PETROLOGICAL, STRUCTURAL AND MAGNETIC STUDIES OF A LAYERED BASIC INTRUSION, BIRD RIVER SILL, MANITOBA

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by
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ABSTRACT

The Bird River Sill, situated in southeastern Manitoba is a layered ultramafic to basic intrusive. In this sill 45 layers consisting of serpentinized peridotite interlayered with chromite bearing layers, pyroxenite, gabbro, anorthositic gabbro, anorthosite, hornblende gabbro, and porphyritic gabbro form a thickness of approximately 2,000 feet.

Primary structures in the chromite bearing layers and in the gabbros are evidence of thermal or density currents in the magma during crystallization and cryptic variation of anorthite percent in the plagioclase shows an inverted trend indicating crystallization downwards from the roof as well as accumulation on the floor of the magma chamber.

Complex faulting across and parallel in strike to the layering of the Sill has resulted in apparent change in thickness of, and omission of rock units in the Bird River Sill.

Magnetic susceptibility study and a vertical field magnetic survey indicates a lack of magnetite in the gabbroic rocks. The consequent magnetic signature can thus be utilized with a knowledge of the geology to prospect for non-magnetic chromite in the Bird River Sill.

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INTRODUCTION

Location, Access, and Topography

The portion of the Bird River Sill studied is situated in the Superior Province of the Precambrian Shield of southeastern Manitoba, approximately 35 miles east of Lac du Bonnet. The Bird River Sill outcrops extensively in this area, marginal to, and north of Peterson Creek.

Two "all weather" roads, (Provincial Trunk Highways, 314 and 315), linking Lac du Bonnet, Bird Lake, and Cat Lake, provide access to within 1/4 mile of the study area. Winter trails bridge Peterson Creek and join with these roads 1.5 miles southwest of, and 1.4 miles northeast of the junction of P.T.H. 314 and P.T.H. 315. Within the map area winter logging trails provide good access to all points, and afford a measure of location control.

The topography is typical of most of the Precambrian Shield and consists of high rock outcrop, surrounded by low, wet, or tree covered ground, Relief is moderate and seldom exceeds 50 feet.

Drainage in the area is by way of Peterson Creek west into the Winnipeg River system. Peterson Creek is not navigable.

Glacial deposits observed consist of boulder till, minor gravels, and varved clays. Glacial striae, chatter marks, and plucking features indicate movement of the Patrician ice sheet as having been from North 40° East.

Previous Work and Economic Development

The first systematic exploration in the Bird River area was conducted by J.B. Tyrell in 1898. In 1912 E.S. Moore correlated the rocks of this area with those of the Rice Lake district to the north.

The discovery of copper-nickel sulphide deposits near Maskwa in 1917 prompted study of the Bird River Sill by Colony (1920,-21), McCann (1921), and Cooke (1922). In 1942 the discovery of chromite in the Sill resulted in extensive investigation by Bateman (1942,-43,-45) and Brownell (1942). Later, regional mapping was conducted by Springer (1948, -49,-50), and Davies (1952,-55). Selected aspects of the Bird River Sill have been studied by Osborne (1949), and Gait (1964).

In previous literature the portions of the Bird River Sill studied are known as the Chrome and Page Properties, (see also Fig. 1, page 7). This nomenclature is retained below, and the following excerpt from Davies et al (1962) is a concise summary of the development of the chromite deposits in this area.

> "Parts of the main chrome band have been drilled to a depth of 650 feet and indicated reserves of 874,000 tons grading 25.2 percent Cr_2O_3 on the Page Property, and 1,220,000 tons grading 18.2 percent on the Chrome Property. The actual reserves are probably many times these figures, for only parts of each property have been drilled and the chromite bands are generally persistent."

The iron content of the chromite in these deposits precludes further development and recovery of the chromite without extensive beneficiation processes.

Adjacent to, and east of the study area, copper-nickel sulphides are being explored by Bird River Mines Ltd., and copper-nickel mining operations are being conducted by Dumbarton Mines Ltd. Although interest in the Bird River Sill was first generated by the discovery of sulphide occurrences in the Sill, their relationship to the Sill is not known with any certainty, (Karup-Moller, 1971).

Present Work and Acknowledgements

The ensuing study was undertaken under the auspices of the Ultramafic Project of the Manitoba Mines Branch, and the Department of Earth Sciences, University of Manitoba. The particular study area was chosen for the extensive exposure of the Bird River Sill.

Field work was conducted during the summer and fall of 1970, utilizing pace and compass methods supplemented by vertical aerial photographs, the centres of which are indicated on the accompanying geologic map. Mapping was conducted on a scale of 1 inch = 1/4 mile; the accompanying geologic map being of the same scale. Detail mapping and geophysical work utilized air photo enlargements (1 inch = 330 feet).

The writer would like to acknowledge the assistance of C.D. Anderson and A.C. Turnock of the University of Manitoba

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GENERAL GEOLOGY

Introductory Statement

The ensuing discussion of the rocks adjacent to the Bird River Sill is not intensive. The stratigraphy of these rocks however, provides a necessary key to the structural interpretation of the area.

All of the consolidated rocks of the study area are of Precambrian age. These rocks are subdivided into two groups; the Rice Lake Group, and the Intrusive rocks (Table 1).

The Rice Lake Group, the oldest group in the area, consists of a conformable or paraconformable assemblage of metavolcanic and metasedimentary rocks. Metagabbro sills, the Bird River Sill, and a large quartz diorite - granodiorite body, (Great Falls Pluton, McRitchie, 1971) are intrusive into the Rice Lake Group.

In the study area these rocks are represented in complexly faulted segments of the south limb of an easterly plunging anticline (Figure 1).

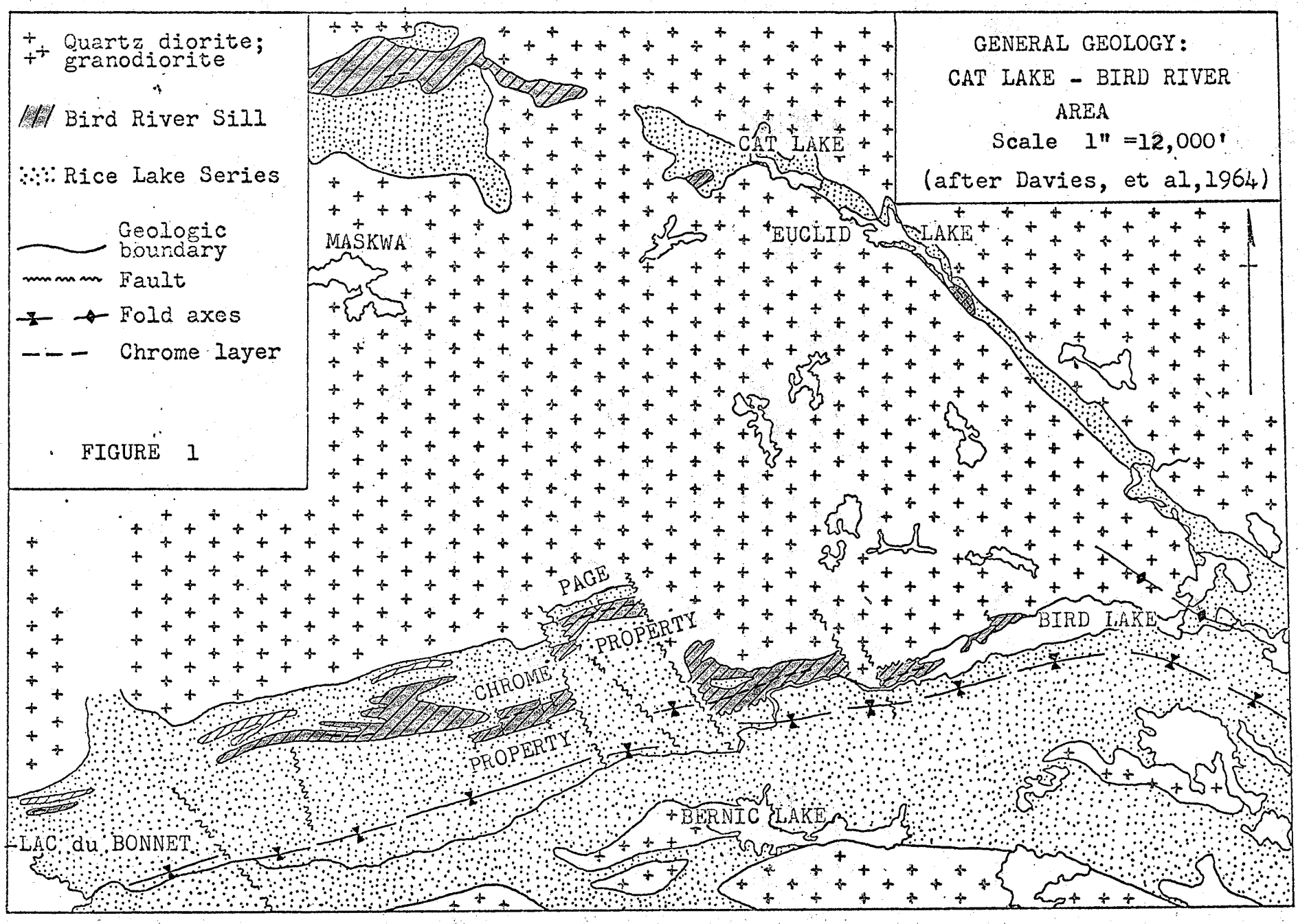
RICE LAKE GROUP

In the study area the rocks of the Rice Lake Group consist of a metamorphosed assemblage of pillowed and flow volcanics, tuffs, fine to medium grained clastic sediments, and conglomerate. These rocks flank the Bird River Sill; the metavolcanic assemblage lying north of, or "below" the Sill, and the metasedimentary

TABLE OF FORMATIONS

RECENT and PLEISTOCENE				Boulder till, sand, gravel, clay
UNCONFORMITY				
PRECAMBRIAN	ARCHAEAN	INTRUSIVE		Quartz diorite - granodiorite
				INTRUSIVE CONTACT
			BIRRIDVSEIRL	Porphyritic gabbro
				Hornblende gabbro
				Anorthositic gabbro, anorthosite, gabbro
				Pyroxenite
				Serpentinized peridotite with interlayered chromitite and chromiferous peridotite
			L	Marginal gabbro
				INTRUSIVE CONTACT
				Metagabbro
				INTRUSIVE CONTACT
		RICE LAKE GROUP		Greywacke, crystal tuff, polymict conglomerate; derived schists
				Basalt, porphyritic andesite; derived schists

TABLE 1


Quartz diorite; granodiorite
Bird River Sill
Rice Lake Series
Geologic boundary
Fault
Fold axes
Chrome layer
FIGURE 1
GENERAL GEOLOGY:
CAT LAKE - BIRD RIVER AREA
Scale 1" =12,000'
(after Davies, et al,1964)
CAT LAKE
MASKWA
EUCLID
LAKE
PAGE
PROPERTY
BIRD LAKE
CHROME
PROPERTY
BERNIC LAKE
LAC du BONNET

assemblage lying south of, or "above" the Sill. Variation of this relationship is the result of faulting.

Dip attitudes in the Rice Lake Group are steep to vertical; strikes are east to northeasterly. Relict volcanic pillows and cross bedding in the metasediments have south - facing tops in the area of the Chrome and Page Properties.

Basalt, porphyritic andesite; derived schists (Map unit 1)

Metamorphosed pillow lavas (1a) are the dominant volcanic rocks. These rocks are dark grey to black weathering, fine to medium grained, and massive to weakly schistose. Pillow structures and relict selvaged edges are well preserved. East of the Page Property, these rocks are characterized by greenish grey weathering, a fine grained texture, moderate schistosity, a siliceous appearance, and garnet metacrysts. Pillow structures in the garnetiferous rock are generally elongate, and often have been completely obliterated by the foliation development.

Both the garnetiferous and the pillowed metavolcanics are seen to consist of nearly equal distributions of hornblende and plagioclase. Accessory and secondary minerals comprise fibrous amphibole, magnetite, chlorite, albite, epidote - clinozoisite, carbonate, quartz, sulphides, and east of the Page Property, garnet.

Porphyritic andesite forms a narrow metamorphosed flow interlayered with the pillowed lavas. This rock is light green to grey weathering, has a fine grained groundmass, is massive, and is characterized by 10 to 15 percent of large (up to 3/8 inch) plagioclase phenocrysts. At one location stretched vesicles are preserved.

In thin section the margins of the plagioclase phenocrysts are corroded, and the plagioclase is saussuritized. The groundmass consists of hornblende and plagioclase (albitized) with minor magnetite, quartz, epidote, carbonate, chlorite, and pyrite.

Greywacke, crystal tuff, polymict conglomerate; derived schists (Map unit 2)

Metamorphosed greywackes outcrop extensively south of the Bird River Sill, and form the major portion of the metasedimentary succession. These rocks are greyish to black weathering, fine to coarse grained, and massive to strongly schistose; lepidoblastic schistosity being imparted by the development of micaceous minerals. Bedding is generally poorly defined and individual beds seldom are in excess of several inches in thickness. Cross bedding structures are not common, and other primary structures were not observed.

The metagreywacke consists of quartz, combined feldspars, hornblende and/or biotite. Sericite, chlorite, magnetite, carbonate, and sulphides are minor constit-

uents.

Locally, large (up to 2 inch) rounded quartzo-feldspathic clasts give rise to conglomeratic phases in the metagreywacke. These clasts may comprise up to 40 percent of the rock and are often rodded in the foliation plane.

South of the Chrome Property several narrow (2-3 inch) chert beds are interlayered with the metagreywacke. The chert is light grey to cream in colour, aphanaitic, and massive. These beds are generally fragmented or brecciated and associated with pyrrhotite mineralization in and near fold structures.

Metamorphosed crystal tuff outcrops near P.T.H. 315 south of the Chrome Property. This rock is greyish weathering, massive to schistose, and displays large euhedral plagioclase crystals interspersed throughout a fine to medium grained matrix. Random orientation of the plagioclase crystals, and a poorly defined bedding in the unit suggest a rapid waterlain origin, which is substantiated by the presence of large rounded granitic clasts.

The crystal tuff consists of up to 45 percent plagioclase crystals set in a matrix of fibrous amphibole, plagioclase, biotite, sericite, zoisite, quartz, and carbonate. Secondary quartz, and carbonate are present as numerous irregular small blebs and stringers injected concordantly into the bedding.

Metamorphosed polymict conglomerate outcrops

east of, and is in fault contact with the central faulted block of the Bird River Sill. This conglomerate is dark weathering, moderately schistose, and characterized by large, rounded, medium to coarse grained amphibolite clasts, as well as smaller granitic clasts. These clasts are rodded vertically in the foliation plane.

Cobble sized amphibolite clasts comprise up to 30 percent of the rock, whereas the granitic clasts, of pebble size and sacharoidal appearance, seldom exceed 10 percent. The argillaceous appearing groundmass consists chiefly of amphibole, biotite, and feldspars, with minor amounts of quartz, sericite and carbonate.

INTRUSIVE ROCKS

The discussion of the intrusive rocks is limited in the following section to the gabbro, present as small sills in the metavolcanic rocks, and to the quartz diorite-granodiorite within the map area.

Metagabbro (Map unit 3)

Metamorphosed gabbro is present as faulted segments of a narrow sill which lies to the north of, and in close proximity to the base of the Bird River Sill. As this gabbro was only observed in the metavolcanic rocks, its positioning in Table 1 is therefore arbitrary.

The metagabbro forming this sill is generally dark grey to black weathering, medium to coarse grained, and

massive. Contacts with the metavolcanic rocks are poorly defined, being gradational over several feet.

Plagioclase and amphibole are the dominant minerals of the gabbro; the amphibole content forming from 60 to 75 percent of the rock. In thin section the plagioclase forms subhedral corroded and extensively saussuritized equant grains, which are partly encroached on by fibrous amphibole. Zoisite, carbonate, magnetite, chlorite, quartz, and traces of sulphide are common throughout.

Quartz diorite - granodiorite (Map unit 9)

Quartz diorite and granodiorite form the major part of the Great Falls Pluton (McRitchie, 1971) which is intruded into the metavolcanic rocks north of the Bird River Sill. The body is heterogeneous in nature and shows little or no systematic variation in the distribution of the quartz diorite and granodiorite phases.

The quartz diorite - granodiorite is greyish to pink weathering, coarse to very coarse grained, and massive to weakly gneissic. Quartz diorite phases are typified by small blebs of bluish quartz which display an augen shape where the rock is foliated. Hornblende, biotite, and plagioclase form up to 90 percent of the rock. Quartz and magnetite are accessory, and sericite, chlorite and epidote are common alteration products.

Intrusive contacts between the Great Falls Pluton

and the metavolcanic rocks are exposed along a pronounced air photo lineament north and west of the Page Property. Here the contact is marked by minor wall rock brecciation, quartz-carbonate stringers, and large angular stoped blocks of the metavolcanic rock. East of the Page Property, near Peterson Creek, the Great Falls Pluton lies in fault contact with the Bird River Sill and the garnetiferous metavolcanic rocks of Map unit 1b.

THE BIRD RIVER SILL

The Bird River Sill is a layered body formed through gravity segregation of crystals during cooling; the resulting rock types of which range from ultramafic to intermediate in composition. The intrusion and crystallization of the magma, based on structural and lithologic relationships, occurred while the Rice Lake Group of rocks was essentially horizontal.

Seven rock units, forming 45 layers, were identified in the Bird River Sill. In addition, a previous study by Osborne (1949) indicates the presence of a marginal gabbro facies.

The rock units (Fig. 2) are described in order of crystallization.

Marginal Gabbro

A marginal gabbroic facies, termed olivine pyroxene gabbro by Osborne (1949) was observed by Osborne in core from a diamond drill hole which intersected the basal contact of the Bird River Sill and the metavolcanic rocks. This gabbro, which is not exposed in the study area, is described by Osborne as exceeding 30 feet in thickness and consisting of;

> "...medium grained basic plagioclase, extensively altered to rectangular patches of clinozoisite....the only primary

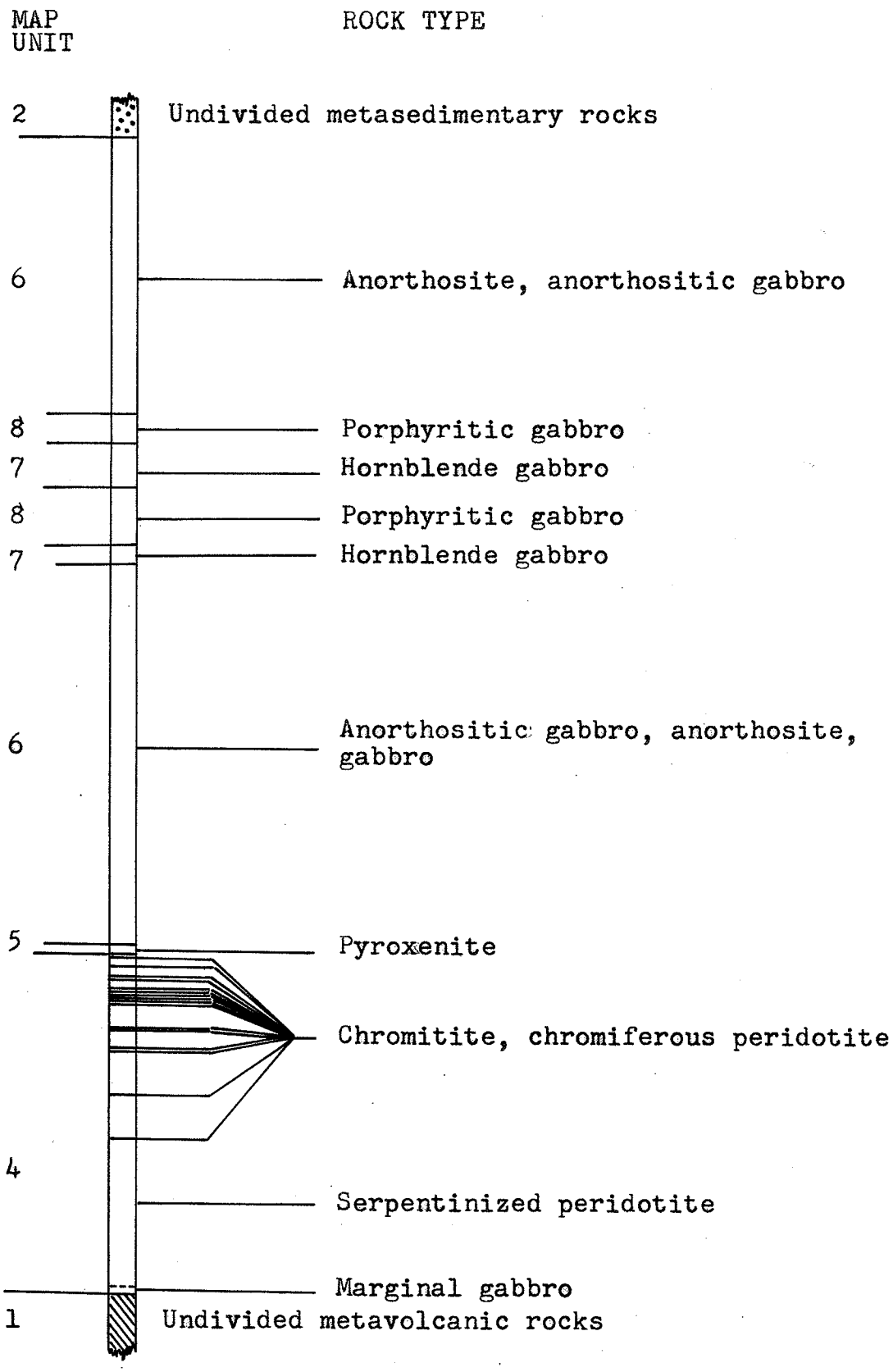


FIGURE 2: Stratigraphy of the Bird River Sill

> mineral seen in the gabbro. Parts of the rock consist merely of clino-zoisite - plagioclase patches in a matrix of fine tremolite needles and mesh-like prochlorite. In many places however, tremolite occurs as large platy crystals, one tremolite crystal commonly enclosing a number of clinozoisite - plagioclase patches. Part of the tremolite in these large crystals is crowded with dusty specks, and part is clear. The clear areas are uniform in size, rounded, and have sharp boundaries with the dusty tremolite. Some of them have prochlorite cores. With crossed nicols, the clear areas are just as sharply outlined, as they have higher interference colours than the dusty tremolite. The clear areas are interpreted as representing original olivine, and the dusty tremolite as representing original pyroxene."

The features described above are similar with features of the gabbroic rocks higher up in the layered series.

Serpentinized peridotite (Map unit 4)

Serpentinized peridotite, interlayered with chromiferous peridotite, forms 19 distinct layers and comprises the basal portion of the Bird River Sill which is approximately 600 feet in thickness.

The serpentinized peridotite near the base of the Sill is typically brown to rusty weathering, massive, and coarse grained. Large (1/4 inch) tremolite metacrysts,