THE PETROLOGY OF ARCHAEAN AND PROTEROZOIC ROCKS AT CROSS LAKE MANITOBA AND THE EFFECTS OF THE HUDSONIAN OROGENY

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ABSTRACT

The Cross Lake Group, consisting of basalt, conglomerate, and sandstone, lies unconformably on the basement biotite granodiorite gneiss. The area probably underwent two periods of folding and these likely correspond to the Kenoran and Hudsonian orogenies. The only recognizable effects of the Kenoran orogeny are the north north-easterly and north northwesterly - trending cross folds. The Cross Lake Group was folded, metamorphosed, and granitized during the Hudsonian orogeny. The major structural features were produced during the Hudsonian orogeny. These consist of a southwesterly-trending syncline and a northwesterly-trending syncline which merge and continue as one to the southwest and a major anticline situated between the two arms of the synclines. Numerous small-scales folds and lineations are present. Structures, in general, plunge steeply. Gabbro and anorthosite in the form of a sill at Pipestone Lake and a batholith south of the Minago River intrude the Cross Lake Group. These bodies were emplaced before or during the early stages of the Hudsonian folding.

The grade of metamorphism at Cross Lake increases from the lower part of the almandine-amphibolite facies in the southeast to the hornblende granulite subfacies of the granulite facies in the northwest

Garnet, clinopyroxene, and hypersthene progressively develop in basalt with increasing metamorphic grade. Hornblende in basalt decreases in amount, becomes darker in color, and shows an increase in the content of Al in the tetrahedral site and (Na+K) with increasing metamorphic grade. Rocks of the Cross Lake group were locally granitized by post-metamorphic intrusions of quartz-feldspathic material. This produced migmatites and most of the rocks of the gneiss complex.

Northwesterly-trending linear features were formed by tensional forces. These, together with mafic dykes and joints, are all post-Hudsonian in age.

Previous writers suggest that the Churchill and Superior provinces in northern Manitoba are separated by a gneissic zone. This study indicates that the contact between the Cross Lake sedimentary - Volcanic belt ("Superior" province) and the gneissic zone is a gradational one. Rocks south of the contact consist of those of the Cross Lake group and migmatites and rocks north of the contact are migmatites and those of the gneiss complex. Evidence is presented which suggests that the Cross Lake area lies within the Churchill province and that the Churchill-Superior boundary lies south of Cross Lake. The contact is likely a gradational one where effects of the Hudsonian orogeny fade into the Superior province.

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CHAPTER I

INTRODUCTION

LOCATION, SIZE, AND PHYSIOGRAPHY OF AREA

The geographic centre of the Cross Lake area lies 44 miles north of Norway House and 37 miles southeast of Wabowden. The area is bounded by latitudes 54°30' north to 54°45' north and longitude 97°30' east to 98°15' east and comprises a total of 510 square miles (see geological map).

The area is one of low relief with numerous swamps and muskegs. Sedimentary rocks are topographically low and outcrops rise only a few feet above lake level. Granodiorite and gabbro rocks locally form cliffs some 50 feet high. The greatest relief, in the order of 100 feet, is made by glacial ridges east and southeast of Cross Lake settlement. The area is drained entirely by the Nelson River System. Drainage is controlled by bedrock rather than glacial deposits.

PREVIOUS WORK

Prior to 1919, geological investigations in the area were in the nature of track or exploratory surveys. These consisted largely of isolated geological observations along major water routes. The first work was done by Bell (1879, 1881) and Tyrrell (1900) in 1890 and 1896. Existing information of the region was compiled by McInnes (1913).

Alcock (1920) did the first systematic mapping of the area at a scale of 2 miles to 1 inch. This comprised the western part of Cross and Pipestone lakes and encompassed the entire area considered in this report. The main areas underlain by sedimentary and volcanic rocks were outlined. Only three rock types, granites, sedimentary rocks, and volcanic rocks are shown on Alcock's geological map and no attitudes are given. He believed that the gneiss complex (9) intruded the sedimentary-volcanic sequence (2, 3, 4). No evidence was found to suggest that conglomerates (3) unconformably overlie volcanic rocks (2) and no volcanic pebbles were found in conglomerates.

Horwood (1934) did reconnaissance mapping at a scale of 4 miles to 1 inch in 1931-32 and this included the eastern two-thirds of the area. He believed that the sedimentary-volcanic sequence (2, 3, 4) lay unconformably on the gneiss complex (9) and that the conglomerates (3) overlie the volcanic rocks (2) unconformably. Evidence presented for the latter is an unconformity and the presence of volcanic pebbles in conglomerate.

In 1960 Bell (1962) remapped the eastern two-thirds of the area at a scale of 4 miles to 1 inch and compiled and revised the previous work. His map differs little from that of the writer. In 1962 Bell commenced reconnaissance mapping of the Wekusko sheet which includes the western one-third of the area. This work is still in progress.

Various mining companies and prospectors have examined showings in the area and some drilling has been done. In 1959 the Noranda Exploration Company did detailed mapping, ground magnetometer work, and drilling in the vicinity of the gabbro sill at Pipestone Lake.

Aeromagnetic maps Wolf 25 and 26 cover most of the area. Copies may be obtained at the Manitoba Mines Branch.

PRESENT WORK AND NATURE OF THE PROBLEM

Three 15-minute sheets, comprising 510 square miles, were mapped during the course of three field seasons from 1960 to 1962. Field data were plotted on vertical aerial photographs at a scale of 4 inches to 1 mile and transferred in the field to maps at a scale of 2 inches to 1 mile. The final map is at a scale of 1 inch to 1 mile.

Shorelines consist largely of rock exposures and virtually all were examined. Outcrops inland are small and few can be recognized on aerial photographs in this heavily bush-covered terrain. Pace-and-compass traverses assisted by aerial photographs as a location guide were run at 1200 to 1500-foot intervals over most of the area. Where swamps and muskeg were extensive, rather wider spacing was used. Representative samples were collected for thin sections, chemical analyses, and age determinations.

The primary purpose of the project was to map in detail the broad Cross Lake "greenstone" belt and surrounding gneisses.

Previous mapping had been limited to cursory track and reconnaissance surveys, mainly confined to shorelines. A close examination was made of the gneiss complex (9) in order to attempt separation of it into more than one rock type. Attention was given to the stratigraphy of the sedimentary-volcanic sequence (2, 3, 4) and its relationship to the gneiss complex (9). This was to test the validity of previous rock groups established, their correlation with other areas, and the contention that the gneiss complex (9) represented the basement upon which the sedimentary-volcanic sequence (2, 3, 4) was deposited. Numerous structural elements were recorded and analyzed in order to determine the configuration and origin of this structurally complex area.

More than 300 thin sections were examined. Point counts were made on a number of specimens to provide sound quantitative data as to the mineralogical content of the various rock types. Total rock analyses were made on 24 specimens. Nine mineral analyses were made together with 13 partial analyses of plagioclase. Age determinations were obtained from 3 specimens.

A rather detailed laboratory investigation was made on basalts (2) and comprised point counts, total rock analyses, mineral analyses, and optical determinations. The purpose was to determine the chemical composition of the basalts together with changes in mineral content and mineral composition under progressive regional metamorphism.

In northern Manitoba the Churchill and Superior provinces of the Precambrian Shield are considered to be separated by a gneissic zone. Commercial nickel deposits along the Thompson-Moak Lake belt, near the northern edge of the gneissic zone, has focused a great deal of attention on this region. This has also generated interest as to the nature of the contact between the Churchill province and the gneissic zone and the Superior province and the gneissic zone. The Cross Lake area straddles the contact between the Superior province and the gneissic zone. This study has clarified the nature of the contact and suggests that the Cross Lake area and the gneissic zone were effected by the Hudsonian orogeny.

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1960 - P. McKenna, Sr. Assist., A. Hodgson, V. Sokalski, E. Kluth.

1961 - R. J. Rector, Sr. Assist., C. Hawn, D. Lawson, L. Grapentine.

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CHAPTER II

GENERAL GEOLOGY

INTRODUCTION

The Precambrian rocks of the area are outlined schematically in the Table of Formations (page 9). These rocks are grouped according to rock types and described in subsequent chapters. Chapter III describes the basalts (2) and basalt migmatites (6) and Chapter IV sedimentary rocks (3, 4) and sedimentary migmatites (7, 8). Acid and intermediate rocks are discussed in Chapter IV and these include the basement biotite granodiorite gneiss (1) and rocks of the gneiss complex (9). Gabbro-anorthosite (5) and mafic dykes (10) are dealt with in Chapter VI.

STRATIGRAPHY AND CORRELATION OF THE SEDIMENTARY-VOLCANIC SEQUENCE

Previous Interpretation

Horwood (1934) divided the sedimentary-volcanic sequence into the Hayes River Series and an overlying Cross Lake Series. The Hayes River Series consisted largely of basalt with minor conglomerate and the Cross Lakes Series of sandstone, some conglomerate, and minor basalt.

Horwood (1934) correlated the Hayes River Series with Keewatin volcanic rocks of the Lake of the Woods area, Ontario. This was based on structural and lithological similarities. The Hayes River Series of the Cross Lake area was directly correlated

TABLE OF FORMATIONS

PRECAMBRIAN	MIDDLE OR UPPER PROTEROZOIC?		(10) Mafic dykes: hornblende gabbro, diorite, hypersthene gabbro, peridotite.
			INTRUSIVE CONTACT
PRECAMBRIAN	LOWER PROTEROZOIC	MIGMATITES AND GNEISSES DERIVED FROM (2), (3), (4).	(9) Gneiss complex: biotite granodiorite gneiss, hornblende tonalite gneiss, adamellite, feldspar porphyry gneiss, hypersthene gneiss; aplite, pegmatite, quartz veins.
			GRADATIONAL CONTACT
PRECAMBRIAN	LOWER PROTEROZOIC	MIGMATITES AND GNEISSES DERIVED FROM (2), (3), (4).	(8) Sandstone Migmatite: (4) with more than 20% (9) and less than 90% (9) (7) Conglomerate migmatite: (3) with more than 20% (9) and less than 90% (9) (6) Basalt Migmatite: (2) with more than 20% (9) and less than 90% (9)
			GRADATIONAL CONTACT WITH (2), (3), (4).
PRECAMBRIAN	LOWER PROTEROZOIC		(5) Biotite gabbro, hornblende gabbro, anorthosite, ovoid gabbro
			INTRUSIVE CONTACT
PRECAMBRIAN	ARCHAEAN	CROSS LAKE GROUP	(4) Sandstones and associates rocks: arkose, subgreywacke, minor feldspathic and lithic greywacke, siltstone, grit, conglomerate; rare protoquartzite, limey shale. Metamorphic equivalents: quartz-plagioclase-biotite--(garnet) paragneiss, sillimanite paragneiss, staurolite schist, meta-argillite. (3) Conglomerate (2) Basalt: hornblende schist, garnet-diopside schist, hypersthene schist, breccia, gabbro.
			UNCONFORMITY
PRECAMBRIAN	ARCHAEAN		(1) Basement biotite granodiorite gneiss.

with the Hayes River of the area around Oxford Lake. He applied the term Cross Lake Series for geographical reasons alone, and correlated this series with the Oxford Series on the basis of lithology and steep dips.

Horwood's (1934) separation of the sedimentary-volcanic sequence in the Cross Lake area into two series was based on two criteria. The first was the presence of a supposed unconformity between the Hayes River and Cross Lake Series located at the western end of the second largest island between Pipestone and Cross Lakes. The second criterion, considered the most important, was that basalt pebbles at the base of the Cross Lake Series were derived from the Hayes River basalt whereas tonalite fragments predominate higher in the series. The suggestion was that erosion cut through the Hayes River Series and exposed the tonalite basement.

Horwood (1934) considered that the Hayes River Series lay unconformably on tonalite gneiss and that the latter rock covered much of the area. Although no unconformity was observed by Horwood, this was based on the contention that tonalite did not intrude Hayes River rocks and all intrusions cutting the Hayes River were later granite. Because the Hayes River Series was correlated with the Keewatin, Horwood suggested that the tonalite underlying the Hayes River (his Pre-Keewatin tonalite) may represent the oldest rocks in North America.

Present Interpretation

Present detailed mapping suggests a different interpretation from that of Horwood. The "unconformity" used as a criterion for subdividing the sedimentary-volcanic sequence into two series was examined and later re-examined (located at 97°48'W, 54°34'N). An unconformable relationship was not evident between basalt (2) (Horwood's Hayes River) and conglomerate (3) (Horwood's Cross Lake) to the south. A similar conclusion was reached independently by Bell (1962).

The second criterion, that basalt pebbles of Hayes River origin occur at the base of the Cross Lake Series and tonalite pebbles further up cannot be substantiated either. The conglomerate overlying the "unconformity" consists of pebbles of quartz, quartzite, and silty shale. Six hundred feet further south pebbles are 75 per cent silty shale and 25 per cent quartz, quartzite, and granodiorite. The conglomerate is interbedded with arkosic sandstone and followed by a thick succession of basalt. The section is apparently repeated by folding.

Because of intense folding characterized by numerous reversals and repetition of beds, the writer believes the only location where the stratigraphic succession can be deduced with certainty is that above the uncomformity on Cross Island. There, conglomerate (3) immediately above basalt (2) consists of pebbles of quartz, quartzite, and granodiorite. The writer has specifically recorded in his field notes the absence of basalt pebbles. South of the channel to Ebb-and-Flow rapids conglomerate (3) is exposed immediately to the south of basalt (2). Pebbles are mainly granodiorite. Numerous contacts observed between sedimentary and volcanic rocks on islands in Cross Lake northeast of the settlement, the west end of Pipestone Lake, and the west end of Cross Lake, are all conformable. Nevertheless there appears to be some local erosion of basalt. Greywacke (4) overlies basalt (2) unconformably in an exposure along the Minago River. On the south shore of Pipestone lake, minor beds containing basalt fragments and some quartz pebbles (2e) are enclosed in basalt.

In summary, erosion of basalt (2) appears local rather than general. Erosion did not cut through basalt in order to expose basement granodiorite gneiss (1) (Horwood's tonalite). Exposed areas of the basement were present and supplied sediments throughout the deposition of sedimentary and volcanic rocks.

The writer agrees with Horwood's contention that the sedimentary-volcanic sequence lay unconformably upon basement rocks (1). An unconformity discovered at the north end of Cross Island shows conglomerate (3) overlying basement biotite granodiorite gneiss (1) (Plate 1, page 13). Horwood believed the basement was tonalite and assumed an unconformable relationship because tonalite was never observed cutting the sedimentary volcanic sequence. Present mapping and chemical analyses indicate hornblende tonalite gneiss (9b) was produced by the granitization of basalt (2) by injected quartzo-feldspathic material. Horwood's correlation of the basalts