The Proposed Voyageurs National Park

Its geology and mineral potential

MINNESOTA GEOLOGICAL SURVEY
UNIVERSITY OF MINNESOTA
Minneapolis, 1969

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an evaluation of the mineral potential of the proposed Voyageurs National Park

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SUMMARY

The proposed Voyageurs National Park, in northern Minnesota adjacent to the International Boundary, is a scenic glaciated area underlain by very ancient (Precambrian) rocks of diverse types. The area was mapped geologically by the Minnesota Geological Survey in the summer of 1968 to appraise the potential for significant metallic mineral deposits.

The proposed park straddles the transition from granitic rocks of the Vermilion batholith on the south to metamorphosed sedimentary and volcanic rocks on the north. Biotite schist, a dark gray, slabby rock, is the most abundant rock type in the area, comprising most of Kabetogama Peninsula and much of the shorelines of Rainy, Kabetogama, and Namakan Lakes. A "greenstone belt" passes through the extreme northwestern corner of the proposed park. This belt contains one formerly productive gold mine, the Little America, and several prospect pits and adits. Of seven selected samples of mineralized rock taken in the greenstone belt, three contain anomalous amounts of gold, silver, and copper and one contains detectable amounts of platinum group metals. The geologic mapping and sampling are inadequate to test the full mineral potential, but indicate the possible existence of significant mineral deposits within the belt.

Insofar as mineral potential is a factor, the area underlain by the greenstone belt in the extreme northwestern part of the proposed park is not suitable for inclusion in the park. The area involved is small, and includes Big American Island, Dryweed Island, and the small islands between Dryweed Island and the mainland. These islands should remain open for prospecting and possible mining.

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VOYAGEURS NATIONAL PARK

INTRODUCTION

Because of the possibility of commercial metallic mineral deposits in the greenstone belt that passes through the northwestern part of the proposed Voyageurs National Park, an economic appraisal of the area was carried out by the Minnesota Geological Survey in the summer of 1968. Emphasis was placed on geologic mapping and sampling in the greenstone belt, but mapping was extended to include all the shorelines of Rainy and Kabetogama Lakes and the western part of Namakan Lake. The geologic mapping was done by Dr. R. W. Ojakangas and Dr. D. L. Southwick of the Minnesota Geological Survey, assisted by James Huss and Charles Heinonen. U. S. Army, Corps of Engineers, U. S. Lake Survey charts 819, 820, 821, 822, and 823 were used as base maps for plotting the geologic data. The charts were combined at a scale of 1:62,500 (one inch equals one mile) as a base for the geologic map (plate 1).

The study was carried out as a part of the program of the Minnesota Geological Survey to prepare a Geologic Map Atlas of the state. This program is supported mainly by funds provided by the Minnesota Resources Commission. The area is within the International Falls 1:250,000 map sheet, one of the 11 sheets that will be included in the Geologic Map Atlas.

LOCATION OF PROPOSED PARK

The area proposed for the Voyageurs National Park is in northern St. Louis County and adjacent parts of Koochiching County, along the International Boundary (pl. 1). The current proposal, as indicated in the October, 1967 report of the State of Minnesota, Department of Conservation, involves approximately 106,000 acres of land and 60,000 acres of water. The area is immediately east of International Falls and includes Kabetogama Peninsula, Kabetogama Lake, and parts of Rainy and Namakan Lakes. The proposed park has an irregular shape and is some 24 miles long, east to west, and from three to 15 miles wide, north to south.

The site was selected primarily because of its "exceptional scenery of an unusually beautiful system of lakes, streams, and forests; an outstanding representation of Precambrian geology and a land surface shaped by continental glaciation; and historic associations with the fur trade and the era of exploitation along the International Boundary."[1]

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[1] Statement by National Park Service, U.S. Department of Interior, quoted in October, 1967 report by State of Minnesota, Department of Conservation, p. 13.

GEOLOGIC SETTING

The area of the proposed park is in the southern part of the Superior Province of the Canadian Shield, a vast area of ancient Precambrian rocks that forms the nucleus of the North American continent. Specifically, it lies in the transition zone between a large area of granitic and metamorphic rocks, called the Vermilion batholith, which underlies much of northern St. Louis County, and a complex greenstone belt that crosses the International boundary in the Rainy Lake area.

The bedrock is rather well exposed in the eastern part of the area, particularly along the lake shores, and typically forms a knobby, rocky terrain. In the western part of the area and in much of Kabetogama Peninsula, the bedrock is covered by soil, unconsolidated glacial materials, and swamps.

ROCKS EXPOSED IN THE AREA

Two rock types, granite and biotite schist, underlie more than 95 percent of proposed park area. The "greenstone belt", diverse in composition and complex in structure but characterized by rocks having a green color, underlies Dryweed Island and adjacent islands and extends southwesterly onto the mainland and comprises much of the south shore of Rainy Lake east of Jackfish Bay.

Biotite Schist

The most widespread rock type in the proposed park is biotite schist, a gray to nearly black rock that weathers to various shades of grayish brown. It forms the bedrock for most of the Kabetogama Peninsula north of a line extending roughly between the point north of Peterson Bay, on Kabetogama Lake, and the north end of Kubel Island, in Namakan Lake. The schist can be split readily into thin slabs because the grains of biotite it contains are oriented more or less parallel to one another. This direction of ready splitting (schistosity) is nearly parallel to bedding in much of the outcrop belt, but crosses bedding in the hinge-areas of tight folds and locally in moderate-sized areas as at Saginaw Bay, in Rainy Lake. Beds are generally 3 inches to 12 inches thick (but locally as thick as several feet) and are distinguished from each other by differences in grain size and the amount of biotite and other minerals. Graded beds, in which

there is a gradual decrease in grain size from bottom to top, are fairly common.

Most schist outcrops are relatively low and flat, although cliffs several tens of feet high are not rare. This relatively low relief has resulted from erosion by the glaciers that moved over the area. The schist was eroded more easily by the glaciers than was the associated granite, and it commonly forms lower, less rugged exposures.

Mixed Gneiss

Trending through the middle of Kabetogama and Namakan Lakes is a broad belt of mixed gneisses, which lies between biotite schist on the north and more or less massive granite on the south, and represents a transition zone between these terranes. These rocks consist of layers, slabs, and irregular masses of biotite schist that are separated from one another by sheets of granite. The proportion of schist to granite varies widely; in places the rock is principally schist cut by numerous narrow stringers of granite, whereas in other places it is chiefly granite with only scattered lenses and wisps of schist. Ratios of schist to granite are commonly in the range 30:70 to 70:30. The schist layers are gray, grayish-brown, or nearly black, whereas the granite layers are white, whitish gray, or pinkish gray. Individual layers range in thickness from less than an inch to more than 10 feet and typically pinch and swell. Highly contorted folds can be seen in most outcrops.

Granite and Related Rocks

South of a line extending roughly from Sphungs Island (southwestern part of Kabetogama Lake) to Sullivan Bay is a terrane composed mostly of massive to weakly gneissic granitic rocks. Small bodies of massive granite also cut the belt of mixed gneiss (which is itself partly composed of granite) and the biotite schist, especially on the islands in the northern part of Kabetogama Lake. The principal area of massive granitic rock is south of the lake. The highlands along Ash River for several miles south of Sullivan Bay are underlain chiefly by massive granitic rocks. Granite outcrops generally are rounded and smooth, and commonly display glacial striations, chattermarks, and polished surfaces.

The terms "granite" and "granitic rock" are here used in a general sense to include several rock types that range in composition from true granite to hornblende quartz diorite. All these rocks are medium- to coarse-grained and are composed of microcline, plagioclase, quartz, biotite, and hornblende in varying proportions. Commonly, the mineral composition and texture vary rapidly over short distances, so that a large exposure may contain rocks of various colors and textures swirled together in "marble cake" fashion. Such an outcrop might contain pink granite, grayish pink granodiorite, and light gray quartz diorite mixed together and cut by narrow dikes of pegmatite.

Despite the compositional and textural inhomogeniety of these rocks, it has been possible to work out their general age sequence. Throughout the gradational zone between biotite schist and massive granite the oldest member of the granitic series is white to light grayish pink leucogranite, which in turn is cut by pink biotite granite. Along Ash River and the Ash River Trail the earliest granitic rock is dark gray hornblende quartz diorite. This is cut by gray to light gray biotite quartz diorite and granodiorite, which in turn is cut by pink biotite granite. The most voluminous and widespread member of the series is pink biotite granite, but within the proposed park area white, light gray, and pinkish gray granitic rocks also are very common.

Dikes of Mafic Igneous Rocks

The youngest rocks in the area are mafic dikes, dominantly having the composition of gabbro or diorite, that cut late members of the granitic series. The largest dike is well exposed in a road cut along St. Louis County Road 22, about 500 feet south of the Pine Ridge Inn. Smaller dikes occur on State Point and east of Shelter Bay, in Kabetogama Lake, and on the mainland and islands in the western part of Rainy Lake.

The large dike, exposed on County Road 22, is at least 300 feet thick and 3/4 mile long. It is composite in that it consists of two distinct rock types that were injected separately. The edges are dark gray, medium- to coarse-grained hornblende diorite; the central part is gray to pinkish gray medium-grained porphyritic hornblende quartz diorite that has been extensively altered hydrothermally. Hornblende gabbro occurs locally along strike.

VOYAGEURS NATIONAL PARK

Greenstone Belt

The greenstone belt that passes through the northwestern corner of the proposed park area consists of several interbedded and intertonguing rock types (pl. 2). Chloritic schist, massive greenstone, and meta-arkose are the dominant types; felsic tuffs, pillowed lava flows, and conglomerate occur in lesser quantities.

Chloritic schist is a bedded schistose rock composed chiefly of quartz, feldspar, and chlorite. Individual beds range in thickness from 1/2-inch to 3 inches and differ from one another in shade of green, depending on the amount of chlorite present. Outcrops typically weather to rough pitted surfaces that are light grayish green. The grain size varies considerably; the coarsest material, exposed on the small point that protrudes eastward into the bay at the east end of Dryweed Island, contains elongate ellipsoidal fragments about 4 inches long that may be volcanic bombs.

Massive greenstone, as the name implies, consists of beds as much as 10 feet thick that are composed of a coarse-grained green rock that weathers to distinctly rough surfaces. It comprises Capstan Rock, north of the western part of Dryweed Island, Cranberry Island, the reef just northeast of Cranberry, the large island due east of Cranberry, the small island north of Steamboat Island, and all the Fox Islands. The rock is interbedded with the chloritic schist on Cranberry Island, on the western-most of the Fox Islands, and at the western end of the longest of the Fox Islands.

Pillowed lava flows, also having a distinctly green color, are associated with and apparently interbedded with chloritic schist at a few localities. Because of pervasive shearing that tends to obscure original structures in these rocks, definite pillowed flows were observed at only one locality--on the small island south of Steamboat Island. At this locality the pillows are as much as three feet long. Possible pillowed flows occur on Powder Island, which is north of the east end of Dryweed Island, and on the small island southeast of Powder Island. They also occur on other islands and the mainland west of the park area. In Canada, pillowed flows were observed on Red Pine Island, which is just northwest of the northwest corner of the proposed park.

Gray meta-arkose (metamorphosed feldspar-rich sandstone), which weathers to a buff color, comprises most of Big American and Dryweed Islands. It forms a discontinuous unit about 10 miles long and a maximum of a half mile or more wide that extends west-southwestward onto the main-

land south of Jackfish Bay. The meta-arkose is gradational with and interbedded with mixed chloritic and biotitic schist on Big American Island and with chlorite schist on both the north and south sides of Dryweed Island. Individual beds within the unit generally are 4 to 12 inches thick, but some are as thick as 3 feet. Commonly, interbeds of a light green sericitic schist as thick as 4 inches occur in the unit; also, angular fragments of the schist occur in some arkose beds. Primary convoluted bedding and graded beds are present at places. Many outcrops show excellent cross-bedding.

Massive tuff, which is light gray to greenish gray, coarse-grained, and contains "eyes" of bluish quartz, forms the southern half of Steamboat Island and part of the island to the southwest of it. The rock is pervasively sheared and is interbedded with thin-bedded chlorite schist.

Conglomerate occurs at one locality within the area of the proposed park, at the eastern tip of Dryweed Island. Because of the small size of the body it is not shown on the detailed geologic map (plate 2). The conglomerate contains pebbles of feldspar porphyry, white quartzite, soft punky schist, and quartz in a chloritic matrix. Most pebbles have been deformed into ellipsoids by stresses that accompanied metamorphism.

The contact zone between the rocks of the greenstone belt and the biotite schist is marked by a narrow transitional zone characterized by interlayered, thin bedded chloritic and biotitic schists. The mixed rocks are mapped as a separate unit on plate 2.

Vein Quartz

Veins of white milky quartz are common in the Rainy Lake part of the area. For the most part the veins are one- to six-inches thick, subparallel to the bedding in the country rock schists, and contorted as a result of folding. Because of the small size of the veins, they are not shown on the geologic maps.

Origin of the Rock Types

The bedded rocks in the area, which include all but the granites and younger intrusive dike rocks, are dominantly metamorphosed sedimentary rocks. The thick biotite schist unit is a metamorphosed sedimentary succession that probably represents original graywacke and shale beds

derived from the weathering and erosion of pre-existing rocks. Some chlorite - and amphibole-rich beds interbedded with the biotite schist may have been derived directly from volcanic ash falls. The rocks of the greenstone belt are likewise dominantly sedimentary strata, but for the most part were probably derived directly from volcanic sources. The chloritic schist, massive greenstone, and felsic tuffs appear to represent volcanic fragmental rocks, mainly tuffs. The pillowed lavas probably represent submarine andesite-basalt flows. The source of the meta-arkose and the conglomerate is conjectural.

The granitic rocks are intrusive into and younger than the bedded rocks. The complex of granitic rocks has been referred to as the Vermilion batholith, and the pink biotite granite has been called the Vermilion Granite.

Structure and Metamorphism

The bedded rocks are folded and faulted, and metamorphosed by regional dynamothermal metamorphism. The intensity of metamorphism increases gradually from north to south, toward the granitic rocks of the Vermilion batholith, and ranges from greenschist facies in the extreme northern part of area to amphibolite facies in the southern part.

The rocks of the area are folded on easterly-trending axes, and for the most part dip steeply. In the area of Kabetogama and Namakan Lakes and at Saginaw Bay of Rainy Lake, dips are more moderate and locally are gentle. The moderate or gentle dips reflect more open folds than in the remainder of the area. The open folds and associated lineations plunge consistently eastward at angles of 20°-50°.

Throughout most of the area, schistosity (or foliation) is nearly parallel to bedding except in the axial areas of folds. A notable exception is the southern part of Saginaw Bay, in Rainy Lake, where bedding and schistosity dip in opposite directions at a high angle to each other.

Small-scale faults of two types, longitudinal and oblique, have been noted throughout the area. Longitudinal faults (nearly parallel to bedding) are most common in the greenstone belt, so far as known, and are indicated by local slickenside striae, brecciation, and disoriented schistosity. Oblique faults that have displaced bedding or granitic dikes a few inches to a few feet occur in all rock types. In general, these minor faults are too small to show on the geologic maps (plates 1 and 2).

EXPLANATION

Sequence does not necessarily indicate relative age

Biotite schist

Interlayered chloritic and biotitic schist

Chlorite schist and massive greenstone

Felsic tuff

Meta-arkose

Ultramafic rock

PRECAMBRIAN

--...?...?...

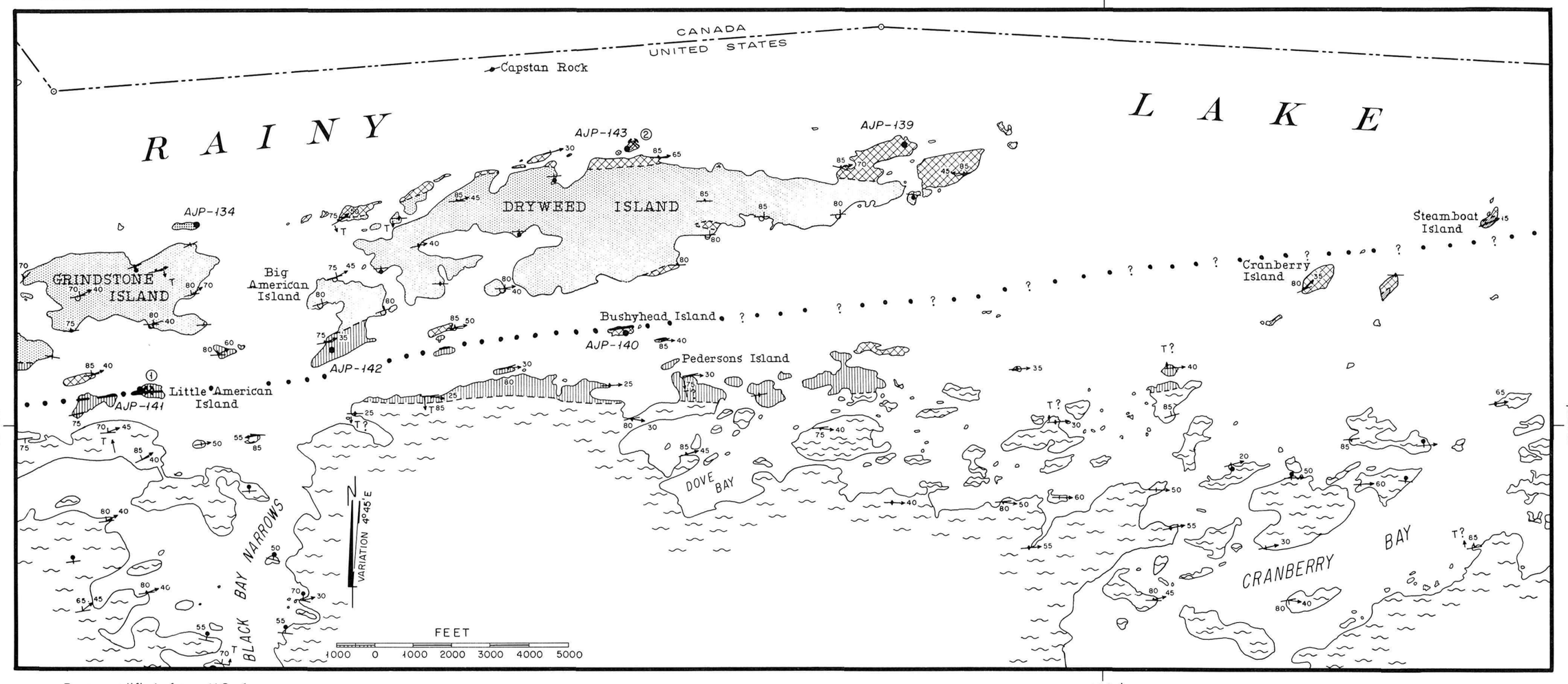
Major fault zone
(Dashed where approximately located; dotted where concealed; queried where existence uncertain)

Abandoned shaft
1, Little America mine; 2, Lyle prospect

• AJP 134

Sample locality
(Analytical data given in table 1)

Note: Explanation of geologic structure symbols is given on plate 1.



Base modified from U.S. Army, Corps of Engineers, U.S. Lake Survey Charts 821 and 823. Published by permission.

Geology by R.W. Ojakangas, 1968

Geologic map of greenstone belt, Rainy Lake, Minnesota

Major faults having substantial displacements almost certainly occur in the area also, but their existence is difficult to prove. A major longitudinal fault is postulated through the channel of Rainy Lake south of Dryweed Island (plate 2) because (1) there are numerous small faults and shear zones on Little America Island; (2) the meta-arkose or Grindstone and Dryweed Islands tops to the south whereas biotite schist on the mainland tops to the north; and (3) Canadian geologic maps show a major fault coming into this vicinity from the northeast. Other major longitudinal faults may be responsible for prominent topographic lineaments such as the lowland occupied by Locator, War Club, Quill, and Loiten Lakes or the depression partly filled by Mica Bay of Namakan Lake, but faulting hasn't been proved in these areas.

A prominent set of topographic lineaments trends northwestward. These lineaments (such as those through Mud Bay, Blind Ash Bay, or Ek Bay in Kabetogama Lake) may be controlled in part by oblique faults, but they are known to be subparallel to a prominent joint set. The late dikes of hornblende gabbro and diorite trend parallel to the lineaments and probably are controlled by the same fracture system.

ECONOMIC GEOLOGY

The greenstone belt that passes through the extreme northwestern corner of the proposed park has been a minor source of gold, and contains gossans_/ and other indications of sulfide mineralization. The gold was produced in the late 1890's, at a time when the area was not accessible by railway and the expense of bringing in equipment and supplies was great. Since the turn of the century there has been no mining in the area and very little prospecting. Other small gossans were observed during the geologic mapping in the biotite schists along the shores of Locator, War Club, Quill, and Loiten Lakes on Kabetogama Peninsula.

The Little America mine, which produced about $4,600.00 worth of gold in 1894 and 1895, is on Little American Island, south of Grindstone Island near the south shore of Rainy Lake (plate 2). It is about one-half mile west

_/ Gossan is the weathered surface expression of mineralized rocks, characterized by abundant oxidized and hydrated products such as limonite, which are derived from the alteration of sulfides of iron and other metals.

of the west boundary of the proposed park. The ore was stamp milled on the mainland near the island, yielding about $17.00 per ton (Grout, 1937, p. 57). The mine develops a 4- to 6-foot composite (segregated)quartz-vein zone with intermixed chloritic and biotitic schist that is impregnated with quartz. The vein is within an intensely sheared and altered zone. In addition to gold, the vein contains siderite (or ankerite), pyrite, and minor chalcopyrite.

Other prospects, apparently dug in the search for gold, were opened along the approximate east-northeast extension of the vein zone encountered in the Little America mine. A shallow shaft was sunk on a quartz vein on Big American Island, and an adit was driven on the south side of Bushyhead Island just above water level. The adit penetrated a 4-foot shear zone, which contains quartz and massive pyrite, as well as several subsidiary subparallel zones. Also, a shallow pit was sunk on a quartz-pyrite vein in mixed chloritic and biotitic schist on the mainland southeast of Big American Island. On a small island 1,200 feet southeast of Pedersons Island there is a shallow pit, and on the island composed of mixed chloritic and biotitic schist that is south of the east end of Dryweed Island (pl. 2) there is a shaft, now filled and covered by a small building.

Elsewhere in the greenstone belt, gossans were observed during mapping at (1) the southwest end of the island east of Cranberry Island, (2) in the chloritic schist on the west end of the island south of Steamboat Island, and (3) in the chlorite schist at the northeast tip of Dryweed Island. At the last locality, pyrite occurs in quartz-siderite veins in sheared and altered country rock. Similar veins occur on the dump of the so-called Lyle mine, on the small island just north of the north tip of Dryweed Island. Earlier geologic reports (Grout, 1937) describe mineralized veins on Cranberry Island, Steamboat Island, and Grassy Island. Grassy Island is west of the proposed park.

In addition, the meta-arkose on Dryweed Island and on the islands to the west contains moderate amounts of disseminated pyrite.

To appraise the mineralized character of the greenstone belt, six of the samples that were collected during mapping were analyzed to supplement the record of past mining activities. An additional sample was collected from Locator Lake on the Kabetogama Peninsula. Sample localities for all but that from Locator Lake are shown on plate 2; analytical results are given in table 1.

Table 1--Analyses of samples from the Rainy Lake area
(Analyses by U.S. Geological Survey, Denver Laboratory)

Sample number	Chemical 2/ (ppm)				Semiquantitative spectrographic 1/ (ppm)					
	Au	Ag	Cu	Zn	Ni	Mn	B	Ba	Co	Cr
AJP-134	N	0.8	39	60	700	1500	30	N	200	G5000
-138	N	.2	45	N	80	500	20	300	150	150
-139	N	.8	N	82	46	2000	L	150	30	5
-140	N	4.4	100	50	40	500	30	70	100	15
-141	1.8	.8	N	50	78	2000	G2000	200	70	300
-142	N	.6	34	150	20	100	700	700	7	50
-143	0.04	1.2	350	60	70	G5000	N	L	5	L

1/ Spectrographic analyses by J. Motooka. Spectrographic limit of semiquantitative analysis, in ppm (parts per million).: Mn, 10; B, 10; Ba, 20; Co, 5; and Cr, 5. N, not detected; L, detected, but below the limit of semiquantitative determination; G, greater than value shown.

2/ Analyses by atomatic-absorption spectrometry by J. G. Frisken, M. S. Rickard, L. W. Bailey, and J. G. Viets. Limit of detection for Au, 0.02 ppm; Cu, 10 ppm; and Zn, 25 ppm. Pb looked for but not found.

Description of samples:

AJP-134 Ultramafic body, small island 400 feet north of northeast end of Grindstone Island
-138 Sulfide-bearing breccia, Locator Lake, Kabetogama Peninsula
-139 Sulfide-bearing breccia, east end Dryweed Island
-140 Altered quartz-pyrite vein, Bushyhead Island
-141 Mineralized breccia from dump Little America mine, Little American Island
-142 Altered schist, Big American Island
-143 Sample siderite-rich rock, dump, Lyle "mine", small island just north of north tip of Dryweed Island

Three of the samples (AJP-140, from Bushyhead Island; AJP-141, from the Little America mine, and AJP-143, from the Lyle "mine" dump) contain significant amounts of gold, silver, and copper. A grab sample of the ultramafic body on the small island 400 feet north of the northeast end of Grindstone Island (sample site AJP-134) was determined by analysis (by U.S. Geological Survey) for platinum group metals to contain 0.018 ppm platinum and 0.022 ppm palladium. The rhenium content of the sample was below the limit of detection. As indicated in table 1, the same sample contains more than 5,000 ppm chromium and 700 ppm nickel. The samples are inadequate to determine the economic potential of the sample sites, but are useful as a guide to further sampling and study.

ECONOMIC APPRAISAL

The past production of gold from the Little America mine, which is adjacent to the proposed park, the presence of local anomalous values for gold, silver, and copper, and the existence of widespread disseminated pyrite in the rocks of the greenstone belt that passes through the northwestern corner of the proposed park indicates that this belt is a potential source of valuable mineral deposits. It is part of a broader mineralized zone called the Rainy Lake district that crosses the International Boundary. In Canada, production from the district has amounted to more than a million dollars in gold (Grout, 1937, p. 59), and several copper prospects have been investigated.

Greenstone belts are the source of a substantial proportion of the metallic mineral production in Ontario and Quebec, Canada, which exceeds a billion dollars annually. In addition to gold, the belts have significant deposits containing copper, zinc, nickel, iron, and silver. The greenstone belts in Minnesota did not receive serious attention from the mining industry until about 1967, but now are being investigated by several major companies. The principal interest has been in the greenstone belt of the Vermilion district, in St. Louis County and adjacent areas in Itasca and Koochiching counties, and in a belt in western Koochiching and adjacent Lake of the Woods County, near Indus, Minnesota. State lands in these two areas were leased for exploration and mining during 1968 (Sims, 1969).

A major factor responsible for the current high level of interest in the greenstone belts, here as well as in Canada, has been the relatively recent development of sophisticated electromagnetic geophysical equipment. This equipment is an aid to geology in exploration and is considered by the mining

industry to be an important tool in the search for sulfide ore bodies. It provides industry with an effective tool to prospect areas in which the bedrock is covered by soil and other unconsolidated deposits.

So far as known, the greenstone belt that passes through the northwestern corner of the proposed park has not been explored in recent years by industry, perhaps because of its relatively small size as compared to the others now being investigated. Also, accurate geologic maps have been lacking until now.

RECOMMENDATIONS

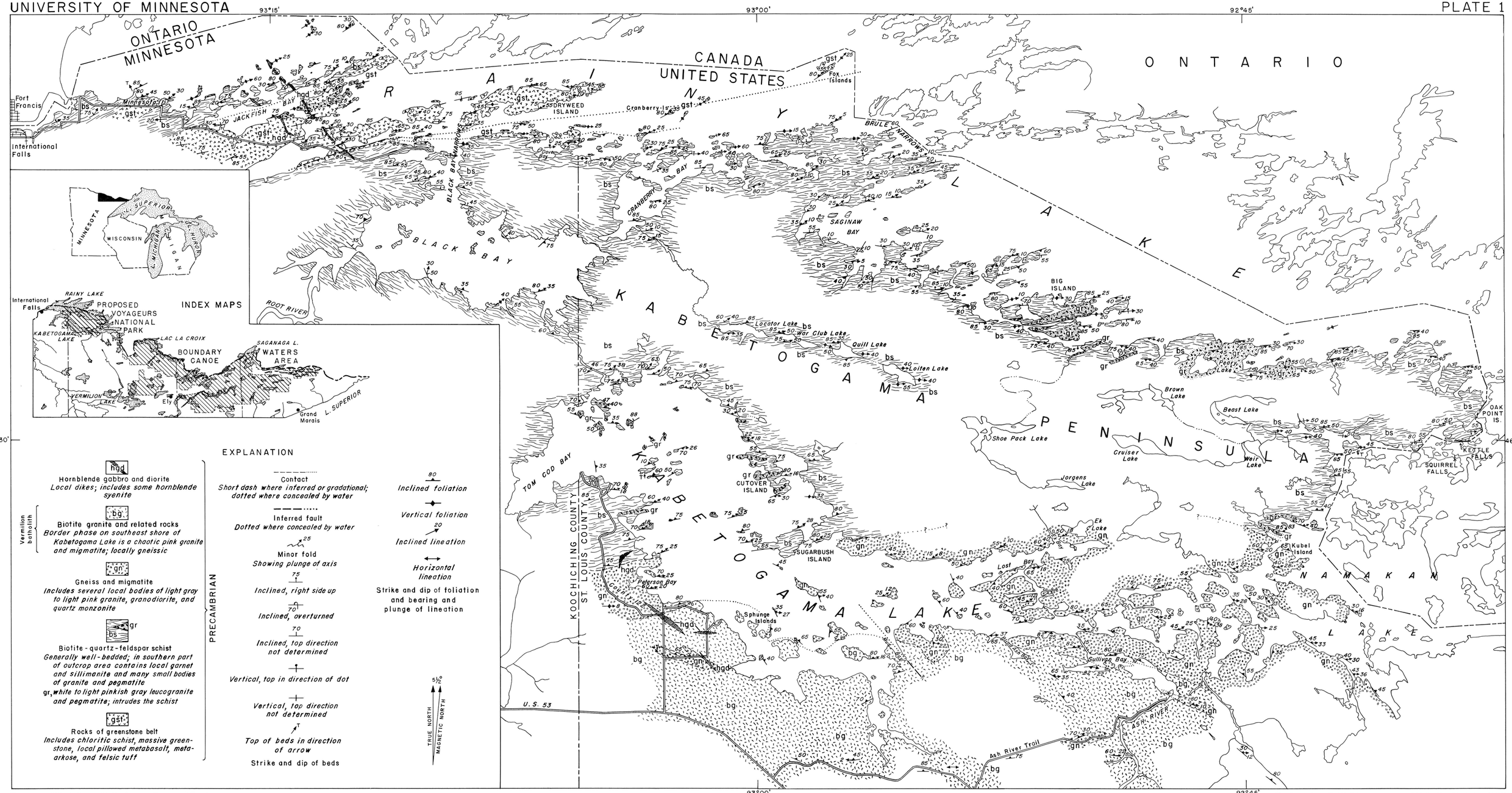
Insofar as mineral potential is a factor, the greenstone belt in the extreme northwestern part of the area is not suitable for inclusion in the proposed national park. The islands underlain by rocks of the greenstone belt--Big American Island, Dryweed Island, and the smaller islands between Dryweed Island and the mainland--should remain accessible for prospecting and possible mining. Similarly, the shore area of the mainland between Black Bay Narrows and Dove Bay should remain open for prospecting (see plate 2).

Although our present knowledge is inadequate to state unequivocally that the greenstone belt contains minable ore bodies, the belt is favorable for their occurrence. Geophysical work, additional geologic studies and, probably, core drilling would be required to fully evaluate the belt.

According to the report by the State of Minnesota, issued in October, 1967, the surface rights in the greenstone belt are entirely privately owned. The ownership of mineral rights is not known, and should be determined.

APPRAISAL OF CRANE LAKE AREA

The Crane Lake recreation area, which has been proposed for inclusion in Voyageurs National Park by Governor Harold LeVander, does not appear to be favorable for the occurrence of significant mineral deposits. To judge from our present incomplete knowledge of the geology, this area is underlain dominantly by granite and related rocks, similar to those that lie south of Kabetogama Lake. Such rocks are not known to contain valuable mineral deposits, but future discoveries cannot be ruled out as a possibility.



Base modified from U.S. Army, Corps of Engineers, U.S. Lake Survey charts (published by permission); additions from County Road Maps and U.S. Geological Survey topographic maps.

1 0 1 2 3 4 MILES

4000 0 4000 8000 12000 16000 FEET

Geology by R. W. Ojakangas and D. L. Southwick, 1968

GEOLOGIC MAP OF PROPOSED VOYAGEURS NATIONAL PARK NORTHERN MINNESOTA 1969

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