which showed the maximum readings was stripped of moss and overburden and carefully mapped, Geiger counter readings being taken on a two-foot grid, to localize exactly the radioactivity (see Map 6).

Radioactive Occurrences

Mosher vein, Claim T-28721 (see Map 5 and Plate IV-A)

Hogg (22) gives the following detailed report on this:

"The vein that constitutes the Mosher discovery is a carbonate vein, which strikes magnetic north and dips at 75°W. It follows a pronounced zone of fracturing, which forms a prominent topographical feature even beyond the limits of the vein as outlined at present. The zone of fracturing is about 25 to 30 feet in width and forms a cleft in the rocks, which cuts across the regional strike of the gneisses at right angles. Individual fractures within the zone parallel it in strike and dip and are from half an inch to two feet apart. There has been apparently no movement along the fracture zone in a horizontal direction and very little, if any, in a vertical direction. Contacts between the gneisses and diabases can be followed without any visible offset across the zone of fracturing.

Several types of vein material are present in this zone of fracturing, in veins and stringers running parallel to or at a small angle to the fractures. These veins and stringers are found cutting the diabase, gneisses, and pegmatites, but their relationship to the lamprophyre dikes was not seen.

Radioactivity seems to be confined to a single vein of carbonate material. The carbonate is a pale grey-green colour and crystalline, with a granular texture, weathering to a smooth brown surface. It is probably impure dolomite and reacts only slightly to cold dilute hydrochloric acid. It strikes parallel to the fracturing and is continuous on the exposures visible at the time of examination occupying a place near the centre of the zone where the fractures are closely spaced. Its width ranges from six inches to about two feet, but in the wider parts it generally has inclusions of gneiss and crude ribbon structure caused by unreplaced remnants of wall rock lying between the closely spaced fractures.

The only common ore mineral noted in the carbonate vein is specularite, which occurs in disseminated form throughout most of the vein and as hair-like fracture-fillings in some places, always surrounded by red alteration products. There is some evidence that the amount of radioactivity is directly proportionate to the amount of specular hematite. Pyrite is sparsely present in tiny cubes and tetrahedrons in the carbonate and is more plentiful in inclusions of wall rock and in the wall rock along the margins of the vein. Chalcopyrite was also noted but is very rare and in very small grains. It is interesting to note that some of the lamprophyre dikes in the vicinity are also mineralized with specularite, pyrite, and chalcopyrite and are highly altered to carbonate.

Microscopic examination of the vein materials shows it to consist of more than 75 per cent carbonate, with the remainder made up of feldspar, mica, and hematite. The feldspars are in poorly formed phenocrysts of orthoclase and albite, which show all stages of replacement and veining by carbonate. This suggests that the so-called carbonate "vein" is possibly a dike that has been almost completely replaced by carbonate. The mica is pale-green muscovite, which is not visible in hand specimens but is probably the cause of the greenish colour of the vein. The hematite is in disseminated grains of very irregular outline. Most of it has been converted to the red variety, but in the larger grains the core consists of black specularite.

No shattering or other phenomena that might result from radioactivity were present in the section studied microscopically.

A second type of carbonate and quartz-carbonate vein occurs in the fracture zone. This type in general consists of coarsely crystalline, pale-yellow ferrodolomite, which weathers to a brown colour similar to the vein previously described. In some of the wider sections it has associated with it a core of clear glassy quartz, which may make up most of the vein. Widths range from a fraction of an inch to about two feet, but the coarse texture is maintained even in the small stringers. These veinlets and stringers generally strike parallel to the fracturing but also cut across it at small angles. They are found lying along the grey-green carbonate vein and even within it but never cutting directly across. The relationship

A. Looking north from Mosher vein,
Claim T-28721, Otter Rapids, Ont.

B. Strongly radioactive pegmatite
area, Claim T-28799, Otter
Rapids, Ont.

suggests that the radioactive carbonate vein is the latest vein material present, and, as previously stated, it may be post-Middle Devonian in age. The radioactivity within the vein, therefore, should not be compared in origin to the radioactivity in the pegmatites, which are of Precambrian age.

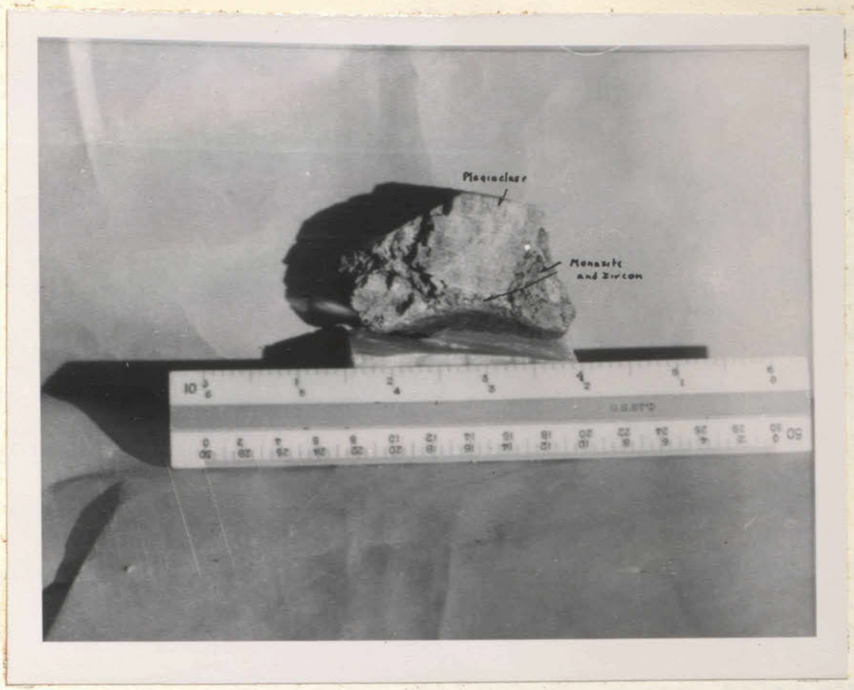
The fracture zone is characterized, particularly in the two feet adjacent to the grey-green carbonate vein, by a red discoloration. The feldspars in the gneiss are stained red, and the diabase is also reddened. The colour, however, is similar to the colour along fractures in the gneiss and diabase some distance away and is no doubt partly the effect of iron-oxide stain rather than any phenomenon of radioactivity. The intensity of alteration near the carbonate vein can be accounted for by the greater intensity of fracturing in this vicinity.

The vein at the time of the present examination was exposed over a length of 240 feet. On the south end it passed under the rubble and boulders of the river flood channel, and at the north end it disappears under the river. Wherever it is exposed, it causes activity in the Geiger counter. On the most sensitive (2M) scale, the meter will go off scale in most places on the vein, but on the intermediate (10M) scale, the readings over the vein, with the Geiger counter resting on the outcrop, are about four to eight times normal.

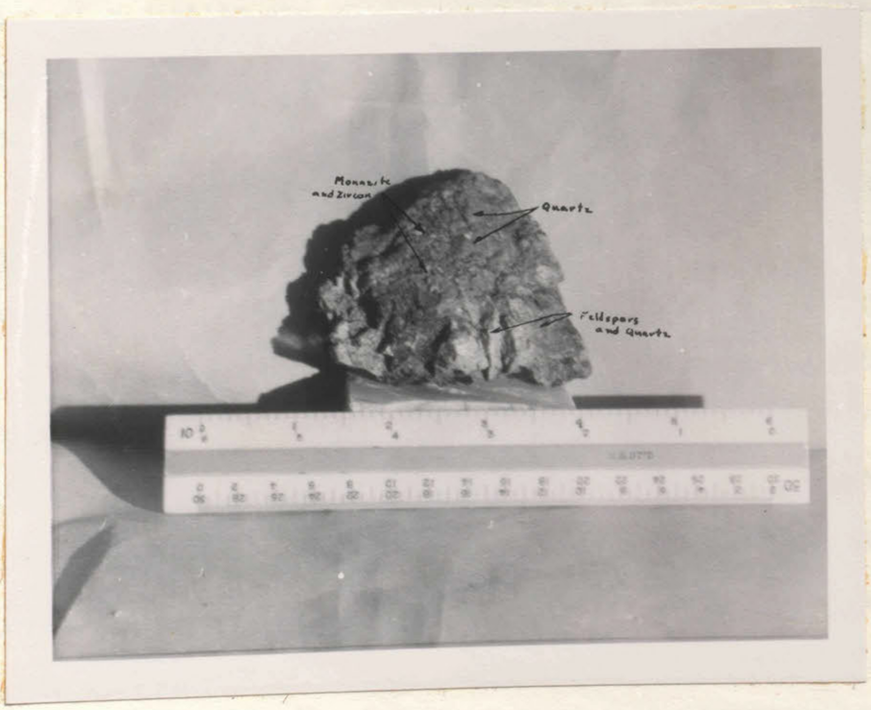
The projection of the vein to the north is under water for a distance of 950 feet, except for a point of rock 150 feet to the north. This point shows weak north-south fracturing but drops off precipitously into the river, and no vein is exposed. About 950 feet to the north, the rock rising from the river is split by a prominent cleft, which cannot be missed when one is standing on the showing and may be seen on the accompanying map. This cleft is filled with rubble, and no radioactivity was indicated in it by the Geiger counter." (See Plate IV-A)

There is also a second vein, showing very weak radioactivity over parts of its length, located about ten feet to the east of the main vein. It strikes nearly due north and dips between 65° and 70° west. It is composed of coarsely crystalline carbonate. (See Map 5).

Optical and staining tests on specimens from the main vein indicate that the carbonate is dolomite and that besides pyrite and chalcopyrite there are also small amounts of pyrrhotite. No sulphides which crystallize as tetrahedrons were recognized. Other minerals noted correspond to those observed in thin section by Hogg with the addition of several unidentified opaque minerals.



A. Specimen of pegmatite from Claim T-28799 with monazite and zircon crystals surrounding a large plagioclase feldspar crystal.



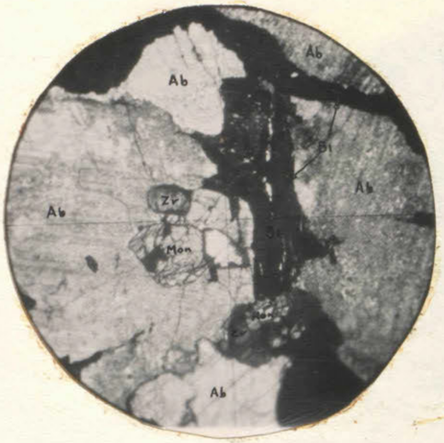
B. Specimen of pegmatite from Claim T-28799 with exceptional concentration of monazite and zircon.

It was found impossible to isolate definitely the source or sources of the radioactivity by any of the available means. It is believed that either the minerals containing the radioactivity are so finely disseminated that it is impossible to separate them by specific gravity methods or that they slime very readily. There is some indication that there is more radioactivity associated with a non-magnetic fraction containing considerable hematite than with other fractions, but, in general, radioactivity is found in all separations.

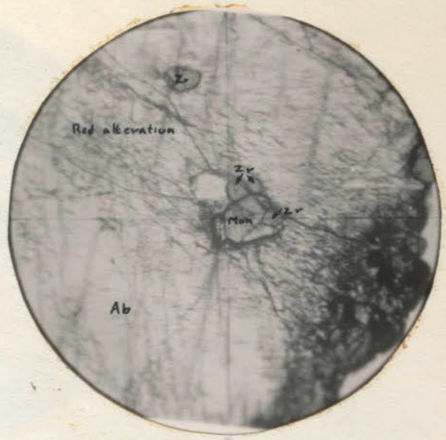
Radioactive Pegmatites

Numerous small areas in the pegmatites show a decided rise in the radioactivity. In all cases, there is a salmon pink coloration of the feldspars which contrasts sharply with the normal paler pink colour. Where moss is stripped from these areas, the feldspars are seen to be disintegrated to a somewhat greater depth than elsewhere in normal pegmatite. This is considered to be due primarily to the disruptive action of radiation and only secondarily to the more normal weathering processes.

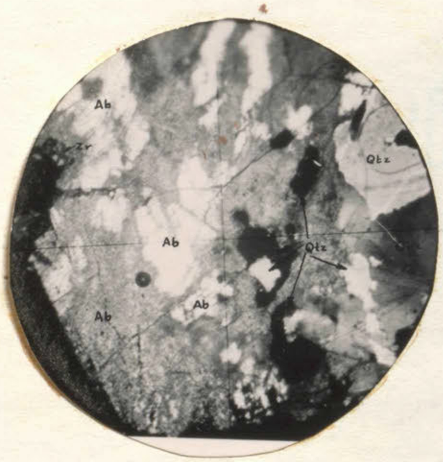
The essential minerals of these pegmatites are very similar to those in the more common pegmatites, except that there is a certain loss in definition of the crystal boundaries and the mica books are usually contorted. Where radioactivity is high, clumps of subhedral or anhedral crystals of a deep red, almost black, zircon and a bright pink monazite are almost invariably found. The crystals are small; the largest zircon found is about 2 mm long by 1 mm in diameter and the largest monazite crystal is about 2 mm in diameter. In hand specimens these crystals generally appear to surround the large euhedral plagioclase crystals (see Plate V-A), but in thin section some zircon and monazite are seen to lie within the boundaries of large albite crystals (see Plate VI).



A. Slide #1, crossed nicols. Magnification 24x, Albite,fresh and altered; altered biotite; zircon and monazite.



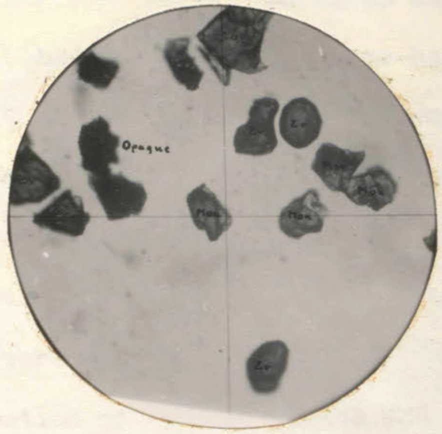
B. Slide #2, lower nicol. Magnification 24x. Albite (salmon pink feldspar) with fine, thread-like red alteration, zircon and monazite. Cracks in feldspar radiate out from monazite crystal.



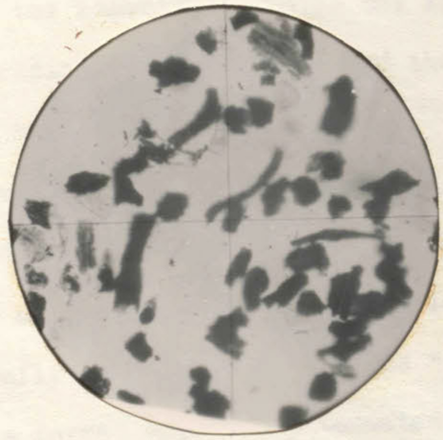
C. Slide #3, crossed nicols. Magnification 24x. Albite, fresh and altered; quartz in several orientations and zircon.

D. Slide #1, crossed nicols. Magnification 80x. Microcline and altered albite as inclusions in altered biotite. Lenticular mass of unidentified reddish brown mineral in microcline crystal.

Photomicrographs of thin sections of specimens from the strongly radioactive pegmatite, Claim T-28799.



A. Heavy mineral fraction from pegmatite.
Specific gravity above 3.32.
Magnification 80x, lower nicol.
Particles of zircon and monazite, two basal sections of zircon and one opaque(red brown in reflected light).



B. Heavy mineral fraction from pegmatite.
Specific gravity between 2.6 and 2.89.
Magnification 80x, lower nicol.
Various opaque and semi-opaque fragments, altered biotite, some quartz and feldspar particles.

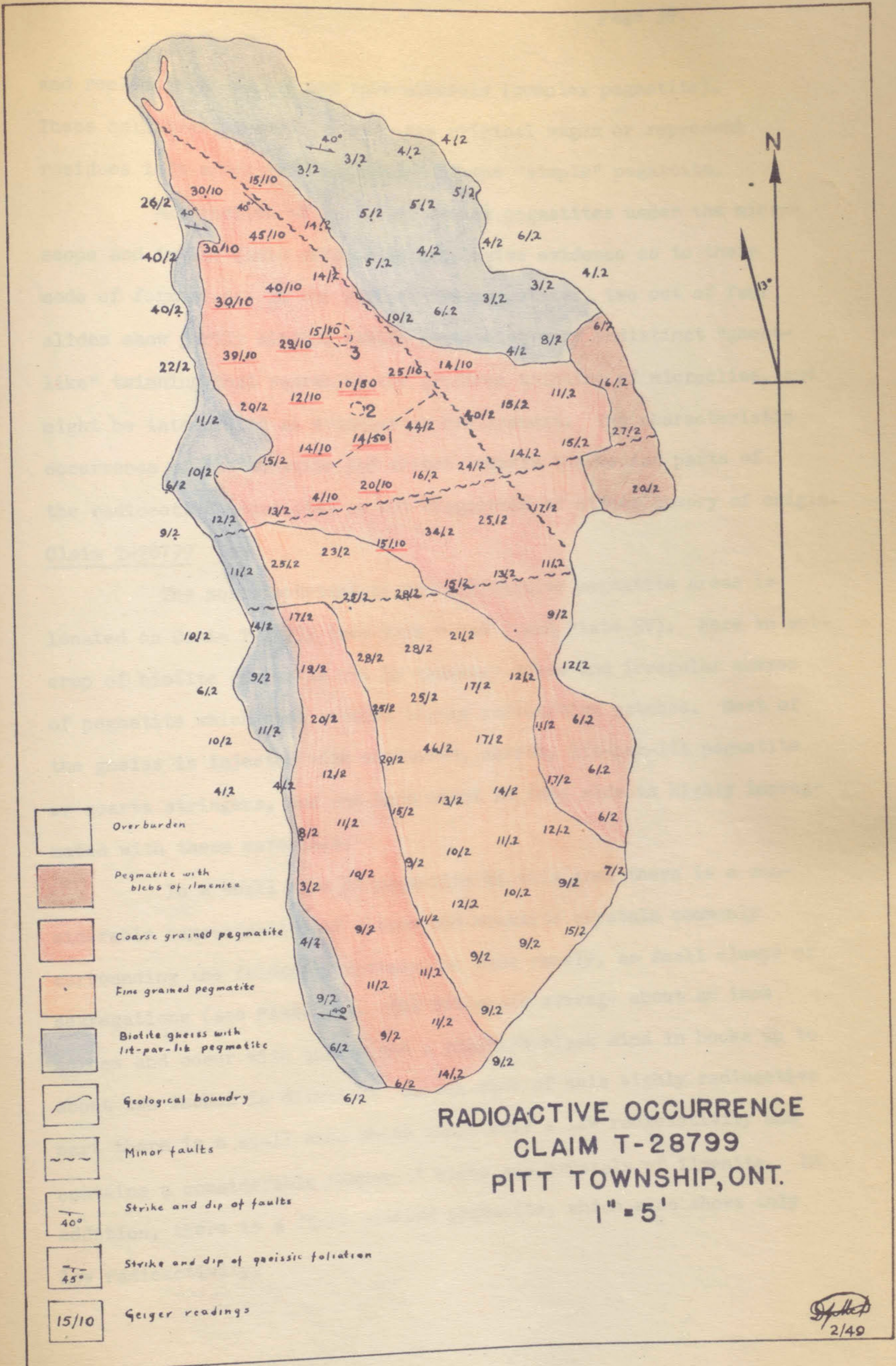
Photomicrographs of fragments from heavy mineral separations of specimens from the strongly radioactive pegmatite, Claim T-28799.

Other minerals of the pegmatites, in some areas found near, but not in, strongly radioactive areas, are blebs and crystals of ilmenite, with individual crystals as much as one-half inch across, and an unidentified black mineral, metallic to sub-metallic in lustre with a reddish streak, which occurs in crystals about one-quarter of an inch on a side. This was very tentatively identified in the field as specularite but may be a columbate mineral. Unfortunately, all samples of this mineral were lost.

Optical examination of mineral suites and thin sections disclosed that the radioactive pegmatites are composed of albite with altered areas, quartz, altered biotite, deep red zircon and green monazite (which is pink in hand specimens). Other minerals present in smaller amounts are microcline, fresh muscovite and biotite, chlorite and several unidentified minerals (see Plates VI and VII). Chemical tests were used to check the identification of the zircon, monazite and ilmenite, and tests for radioactivity established that this property is concentrated only in the monazite.

Landes (15) summarizes opinions concerning the genesis of pegmatites in general and classifies them into the aqueous and magmatic theories. Of these, two of the magmatic theory varients appear to be most popular today. Briefly stated, these are the "aqueous magma" theory, in which the pegmatite is formed from the attenuated residual magma resulting from the crystallization of a batholith, and the"hydrothermal replacement" theory where the pegmatite is, as before formed from a residual magma but is not as attenuated as a hydrothermal solution.

In the first case, a progressive crystallization is considered to occur with the rarer minerals crystallizing out as a final product. The second assumes an original rock (simple pegmatite) composed mainly of microcline, which hydrothermal solutions subsequently albitize


N
13°
Overburden
Pegmatite with blebs of ilmenite
Coarse grained pegmatite
Fine grained pegmatite
Biotite gneiss with lit-par-lit pegmatite
Geological boundry
Minor faults
Strike and dip of faults
40°
Strike and dip of gneissic foliation
45°
Geiger readings
15/10
RADIOACTIVE OCCURRENCE
CLAIM T-28799
PITT TOWNSHIP, ONT.
1" = 5'
2/49

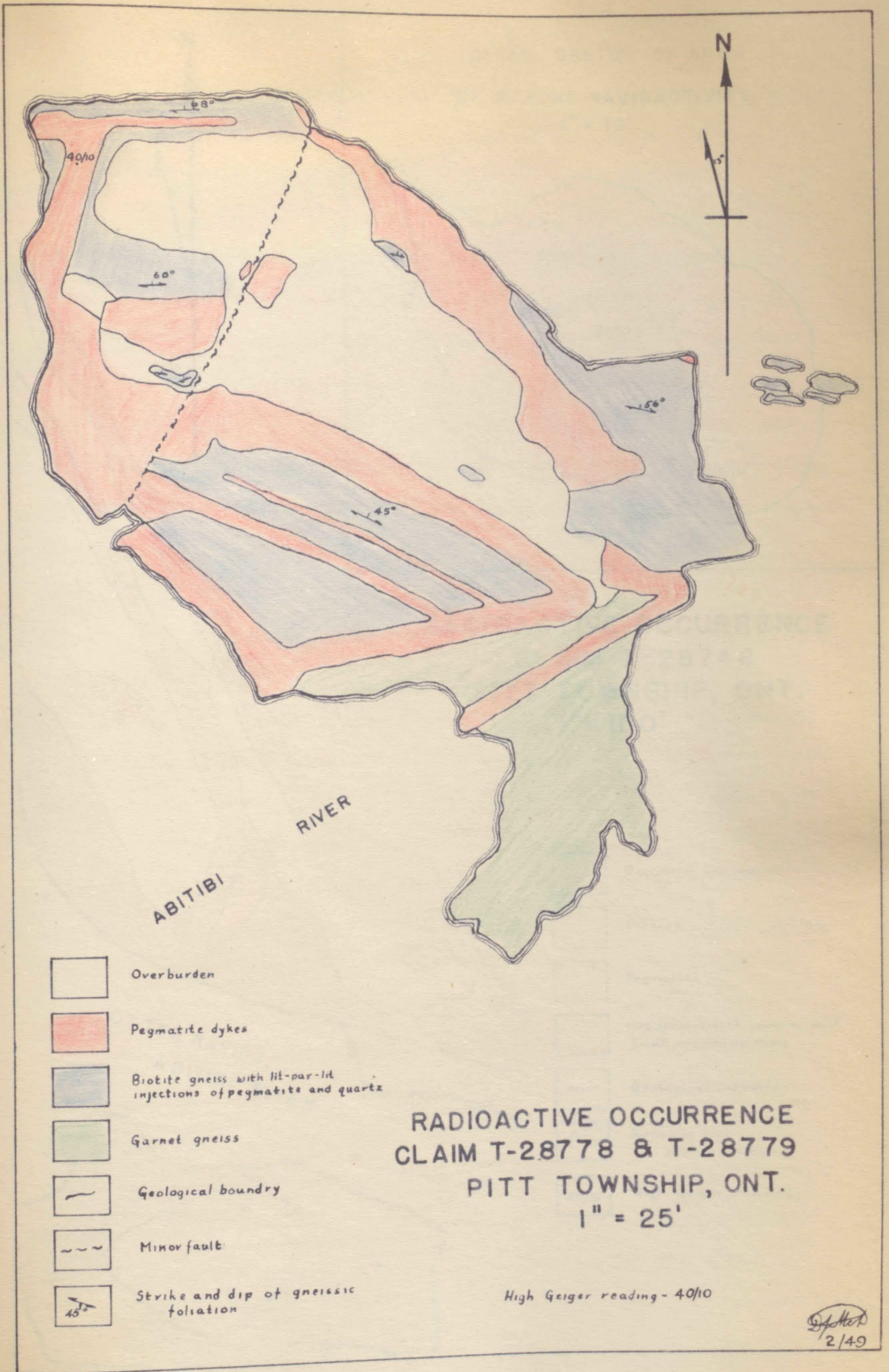
and replace with quartz and rare minerals (complex pegmatite). These solutions either rise from the original magma or represent residues left after crystallization of the "simple" pegmatite.

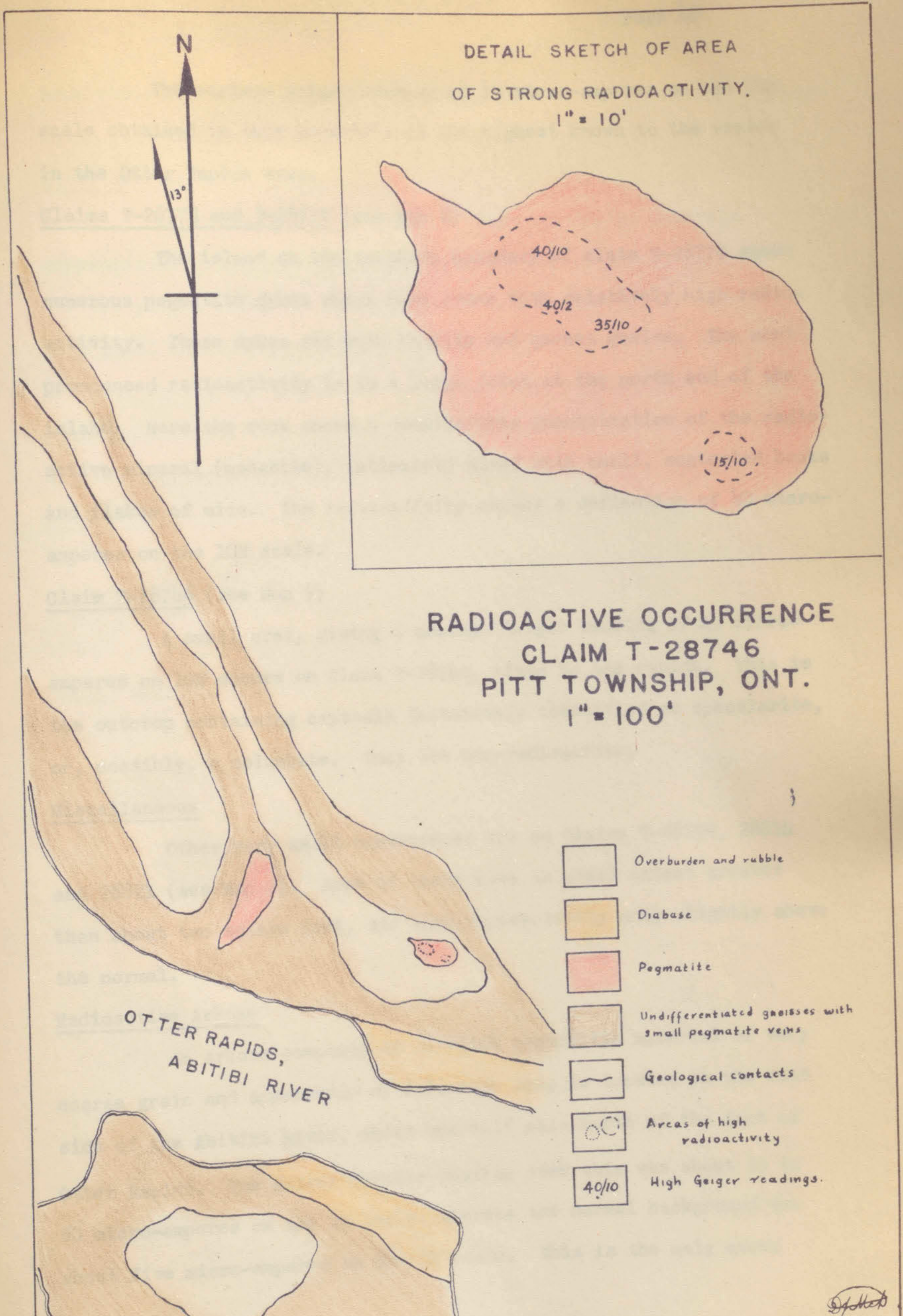
Examination of the Otter Rapids pegmatites under the microscope and in the field affords no conclusive evidence as to their mode of formation. In the radioactive pegmatites, two out of four slides show partly altered albite containing very indistinct "ghost-like" twinning that resembles the gridiron twinning of microcline, and might be interpreted as evidence of replacement. The characteristic occurrence of the monazite and zircon towards the median parts of the radioactive pegmatites is not diagnostic of either theory of origin.

Claim T-28799

The most important of the radioactive pegmatite areas is located on Claim T-28799 (see Maps 6 and 7 and Plate IV). Here an outcrop of biotite gneiss is cut by numerous dykes and irregular masses of pegmatite which show several highly radioactive patches. Most of the gneiss is injected with scattered, narrow, lit-par-lit pegmatite or quartz stringers, and one band about 10 feet wide is highly impregnated with these materials.

In a small mass of pegmatite in this area there is a considerable concentration of zircon and monazite crystals commonly surrounding the feldspar crystals, or more rarely, as small clumps or segregations (see Plate V). The feldspars average about an inch across and occur with quartz and a greenish-black mica in books up to about two inches in diameter. On one side of this highly radioactive part there is a small area which shows only a low radioactivity and contains a considerable number of blebs and crystals of ilmenite. In addition, there is a finer grained pegmatite, which also shows only low radioactivity.


N
13°
68°
40/10
60°
56°
45°
ABITIBI RIVER
Overburden
Pegmatite dykes
Biotite gneiss with lit-par-lit injections of pegmatite and quartz
Garnet gneiss
Geological boundry
Minor fault
Strike and dip of gneissic foliation
45°
RADIOACTIVE OCCURRENCE
CLAIM T-28778 & T-28779
PITT TOWNSHIP, ONT.
1" = 25'
High Geiger reading - 40/10
2/49


DETAIL SKETCH OF AREA
OF STRONG RADIOACTIVITY.
1" = 10'
40/10
40/2
35/10
15/10
N
13°
RADIOACTIVE OCCURRENCE
CLAIM T-28746
PITT TOWNSHIP, ONT.
1" = 100'
OTTER RAPIDS,
ABITIBI RIVER
Overburden and rubble
Diabase
Pegmatite
Undifferentiated gneisses with small pegmatite veins
Geological contacts
Areas of high radioactivity
40/10
High Geiger readings.
2/49

The maximum Geiger reading of 14 micro-amperes on the 50M scale obtained in this pegmatite is the highest known to the writer in the Otter Rapids area.

Claims T-28778 and T-28779 (see Map 8)

The island on the southern boundary of claim T-28778 shows numerous pegmatite dykes which have areas with relatively high radioactivity. These dykes cut both biotite and garnet gneiss. The most pronounced radioactivity is in a large joint at the north end of the island. Here the rock shows a considerable concentration of the radioactive mineral (monazite), intimately mixed with small, contorted books and flakes of mica. The radioactivity causes a deflection of 40 micro-amperes on the 10M scale.

Claim T-28746 (see Map 9)

A small area, giving a maximum Geiger reading of 40 micro-amperes on 10M occurs on Claim T-28746, close to the rapids. This is the outcrop containing crystals tentatively identified as specularite, or, possibly, a columbate. They are non-radioactive.

Miscellaneous

Other very small occurrences are on Claims T-28799, 28814 and 28821 (see Map 2). None of these have an areal extent greater than about two square feet, and show radioactivity only slightly above the normal.

Radioactive Arkose

An arkose composed of detrital pegmatitic material of very coarse grain and apparently of Paleozoic age, is located on the west side of the Abitibi River, about one-half mile north of the foot of Otter Rapids. The Geiger counter reading over this was about 15 to 20 micro-amperes on the 2M scale, whereas the normal background was about five micro-amperes on the 2M scale. This is the only known occurrence of higher than usual radioactivity in the Otter Rapids area which is not in Precambrian rock.

River Gravels

In an effort to determine if any radioactive minerals were concentrated in the river gravels, several samples of gravel from various places along the rapids were panned and the "tails" examined. Very small quantities of minute garnets were obtained from some of the samples, but if any radioactive minerals were present, they were in such small quantities that they could neither be identified nor cause any reaction on the Geiger counter.

ECONOMIC CONSIDERATIONS

The discovery and staking of the radioactive vein at Otter Rapids touched off a small staking rush in the fall of 1947 and spring of 1948. Some 300 claims were staked but due to legal complications, only about 200 of those staked in Pitt Township were recorded.

The writer, or men under his direction, examined all the known outcrop areas within 97 of these claims and numerous outcrops on about 25 others. No additional radioactive carbonate veins were discovered as a result of this survey and only one of the strongly radioactive pegmatites located was considered to show sufficient intensity of radiation over a moderately large area to be worth sampling.

Assay results on samples from the Mosher vein and the main pegmatite find are as follows:

Mosher vein - samples taken from points showing the highest Geiger readings, each equivalent to a good chip sample across 0.5 feet (see Map 5).

Sample No.	Beta Equiv. % Uran.	Content % Th.	Content % Ur.
M1	0.034	0.14	0.009
M2	0.049	0.23	0.007
M3	0.045	0.18	0.012
M4	0.043	0.18	0.010
M5	0.103	0.44	0.023
M6	0.053	0.22	0.013

Hogg gives the following data on samples taken by him:

"Three character samples from the vein were submitted to the Provincial Assayer and returned U_3O_8 equivalents of 0.03, 0.12 and 0.055 percent".

Pegmatite, Claim T-28799 (see Map 6) - three samples were taken from the small area showing the maximum radioactivity. A rough chip sample, 4.6 feet long, was taken across the portion showing the highest readings on the Geiger counter, and two grab samples were taken from near by. These gave the following results:

Sample No. 1 (Chip)	0.037%	U_3O_8 equivalent
Sample No. 2 (Grab)	0.027%	" "
Sample No. 3 (Grab)	0.139%	" "

At the time of the survey the Canadian Government was offering $2.75 per pound for concentrates containing 10% U_3O_8 or better. Thorium minerals, unless they contained an appreciable amount of uranium, were not required since their value as fissionable material was quite uncertain.

As the above results clearly indicate, the vein material does not even remotely approach ore grade, and the radioactivity is due in considerable part to thorium.

The strongly radioactive pegmatite occurrence on Claim T-28799, is of equally low grade with the radioactivity being due to thorium-bearing monazite. Its maximum dimensions are about seven feet by sixteen feet. The remainder of the occurrences are much smaller in size and do not contain as high a percentage of monazite. In brief, the known radioactive minerals of the area are of mineralogical rather than economic interest.

LABORATORY INVESTIGATION

Introduction

The purpose of the laboratory investigation was to identify the sources of radioactivity in the pegmatites and carbonate vein, to identify the associated minerals from both types of occurrences and, finally, by comparison of the mineralogy to deduce if any genetic relationship between the two types of radioactive material is indicated.

In the field it had been shown that a rough concentration of the radioactive portion of the pegmatite could be made by crushing and panning samples from the more radioactive parts of the pegmatite masses. The major part of the radioactivity was concentrated in the heavy "tail", which consisted largely of small crystals of zircon and monazite plus a certain amount of feldspar and quartz. At the same time it was apparent that these small crystals and others associated with them were brittle, and that some had been lost by being crushed to a slime. No similar treatment had been tried on the vein material so that no parallel data existed as to its susceptibility to separation by means of specific gravity, or to the extent to which the minerals might "slime" on crushing.

In the light of the above information on the pegmatite minerals it was decided that the best procedure to follow was a careful crushing of the sample, followed by separation into suites of different specific gravities. The minerals of the different suites would then be identified as nearly as possible by optical means or by such other tests as were found necessary. It was hoped that samples of the carbonate vein could be treated by the same method.

Details of Procedure

To eliminate overcrushing as far as possible and to reduce the possible loss of brittle minerals and the difficulties of identification of mineral fragments smaller than 200 mesh the following procedure was used. The original sample was carefully broken into fragments with a hammer and then further crushed in a diamond mortar. In using the mortar, the powdering effect was kept at a minimum by crushing only a small amount at one time and never attempting to drive the pestle to the bottom of the mortar. The crushed material was removed from the mortar after each crushing and screened in a nest of screens of the following meshes: 30, 70, 100, 150 and 200. Alternate crushing and screening was continued until all had passed through the 30 mesh screen. The powders on the successively finer screens were ground in an agate mortar and screened in stages, until the final product was between +200-150 or +200-100 mesh, plus the fines of -200 mesh.

A variation of this was used in one case where it was desired to obtain as nearly complete crystals as possible. In this case almost all the preliminary crushing was done very carefully with a geologists' pick and the product was first passed through a piece of coarse wire gauze to remove the larger pieces which were again crushed to remove crystals still remaining in them. This operation was facilitated by the fact that the small crystals of the accessory minerals separated very readily from the feldspars and quartz.

In another case, where it was necessary to crush a large sample of the carbonate vein, crushing, grinding and screening equipment of the Mineral Dressing Laboratory, McGill University, were employed.

Several of the possible methods for separating minerals were considered. Methods adopted and used at various times, which depend on the relative specific gravities of the minerals were simple panning, heavy liquid separation and separation with the super-panner. Other methods depending on other properties of the minerals, which were also used, included hand picking and magnetic separation. Still other possible methods of performing separations which were considered but were found to be impractical due to lack of supplies, are low temperature melts of nitrate salts for minerals whose specific gravities are beyond the range of the heavy liquids, electrostatic separation, and separations based on the relative conductivities of the minerals.

Hand picking was used to separate some of the larger crystals of the accessory minerals from the quartz and feldspar fragments. Simple panning on a large watch glass, usually in air, was occasionally found to be quite useful where further separation of a fraction was desired. Magnetic separation was quite limited in its application, since the only magnetic fraction found is in the heaviest fraction of the carbonate vein material. The method used was to hold a blank microscope slide over the sample and then bring a small, powerful, horseshoe magnet in contact with the glass. By lifting the glass and the magnet at the same time a portion of the magnetic fraction was held on the glass. By removing the magnet from the glass the mineral particles could be dropped where desired. In this way there was no problem of removing particles from the magnet.

The heavy liquids used were bromoform with a specific gravity of 2.89; Thoulet solution, specific gravity about 3.2 and methylene iodide, specific gravity 3.32. Preliminary experiments showed that a good separation of the pegmatite constituents could be made with the bromoform and that no additional separation resulted from the use of either Thoulet solution or methylene iodide. Diluted solutions of bromoform and carbon tetrachloride with a specific gravity of about 2.6 to 2.7 were used for further separations of lighter minerals. The carbonate vein material was easily separated into three fractions by first using bromoform and then further separating the heavy fraction with methylene iodide.

Separationsby means of a super-panner were tried with only moderately satisfactory results on both the pegmatite and vein minerals. The heavy crop of the pegmatite as obtained from the heavy liquids separated fairly cleanly into two fractions, but the light crop from the same source could not be further separated.

Somewhat similar results were obtained with the carbonate material, with a good heavy fraction, and a slightly less clean fraction of lighter weight being obtained. The second was found to be composed of grains of one of the constituents of the heaviest crop, with fragments of the lightest crop adhering to them. The lightest fraction could not be further separated by this means.

The various fractions were immersed in oils of known refractive indices and were examined under a petrographic microscope. This procedure was limited by the fact that the oils available covered the range below 1.80 which is less than the indices of some of the minerals. Identification of most of the minerals which were beyond the range of the oils was found to be possible by other tests. In actual practice, it was found that some minerals only appeared in one slide out of several, due to their extreme scarcity. Since this made it difficult to obtain their refractive index, these were not always successfully identified. Even tentative identification was not possible for numerous opaque minerals, particularly in the case of the carbonate vein which contains a large number of such minerals.

In several doubtful cases and where sufficient material was available, blowpipe or chemical tests were used either to identify the mineral or to confirm optical identification.

Four thin sections of the pegmatite material were made for the purpose of finding out the relationship of the minerals to each other. In their preparation it was found difficult to obtain slices of sufficient size. However, by cutting them abnormally thick (about 1/4 inch) this was overcome. A thin section from a sample of the carbonate vein was available through the courtesy of N. Hogg of the Ontario Department of Mines.

Radioactivity

No quantitative experiments for radioactivity were made on the radioactive material, since qualitative tests were believed sufficient for the purpose.

For the larger samples and separated fractions, an EA-130 Geiger counter was used to determine the relative radioactivity of specimens. On very small quantities such as were obtained from the heavy liquid separations, this instrument was not sufficiently sensitive and a scintilloscope of the type manufactured by Glews of London, England, was used. This instrument consists of a small lens mounted on a brass tube with the same length as the focal length of the lens, and a small screen consisting of two glass plates with a very thin coating of zinc sulphide between them. The screen fluoresces momentarily when struck by alpha particles given off by radioactive material and these scintillations are observed with the lens. An approximation of the degree of radioactivity can be obtained by noting the relative frequency of the scintillations.

Since a certain fluorescence in calcite and quartz is stated to be an indication of an uranium content (*), an attempt to localize the radioactivity by using ultra-violet light was tried. Several

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* Handbook of Uranium Minerals, J. DeMent and H.C. Dake, pp. 63 and 69.

samples from both the pegmatites and the carbonate vein were tested but none of the minerals examined showed fluoresence.

Properties of Zircon and Monazite

	Zircon	Monazite
Megascopic		
Colour	Deep red, almost black	Pink
Crystal Form	Euhedral to anhedral, resembles Fig. 914, Dana, 4th Edition	Subhedral, resembles Fig. 1013, Dana, 4th Edition
Specific Gravity	Above 3.32	Above 3.32
Hardness	7+	6
Microscopic		
Plane Polarized Light		
Colour	Pale purple	Pale green
Relief	High	High
Crystal Form	Euhedral to anhedral	Subhedral
Cleavage	110 (?)	001 (?)
Fracture	Conchoidal	Conchoidal
Refractive index	Greater than 1.8	Greater than 1.8, some fragments doubtfully lower
Crossed nicols		
Isotropic or anisotropic	Anisotropic	Anisotropic
Birefringence	Extreme	Extreme
Convergent light		
Uniaxial or biaxial	Uniaxial	Biaxial
Sign	Positive	Positive
Axial Angle	0^{o}	Very small

Properties of Zircon and Monazite (Continued)

	Zircon	Monazite
Chemical Tests		
	Powder fused with soda on Pt wire and dissolved in HCl colours turmeric paper orange, indicating zirconium content. A crystal heated to glowing changes from dark red to cream colour	Before the blowpipe powder moistened with H_2SO_4 colours flame green, borax bead is yellow when hot and colourless when cold
Radioactivity		
Scintilloscope	None	Present
Geiger counter	None	Doubtful
Ultra-violet light	No fluoresence	No fluoresence

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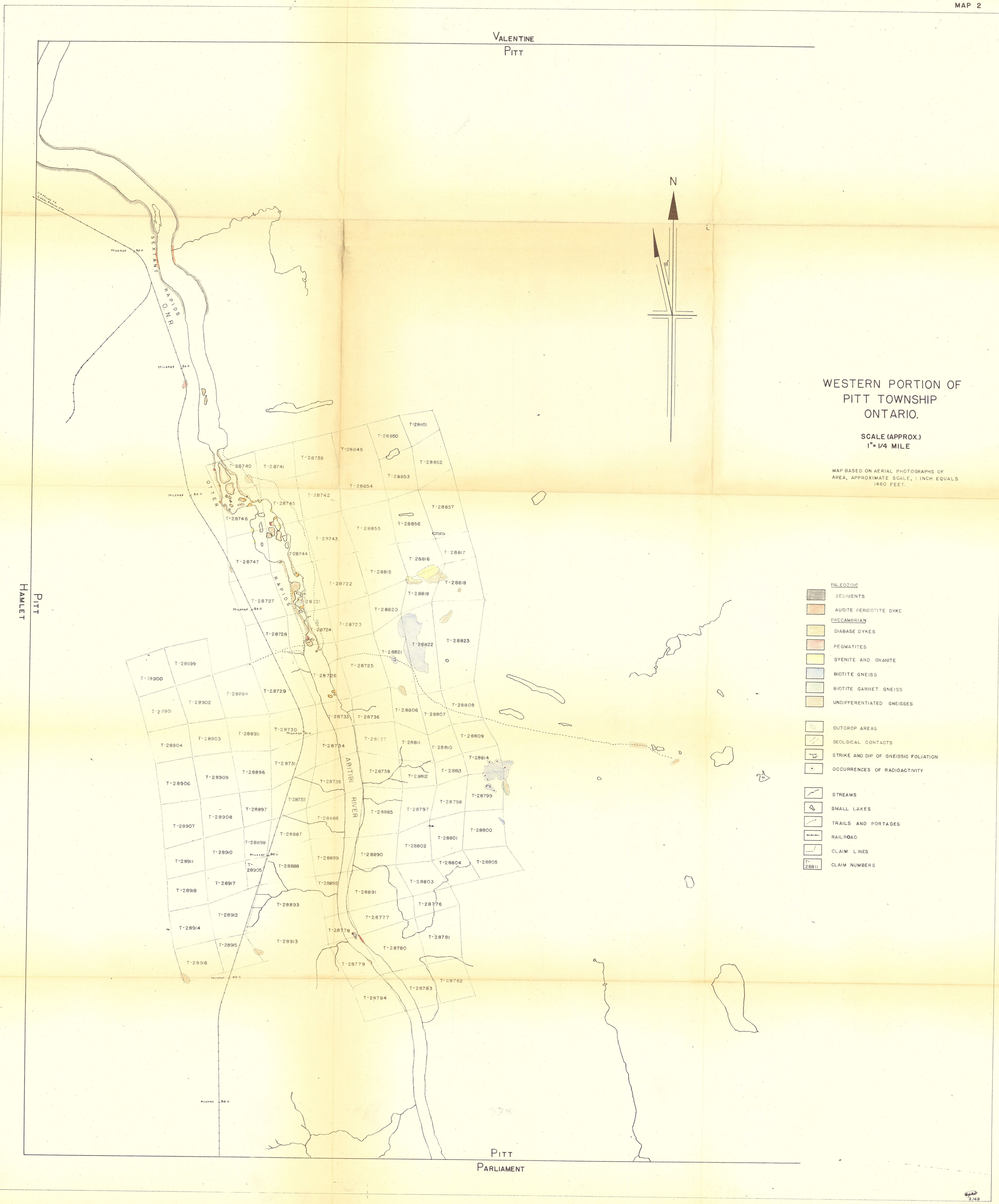
MAP 2



VALENTINE
PITT
HAMLET
PITT
PARLIAMENT
N
WESTERN PORTION OF
PITT TOWNSHIP
ONTARIO.
SCALE (APPROX.)
1" = 1/4 MILE
MAP BASED ON AERIAL PHOTOGRAPHS OF AREA, APPROXIMATE SCALE, 1 INCH EQUALS 1460 FEET.
PALEOZOIC
SEDIMENTS
AUGITE PERIDOTITE DYKE
PRECAMBRIAN
DIABASE DYKES
PEGMATITES
SYENITE AND GRANITE
BIOTITE GNEISS
BIOTITE GARNET GNEISS
UNDIFFERENTIATED GNEISSES
OUTCROP AREAS
GEOLOGICAL CONTACTS
STRIKE AND DIP OF GNEISSIC FOLIATION
OCCURRENCES OF RADIOACTIVITY
STREAMS
SMALL LAKES
TRAILS AND PORTAGES
RAILROAD
CLAIM LINES
CLAIM NUMBERS
ABITIBI RIVER
OTTER RAPIDS
SEXTANT RAPIDS
O.N.R.

GEOLOGY AND RADIOACTIVITY

OVER A PORTION OF THE OUTCROP ON

CLAIM T-28799

PITT TOWNSHIP, ONTARIO.

SCALE: 1" = 10'

- OVERBURDEN
- PEGMATITE
- PEGMATITE WITH ILMENITE BLEBS
- BIOTITE GNEISS WITH LIT-PAR-LIT PEGMATITE AND QUARTZ
- BIOTITE GNEISS
- BOUNDRY OF OVERBURDEN
- APPROX. GEOLOGICAL CONTACT
- 10/2 RADIOACTIVITY INTENSITY CONTOURS

N.B.- CONTOURS BASED ON READINGS TAKEN ON A 10' GRID WITH AN EA-130 GEIGER COUNTER.

NORMAL BACKGROUND COUNT RANGED FROM 2 MICROAMPERES ON 2M TO 15 MICROAMPERES ON 2M.

OVER PEGMATITE, THE BACKGROUND WAS NORMALLY BETWEEN 15 MICROAMPERES ON 2M AND 30 MICROAMPERES ON 2M.

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