F. C. Taylor

CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA
BULLETIN 20

PRECAMBRIAN CORRELATION AND NOMENCLATURE, AND PROBLEMS OF THE KISSEYNEW GNEISSES, IN MANITOBA

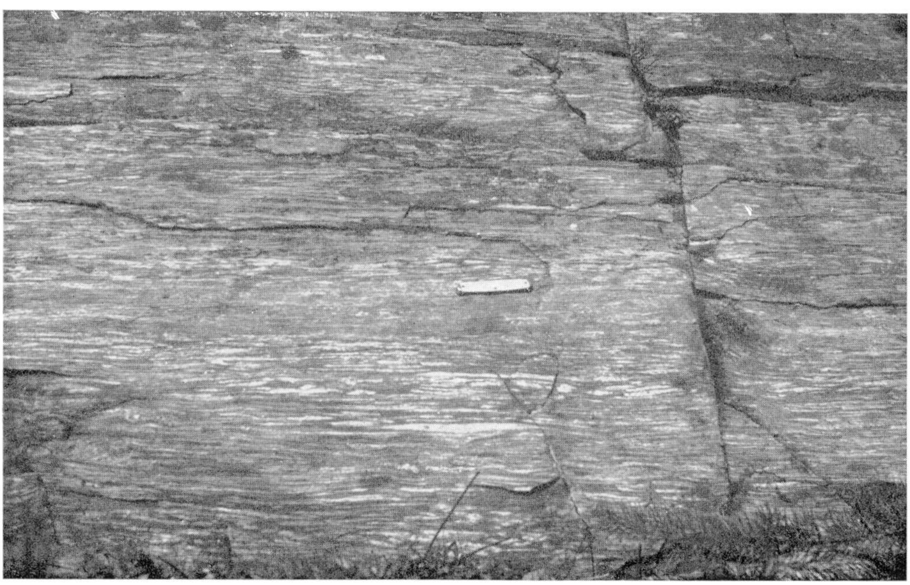
BY

J. M. Harrison

OTTAWA
EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
KING'S PRINTER AND CONTROLLER OF STATIONERY
1951

Price, 25 cents

A. Pillowed structures in coarse hornblende-plagioclase gneiss, near Star Lake. (Page 40.)



B. Stratiform foliation in hornblende-plagioclase gneiss, Kississing Lake. (Page 40.)

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PREFACE

The large number of formational names applied, in the aggregate, to the Precambrian rocks of different parts of Manitoba has provided a special difficulty in correlation to those unfamiliar with the extensive literature on these separate regions. Correlation between isolated areas of Precambrian rocks is never entirely satisfactory, but analogous conditions of rock formation, intrusion, and ore deposition can sometimes be recognized, and the succession of events determined from close study of one area may be more effectively correlated with those that took place in another.

In this report, tentative correlations are made between regions that have been mapped in different degrees of detail and employing a varied local formational nomenclature. All of them are based primarily on data published in the last 30 years or so, but some have been modified by the author's experience in mapping various parts of the province. In particular, he provides a special study of the Kisseynew gneisses and their correlatives, which occupy a wide area in west-central Manitoba north of Flin Flon and Snow Lake and present a special problem, similar to that of the Grenville series of Ontario and Quebec.

GEORGE HANSON,
Chief Geologist, Geological Survey of Canada

OTTAWA, January 15, 1951

PRECAMBRIAN CORRELATION AND NOMENCLATURE, AND PROBLEMS OF THE KISSEYNEW GNEISSES, IN MANITOBA

INTRODUCTION

The following account is an attempt to clarify some of the problems of regional geology in Manitoba in the hope that future investigators will be able to approach these problems with a more critical attitude, and thus will be more likely to reach satisfactory conclusions. In order to present the problems clearly it has been found necessary to divide the paper into three parts. The first part deals with correlation and nomenclature of the Precambrian in Manitoba and adjacent parts of Saskatchewan, except for the Kisseynew gneisses and other similar rocks that are widespread in northern and central Manitoba. The second part presents the problems of the Kisseynew gneisses in some detail, and suggestions are offered for their correlation with other, less altered rocks. The third part is a bibliography of publications in which these problems are discussed or mentioned.

Most of the information presented here is contained in reports of the Geological Survey of Canada, reports of the Manitoba Department of Mines and Natural Resources, and in papers presented to scientific societies; but some of that pertaining to the northwest part of Manitoba is the result of studies made by the writer in the past several years, and heretofore has not been published. The opinions expressed are the sum of those expressed by individuals who have studied the problems, but many of them have been modified to suit a more general pattern and are, therefore, to be regarded as the writer's own.

The detail of geological investigations has varied widely in different regions, and the acceptance of each investigator's conclusions has, in large part, been based on the relative abundance of detailed information provided. Standard scales of mapping are 1 inch to 1,000 feet, 1 inch to 1 mile, and 1 inch to 4 miles, and these are referred to in this report as standard detail, standard 1-mile, and standard 4-mile scales respectively. Maps have also been published on many other scales for areas in which the geology was mapped according to one of the methods now considered standard, and these will be referred to the appropriate standard. In addition to the standard 4-mile scale, considerable parts of Manitoba have been mapped on what may be referred to as a reconnaissance 4-mile scale, in which the map was published on 1 inch to 4 miles but the degree of detail achieved was much less than that of the standard 4-mile scale.

Part I

PRECAMBRIAN CORRELATION AND NOMENCLATURE

INTRODUCTION

The correlation of isolated areas of Precambrian rocks is never entirely satisfactory, but the multiplicity of group and series names applied in Manitoba makes it difficult for anyone not familiar with all the literature

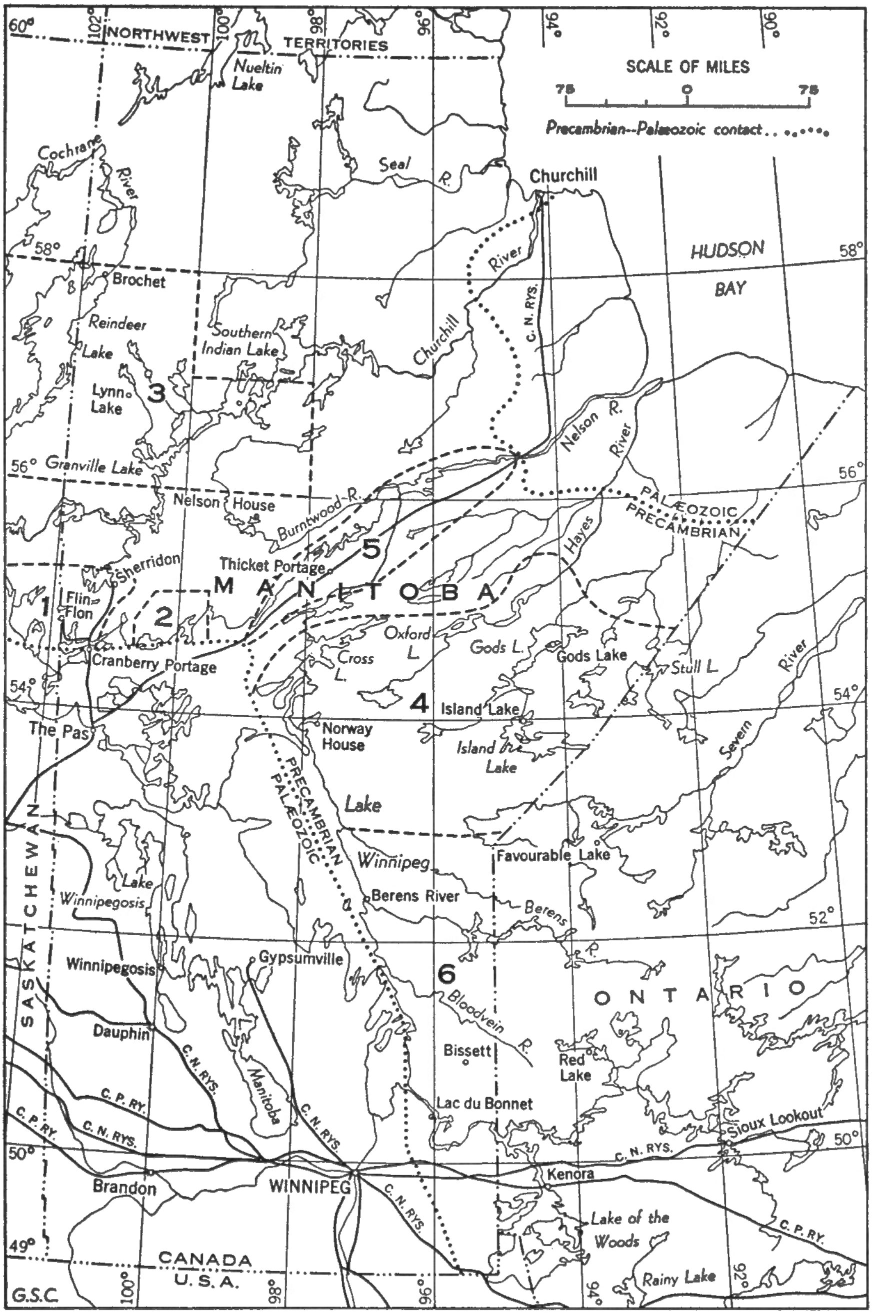

Figure 1. Sketch-map of Manitoba, showing approximate outlines of geological regions referred to in this report: (1) Flin Flon region; (2) Reed-Wekusko region; (3) Granville-Lynn Lakes region; (4) Gods, Island, and Oxford Lakes regions; (5) Thicket Portage region; and (6) Southeastern region.

pertaining to this province to interpret the stratigraphic succession of one region with respect to another. In the following pages the stratigraphic geology of Manitoba is discussed at some length for the various regions where most mapping has been done (Figure 1). An attempt is made to correlate between regions, and a comparison is made with Ontario nomenclature. The application of the terms 'group' and 'series' to map-units is also discussed.

The region around Flin Flon will be used as a standard because it was there that Bruce (31)[1] made the first attempt to establish a regional stratigraphic succession, and the names he introduced have been retained to the present. Correlations are summarized in Table VI, following more detailed discussions of each of the various regions.

HISTORICAL REVIEW OF STRATIGRAPHIC NAMES

The first officers of the Geological Survey of Canada to report on Precambrian rocks in Manitoba were Selwyn (103) and Robert Bell (24) who, in 1873, made track surveys from Lake Superior to Fort Garry (Winnipeg) and Lake Winnipeg respectively. Bell later extended the survey north down Lake Winnipeg, and in the years 1878 to 1880 he and his assistants made track surveys from Lake Winnipeg to Hudson Bay (25, 26, 27). Precambrian rocks seen by them were classed as Laurentian (gneisses and granitic rocks) or Huronian (volcanic and sedimentary rocks), except at Fort Churchill where Bell noted some rocks be named the Churchill quartzites and referred them to the Keweenawan group, then considered to be of early Cambrian age (26, p. 20). Tyrrell, likewise, referred the rocks to Huronian and Laurentian systems (126, 127, 128, 129) in his explorations during the 1890s. Between 1906 and 1910, McInnes (86, 87, 88), Dobbs (56), and O'Sullivan (94) made reconnaissance surveys, and, in his summary of these studies, McInnes (88, pp. 46-47) listed Keewatin schists and basic intrusive rocks, Grenville(?) gneisses, schists, and crystalline limestone, as well as the Lac La Ronge series of intrusive rocks, Laurentian gneisses, and "Igneous" granitic intrusions.

In 1914, Bruce commenced the first systematic geological mapping of a region in northern Manitoba, and continued his work through to 1918. He separated the rocks into three main stratigraphic divisions, applying the local names Amisk, Missi, and Kisseynew to basic volcanic rocks, sedimentary rocks, and gneisses respectively (31, 32). In 1915, Alcock surveyed the lower part of Churchill River (1), and separated the rocks there into Keewatin schists, intrusive granitic rocks, and the Churchill quartzite. The years 1917 to 1919 were spent by Alcock in studying the rocks of the Reed-Wekusko area (4), which he divided into the Kiski volcanics and Wekusko sediments, known collectively as the Wekusko group. Alcock and Bruce continued their explorations in Manitoba for a few seasons, and following their work geological investigations became more frequent, although not much more than half the Precambrian area of northern Manitoba has been geologically surveyed on any scale. Wright examined many mineral deposits and mapped large areas by reconnaissance in the late twenties and early thirties, introducing the names Hayes River group, Island Lake series, and Oxford group (140, 146) for rocks in northeastern Manitoba. Norman (93)

[1]Numbers in parentheses are those of publications listed in the Bibliography, Part III of this report.

named a sedimentary assemblage north of Granville Lake the Sickle series, and Bateman (18, 21) called the volcanic assemblage beneath it the Wasekwan series. Horwood (75) introduced the Cross Lake series to the literature, and Dawson (46, 47) classed some rocks as Assean Lake. Armstrong (16) introduced the term Laguna series, and Harrison (70) named the Snow group, both of these terms applying to parts of Alcock's Wekusko group. Wright (144) modified the terms Wekusko and Missi to Wekuskoan and Missian, and proposed (152) the name 'Churchillian' for the younger intrusive rocks in northern Manitoba.

In southeastern Manitoba the Rice Lake series was introduced by Moore (92) in 1912, and that name has persisted to the present. He also named the Wanipigow series (92). Wright (148), in 1932, divided the Rice Lake series into three phases—the Manigotagan, Beresford Lake, and Wanipigow; and in 1938 Stockwell (115) named the San Antonio formation near Rice Lake.

STRATIGRAPHY OF SPECIFIC REGIONS[1]

Flin Flon Region

History of Mapping

Almost all published accounts of geology in the Flin Flon region were written by officers of the Geological Survey of Canada, of whom J. B. Tyrrell was the first (129). In 1896, he outlined the large belt of sedimentary and volcanic rocks that extends eastwards from Amisk Lake, in Saskatchewan, to Wekusko Lake, in Manitoba, a distance of more than 100 miles. In this belt are the Newcor, Flin Flon, Cuprus, Schist Lake, Mandy, Nor-Acme, and Laguna mines. The same belt was crossed by Dowling (57) in 1899, and McInnes (88) examined parts of it in the years between 1906 and 1910. Bruce (31) mapped the Flin Flon region between 1914 and 1918, and was one of the first geologists to see the outcroppings of the Flin Flon and Mandy orebodies. Alcock (7) did some detailed mapping at Flin Flon in 1922, but no further studies were undertaken there until Wright and Stockwell (151, 153, 154) mapped the Amisk Lake area, in Saskatchewan, in 1932 and 1933. Detailed studies of the sedimentary rocks near Flin Flon were made by Ambrose (14) in 1934, followed by Kerr,[2] who made a detailed study of Flin Flon map-area in 1935 and 1936. Since that time several studies have been made, of which the most detailed published account is that by Stockwell (121).

Stratigraphic Studies

Comparative stratigraphic successions for the Flin Flon region are shown in Table I. The interpretation made by Bruce is that for the entire region, from Hanson Lake in Saskatchewan east to Cranberry Portage in Manitoba; the others are the results of more detailed investigations in parts of the region. It is interesting to note how closely the latest detailed work by Stockwell (121) conforms with the early reconnaissance studies of Bruce (31).

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[1]In the discussion of the stratigraphy of these regions the rocks of the Kisseynew metamorphic complex are not included, but are dealt with in Part II of the report.

[2]Kerr, F. A.: Geol. Surv., Canada, unpublished manuscript.

Table I

Flin Flon Region

Bruce (31)	Alcock (7)	Wright and Stockwell (154)	Tanton (124, 125)	Buckham (39), Bateman and Harrison (122)	Stockwell (121)
Amisk-Athapapuskow Lake district	Flin Flon mine area	Amisk Lake area	Flin Flon and Schist Lake areas	Athapapuskow and Mikanagan Lakes areas	Flin Flon-Mandy area
Kaminis granite Granite and allied rocks	Diorite Granite and allied rocks Basic intrusions	Granite and allied rocks Basic intrusions	Granite and allied rocks Basic intrusions	Boundary-type intrusions Granite and allied rocks Basic intrusions	Kaminis granite Boundary intrusions Granite and allied rocks Basic intrusions
Intrusive contact	*Intrusive contact*	*Intrusive contact*	*Intrusive contact*	*Intrusive contact*	*Intrusive contact*
Upper Missi series: conglomerate, clastic sediments	Upper Missi series: conglomerate, clastic sediments	Missi series: conglomerate, clastic sedimentary rocks	Greenstone complex—mainly intrusive (includes Amisk of most authors)	Missi: conglomerate; clastic sedimentary rocks	Missi: conglomerate; clastic sedimentary rocks
Unconformity ?	*Unconformity*		Missi: conglomerate; clastic sedimentary rocks		
Lower Missi series: clastic sediments					
Unconformity		*Unconformity*		*Unconformity*	*Unconformity*
Cliff Lake granite porphyry		Granite, quartz-feldspar-porphyry		Granite-gneiss ? 'Quartz-eye' granite ?	Cliff Lake granite porphyry
Intrusive contact		*Intrusive contact*		*Intrusive contact ?*	*Intrusive contact*
Amisk series basic volcanic rocks; some acidic rocks	Acidic volcanic rocks, basic volcanic rocks (not named but equal to Amisk of Bruce)	Wekusko group: basic and acidic volcanic, and clastic sedimentary rocks (includes Amisk and part of Lower Missi of Bruce)	Schists derived from volcanic and sedimentary rocks	Basic and acidic volcanic rocks; some clastic sedimentary rocks (not named but equals Amisk, and includes part of Lower Missi of Bruce)	Amisk group: basic and acidic flows and pyroclastic rocks
			Pre-Missi sedimentary rocks		

Bruce established a succession similar to that of the Keewatin-Timiskaming sequence in northern Ontario, but apparently he considered it unwise to use those terms in an area so far removed from the type localities. He, therefore, referred to the volcanic assemblage as the "Amisk" rocks, from their typical occurrence at Amisk (Beaver) Lake in Saskatchewan, and to the sedimentary sequence as the "Missi", from its exposures on, and near, Missi (Big) Island in Amisk Lake. Bruce considered the Cliff Lake granite porphyry to be older than the Missi sequence because numerous pebbles of a similar rock were found in Missi conglomerate at a place where conglomerate outcropped close to the porphyry. He noted, further, that no intrusions similar to this porphyry were found anywhere in the Missi. The Missi was divided into upper and lower parts because Bruce found pebbles of sedimentary rocks, and a boulder of conglomerate, in the Upper Missi. However, he considered that the unconformity was questionable, and that perhaps the Missi strata actually formed one conformable succession.

Alcock (7), from his work in 1922, proposed a stratigraphic sequence similar to that of Bruce, except that he did not name the basal volcanic group and did not consider the Cliff Lake granite porphyry to be pre-Missi. The latter distinction was made because he could find no pebbles in Missi conglomerate that are similar to the porphyry, and further noted that the porphyry cuts basic dykes of a kind similar to dykes found cutting the Missi. As none of Bruce's Lower Missi is exposed in the region mapped by Alcock, that problem was not considered.

In 1932, Wright (151) commenced mapping in the Amisk Lake region to the west of Flin Flon, continued farther west with Stockwell (153) in 1933, and in 1935 published the map (154) from which the stratigraphic sequence in Table I is taken. The term 'Wekusko group', as applied to the basal assemblage of interbedded volcanic and sedimentary rocks, apparently was taken from Alcock's report (4) on the Reed-Wekusko region to the east. At Amisk Lake, the Wekusko strata consist mainly of basic volcanic rocks, some acidic varieties, and some clastic sediments, which are in part intimately interbedded with the volcanic rocks and in places occur as mappable units. The mappable units of the sedimentary rocks are some of those designated as Lower Missi by Bruce (31), so that the Wekusko group of Wright and Stockwell includes Bruce's Amisk and part of his Lower Missi. Hence, the Upper Missi of Bruce is classed simply as Missi strata. The Wekusko rocks are cut by quartz-feldspar porphyry and granite, but Wright could not find similar intrusions in the Missi. In fact, Wright (151, p. 84) described two localities where Missi conglomerate appears to lie unconformably on a pink, rather schistose granite, believed to be part of the pre-Missi granite intrusions.

F. A. Kerr[1] mapped an area about Flin Flon in great detail in 1935 and 1936, and concluded that the rocks could be separated into many divisions with unconformable relations between them, and that there were seven periods of igneous intrusion. As this work was not published, and as other geologists have been unable to recognize Kerr's lithological and stratigraphic distinctions, his conclusions will not be assessed. However, it should be borne in mind that the geological history of the Flin Flon region may be much more complicated than other geologists have realized.

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[1]Geological Survey, Canada, unpublished manuscript.

In 1938, the area about the Gurney gold mine was mapped in detail by Hage (69), who considered that the sedimentary and volcanic rocks there are interbedded, intruded by basic dykes, and all cut by granitic intrusions and their derivatives. No names were applied to the strata.

As a result of field work in 1938 and 1939, Tanton published the Flin Flon and Schist Lake maps (124, 125). He considered the oldest rocks to be some narrow bands of altered sediments that are probably separated from the Missi by an assemblage of schists, mainly derived from highly altered basic volcanic rocks. Although no unconformity is postulated at the base of Missi strata, Tanton noted pebbles in the Missi that are similar to rocks forming the group of schists derived from volcanic rocks. Next in succession is a greenstone complex, which was regarded as mainly basic intrusive rocks, with abundant inclusions of pre-Missi schists. These are the most abundant basic rocks in the area, and are those that other geologists mapped as mainly volcanic rocks, and pre-Missi in age. Thus, the Amisk rocks of Bruce were divided into two groups—a pre-Missi group of schists derived from basic volcanic rocks and occurring largely as remnants in a post-Missi group of predominantly basic intrusions. The pre-Missi group of sedimentary rocks appears as lenticular bands several miles long, mainly in regions of rather high-rank metamorphism.

While working at Flin Flon, Tanton investigated the localities at Amisk Lake where Wright (151) described unconformable relations between Missi strata and an older granite. Tanton concluded (123) that the relations there were better explained by regarding the granite as younger than, and intrusive into, the Missi. He further noted (p. 136) "that greenstones of Keewatin type such as have been mapped in this area as Amisk and Wekuskoan volcanics occur . . . as intrusive bodies in Missi conglomerate, and also as inclusions in granite". In other words, he regarded the Amisk-Missi relationships on Amisk Lake as the same as those he postulated at Flin Flon.

In 1940, Buckham (39) mapped the Athapapuskow Lake area southeast of Flin Flon, and in 1941 Bateman mapped the Mikanagan Lake area east of Flin Flon, except for a strip along the south edge of the map-area that was completed by Harrison in 1943 (22). A composite stratigraphic column is shown in Table I. Bateman, Buckham, and Harrison all found good evidence that Missi strata overlie the volcanic assemblage (Amisk) with angular unconformity. In these areas the Amisk rocks consist mainly of basic volcanic members, but nevertheless contain fairly large amounts of acidic flows and related intrusions as well as mappable amounts of sedimentary material. As Wright (151, 154) had done at Amisk Lake, Buckham considered that Bruce's Lower Missi was part of the Amisk (39). Bateman, Buckham, and Harrison thought that some of the granitic intrusions in the Mikanagan-Athapapuskow Lakes area (*See* Table I) were older than the Missi strata but, lacking direct evidence of such a relationship, were unable to indicate any particular granite as definitely pre-Missi.

In 1943, Stockwell began the first of 3 seasons spent in mapping the Flin Flon-Mandy area in detail. His stratigraphic succession (121), except for some details, is the same as that established by Bruce 28 years earlier. The chief distinctions lie in the more detailed separation of intrusive rocks, and in the fact that the Missi was considered as one series, rather than as two, perhaps unconformable series. Because of exposed angular discordances Stockwell (121) considered that the Missi lay unconformably above the Amisk volcanic and related intrusive rocks, and agreed with Bruce (31) that pebbles of the Cliff Lake granite porphyry, or a rock identical with it, are contained in Missi conglomerate. Stockwell also considered that the rocks mapped by Tanton (124) as predominantly basic intrusions are, actually, mainly volcanic, and are composed of massive and pillowed flows, flow breccias, and pyroclastic members, with some related intrusions of diorite. Many localities have been examined by the writer at various times since 1940, and he is in general agreement with Stockwell on these points.

The writer also examined the localities on Amisk Lake where Wright (151) postulated a pre-Missi granite, and agrees with Tanton (123) that the granite intrudes Missi strata, and that schistose basic rocks are intrusive into Missi conglomerate. However, he does not consider that these basic intrusions are typical of Amisk lavas, although they are so schistose it is difficult to make comparisons. Nevertheless, they are generally of a coarser grain, and, in places, remnants of pyroxene were seen, which at one time formed crystals one-quarter inch or more in length. The writer also agrees with Tanton (123) that these basic intrusions occur as inclusions in the granite, both rocks being sheared in the same plane, but the basic rock much more sheared than the granite. Field relations show that strata near Lookout Island in Amisk Lake are much more sheared than similar rocks at Flin Flon, and the writer considers the basic rocks that intrude Missi conglomerate on Amisk Lake to be the equivalent of the post-Missi basic intrusions at Flin Flon, and that the granite described from Amisk Lake is equivalent to Stockwell's granite at Flin Flon (*See* Table I). When examining these rocks at Amisk Lake in 1948, some pebbles of 'quartz-eye' granite seen in the Missi conglomerate were identical in appearance with the Cliff Lake granite porphyry. According to descriptions, rocks similar to it were found intruding Wekusko (Amisk) lavas by Wright and Stockwell (151, 153, 154). However, J. C. Millbury,[1] who mapped the eastern part of the Amisk Lake area for the Saskatchewan Department of Natural Resources, in 1948, was unable to designate any granite as pre-Missi and apparently regarded the Missi strata as conformable with the Amisk. C. R. Lewis,[2] who mapped the western part of the Amisk Lake area, also in 1948, for the Saskatchewan Department of Natural Resources, concluded that Amisk and Missi strata are interbedded to form what he called the "Neagle Creek" assemblage. The relations between Missi and Amisk in these areas are not clearly defined, but the main exposures of Missi rocks at Flin Flon, where the relations have been established by detailed studies (121), are only 8 or 9 miles from the main exposures of Missi rocks (31, 154) at Amisk Lake. The Missi rocks in the Flin Flon and Amisk Lake areas are identical in appearance; in both areas they contain pebbles of 'quartz-eye' granite (Cliff Lake granite porphyry at Flin Flon), and in neither area are they intruded by similar rocks. For these reasons the writer prefers to retain the term Missi at Amisk Lake until such time as it can be shown that all strata mapped as Missi are not unconformable above the rocks considered Amisk (Wekusko group of Wright and Stockwell).

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[1]Personal communication, 1949.

[2]Personal communication, 1949.

For the Flin Flon region as a whole, the stratigraphic sequence shown in Table VI is proposed. It is the succession established by Bruce in 1918 (31), with the modifications resulting from Stockwell's detailed studies (121), and the addition of sedimentary strata to the Amisk rocks and volcanic rocks to the Missi strata.

Reed-Wekusko Region

The Reed-Wekusko region includes the area between Elbow Lake on the west and Crowduck Bay on the east, and lies to the east of the Flin Flon region (*See* Figure 1). The two regions are separated by an area 30 to 40 miles long that is incompletely mapped geologically.

History of Mapping

Tyrrell (129) first mapped the Reed-Wekusko region by track survey in 1896. He was followed by McInnes (86) in 1906. In 1916, Bruce made a brief examination of rocks about Wekusko Lake (30), and in 1918 made a reconnaissance survey from Elbow to Reed Lakes (34). In 1917 and 1918, Alcock mapped a large part of the Reed-Wekusko region in some detail (4), and in 1922 P. Armstrong studied some of the mineral deposits at Elbow Lake (17). In 1930, Wright (144) visited many mineral deposits in the region, and, in 1934, Stockwell (113) made a fairly detailed study of those in the western part, publishing a geological map on a scale of 1 inch to 2 miles. The next year, Stockwell (114) made a detailed study of a small area in the eastern part of the region at Wekusko Lake. This work was followed by that of J. E. Armstrong (16), in 1939, Harrison (70, 72) in 1944 to 1946, Stanton (109) in 1945, and Frarey (65) in 1946 and 1947, all of whom prepared standard 1-mile maps in the eastern and central parts of the Reed-Wekusko region.

Stratigraphic Studies

Tyrrell (129) referred all the rocks to the Laurentian (intrusive) or Huronian (extrusive and sedimentary) systems. McInnes (88) called the lavas Keewatin and, noting the presence of conglomerate, considered that some of the rocks were probably Huronian (unconformably above the Keewatin). Alcock (4), following Bruce's procedure in the Flin Flon region (31), decided to use local names for rock units. As the Flin Flon and Reed-Wekusko regions were separated by an unmapped area, Alcock used terms local to the Reed-Wekusko region, although Bruce (34) referred the rocks about Elbow Lake to the Amisk series farther west. As shown in the first column of Table II, Alcock (4) included all the volcanic and sedimentary rocks in the Wekusko group, from their typical occurrence around Wekusko (Herb) Lake. The group was separated into the "Kiski volcanics" and the "Wekusko series" of sedimentary rocks, which Alcock (4, p. 24) believed were mainly interbedded, although some members of the Wekusko series were regarded as younger than any of the volcanic rocks. However, in an earlier report (2, p. 13) he considered it possible that the two, in part at least, were unconformable, with the conglomeratic members as the younger. All the formations were intruded by granite rocks, but granite pebbles in the conglomerates indicated an older granite that was not recognized in place.

TABLE II
Reed-Wekusko Region

ALCOCK (4) Reed-Wekusko area	STOCKWELL (113) Elbow-Morton area	STOCKWELL (114) Herb Lake area	ARMSTRONG (16) Wekusko area	HARRISON (70) and STANTON (109) File-Tramping Lakes area	FRAREY (65) Crowduck Bay area
	Diabase Garnet granite Trap dykes				
Granite and allied rocks	Granite and allied rocks 'Quartz-eye' granite, etc., Basic intrusions	Granite and allied rocks Lamprophyre 'quartz-eye' granite	Granite and allied rocks Basic intrusions	Granite and allied rocks Basic intrusions	Granite and allied rocks Basic intrusions 'Quartz-eye' granite, dacite
Intrusive contact	*Intrusive contact*	*Intrusive contact*	*Intrusive contact*	*Intrusive contact*	*Intrusive contact*
Wekusko group: Wekusko series: sedimentary rocks Kiski volcanics	Wekusko group: sedimentary rocks Volcanic rocks	Dacite, dacite breccia	Post-Laguna: conglomerate and clastic sedimentary rocks	Snow group: mainly clastic rocks; some volcanic rocks; some isolated areas of conglomerate; includes some pre-Laguna	Mainly clastic sedimentary rocks; some basic flows; includes Laguna and post-Laguna
			Unconformity	*Unconformity ?*	
			Dacite; quartz-feldspar porphyry	'Quartz-eye' granite?	
		Intrusive contact	*Intrusive contact*	*Intrusive contact*	*Unconformity*
		Basic flows and interbedded rhyolite conglomerate, arkose tuff, and breccia Greywacke and conglomerate, slate, and staurolite schist	Laguna series: basic and acidic volcanic rocks, conglomerate, greywacke, arkose, argillite		
			Pre-Laguna series: basic volcanic and sedimentary rocks	Amisk group: mainly basic volcanic rocks; some interbedded sedimentary rocks	Mainly basic flows; some sedimentary rocks

In 1922, P. Armstrong (17) examined mineral deposits in the Elbow Lake area, at the west end of the Reed-Wekusko region. He followed Bruce (34) in placing the lavas in the Amisk series, no mappable units of sedimentary rocks occurring in the area studied.

Wright (144) examined many mineral deposits of the region in 1930, but used no names for the rocks in particular localities, although he suggested the term "Wekuskoan" for all surficial rocks older than Missian strata (144, p. 7), and considered it possible that subsequent more detailed studies would show that some Missi was included in the Wekuskoan rocks. Thus, Wekuskoan rocks were meant to include the Amisk rocks of the Flin Flon region, and the Kiski and Wekusko series of the Reed-Wekusko region.

In 1934, Stockwell (113) expanded the work of P. Armstrong (17). He investigated a larger area, and, noting much sedimentary material with the lavas, he called the assemblage the Wekusko group. These sedimentary and volcanic rocks are interbedded for about 1,200 feet across the strike, and, therefore, are of the same general age (113, p. 4). Following the deposition of these rocks they were intruded at several successive intervals by dykes and batholiths of granitic and basic rocks. As most of the field season was spent in examining prospects and not in geological mapping, the age relations shown in the second column of Table II are only tentative. However, Stockwell did think that 'quartz-eye' granite, a rock similar to the pre-Missi, Cliff Lake granite porphyry of Bruce (31), was older than other granitic rocks in the area, but, as no rocks of Missi age are known at Elbow Lake, their relations to 'quartz-eye' granite there are not known.

In 1935, Stockwell (114) mapped the area about the village of Herb Lake on the east side of Wekusko Lake, the information being compiled on a scale of 1 inch to 1,000 feet. The results of his stratigraphic studies are shown in the third column of Table II. In the Herb Lake area, the basal group of exposed rocks is sedimentary, and is overlain conformably by a group of basic and acidic volcanic rocks. These, together with some dacite, comprise the Wekusko group of Alcock (4), except that Alcock had lavas overlain by sedimentary rocks. However, Stockwell noted (114, p. 3) that some of the sedimentary members may lie unconformably on the lavas and the rest of the sediments. If so, "they probably should be correlated with the Missi series...at Flin Flon". He noted further that the lavas and 'older sediments' have been intruded by dacite, which in turn is cut by 'quartz-eye' granite. Presumably then, the 'younger sediments' are not cut by this granite and may be younger than it, in which case these assumed younger members would be equivalent to the Missi in all respects.

In 1939, J. E. Armstrong (16) mapped the Wekusko area on the standard 1-mile scale, and this area includes part of Stockwell's detailed map (114). Armstrong called the sedimentary and volcanic rocks of Stockwell's area the Laguna series, and thought they were underlain by an assemblage of more highly metamorphosed rocks derived from sedimentary and basic volcanic rocks. A series of greywackes and conglomerate was thought to rest unconformably on the Laguna series, and on the dacite and quartz-porphyry that intrude the Laguna. Thus, according to Armstrong's succession (Table II), the post-Laguna rocks occupy a position analogous to the Missi at Flin Flon, for the quartz porphyry overlain by post-Laguna rocks was considered by Stockwell (114, p. 4) to be related to the 'quartz-eye' granite. On this basis, Armstrong's pre-Laguna and Laguna successsions are equivalent to the Amisk rocks of Flin Flon, and because the Laguna series is not characteristic of Amisk rocks, it must be regarded as a local facies.

Harrison (70, 72) in 1944-6, and Stanton (109) in 1945, mapped the File Lake and Tramping Lake areas respectively on a scale of 1 inch to 1 mile, and their succession is shown in Table II. The basal assemblage of volcanic rocks was referred to the Amisk group, and some clastic sediments were included in it. The Amisk strata were intruded by 'quartz-eye' granite, which is cut by basic intrusions that, in turn, are cut by dykes and batholiths of biotite granite. Some fresh-looking sedimentary rocks about Tramping Lake consist of conglomerate and greywacke. These are similar to Missi rocks at Flin Flon and may be Missi in age, but it was not possible to learn whether they actually are unconformable above the Amisk. A succession of rocks in the north part of File Lake map-area consists mainly of sedimentary members with lesser amounts of lava flows and pyroclastic rocks. These grade northwards into Kisseynew gneisses and were termed the "Snow group" (70) because of their typical occurrence at Snow Lake. No intrusions of 'quartz-eye' granite, or alteration characteristically associated with these intrusions, were found in the Snow rocks in spite of the abundance of them in nearby Amisk lavas, suggesting that the Snow group is of Missi age. Shepherd (104) in 1943 and Ebbutt (62) in 1944 both pointed out the possibility of an unconformity at the base of the Snow group, but Harrison (70, 72) regarded the contact between Snow and Amisk rocks as a fault. He further pointed out many lithological dissimilarities (72, p. 5) between the Snow rocks and type Missi strata, and concluded that their correlation should be accepted only with extreme reservation.[1] However, the main difficulties in correlation are not so much with the Flin Flon region, 70 miles to the west, as with the rocks in the Wekusko map-area to the east. According to J. E. Armstrong's classification (16), all the rocks in the Snow and Amisk groups of the File Lake and Tramping Lake areas are pre-Laguna, and hence much older than Missi. However, the mapping undertaken in the File Lake area was considerably more detailed than that of Armstrong's, although published on the same scale, and vertical air photographs provided a much more efficient method of collecting data. The writer believes that the rocks mapped by Armstrong as pre-Laguna, and lying north of Snow Creek, are part of the Snow group and, therefore, might be correlated with the Missi. It should also be pointed out that these Snow rocks are, for the most part, more highly metamorphosed than the Amisk rocks, a feature that probably had some influence in Armstrong's designation of them as pre-Laguna (Amisk). However, metamorphic intensity increases from south to north in this region, and degree of metamorphism has no bearing on the stratigraphy, or age, of the rocks.

Stockwell spent 2 or 3 weeks in 1945 mapping formations to the east of Wekusko Lake, and this work was continued by Frarey (65) in 1946 and 1947. As a result of this study it was concluded that the formations equivalent to Amisk rocks consist of a basal sedimentary group conformably overlain by a succession of pillow lavas (*See* Table II). These, in turn, are unconformably overlain by sedimentary rocks and some massive, basic flows. This latter group, which Frarey tentatively correlates with

[1]Relations of the Snow group are considered in more detail in Part II of this report.

the Missi, includes Armstrong's Laguna and post-Laguna series (16), for no evidence of unconformity was found between them. The disturbing feature of this study, from the viewpoint of correlation, is that the rocks considered to be Missi in the area mapped by Frarey are cut by 'quartz-eye' granite, a rock similar to the intrusions overlain unconformably by the Missi at Flin Flon. If the rocks mapped as 'quartz-eye' granite between Wekusko and Amisk Lakes are all of one age, the sediments east of Wekusko Lake cannot be Missi; but it seems more likely that the 'quartz-eye' granite is a type of intrusion that is characteristic of more than one period of igneous activity. Certainly the sedimentary members indicated by Stockwell and Frarey as being probably Missi in age are identical in appearance with Missi rocks near Flin Flon. In 1948, some of the localities where the field relations can be seen to best advantage were visited by the writer, and Frarey's interpretation of the stratigraphic succession was accepted. The 'quartz-eye' granite did not seem to be quite the same as that mapped at Flin Flon and in File Lake map-area, having a finer grained matrix, a pinker colour, and larger phenocrysts of bluish quartz. However, the similarity between the rocks mapped as 'quartz-eye' granite at Flin Flon, File Lake, and Wekusko Lake is sufficiently close to class them together unless some definite means can be established to differentiate them.

Granville-Lynn Lakes Region

Lynn Lake, near which most of the detailed mapping in this region has been confined, lies about 150 miles north and a little east of Flin Flon. In this region, the rocks resemble closely the succession at Flin Flon; but, as they are separated from Flin Flon by a wide belt of virtually unmapped granitic rocks, a local nomenclature was used to designate them.

History of Mapping

McInnes (88) in 1908 was, apparently, the first geologist to see Granville Lake, when he was travelling down Churchill River to Southern Indian Lake. However, he saw only the extreme southeast part of the lake, and makes no specific mention of the rocks there. In 1920, Alcock (6) made a track survey from Threepoint Lake to South Indian Lake village, passing down Rat River about 30 miles east of Granville Lake. The first systematic mapping in the region (on 1 inch to 4 miles) was undertaken by Henderson in 1932, and was continued by Henderson, Norman, and Downie in 1933 (58, 73, 93). In 1940, Bateman (18, 21) did some detailed mapping around McVeigh Lake in the northern part of the Granville Lake area. Following discovery of the Lynn Lake nickel-copper deposits, officers of the Manitoba Mines Branch commenced systematic mapping of the district in 1946. Allan (11, 12), Crombie (42), Fawley (64), and Stanton (110, 111) have all mapped areas on a scale of 1 inch to 1 mile.

Stratigraphic Studies

McInnes (88) mapped the rocks along Churchill River from Granville Lake to Southern Indian Lake as Laurentian gneisses, which included Grenville(?) gneisses and intrusive granite. Alcock (6) separated the rocks along Rat River into an older group of sedimentary gneisses and schists and a younger assemblage of basic volcanic rocks. All of these are cut by granite and allied intrusions, and all are intruded by gabbro and diabase dykes.

In 1928, Stockwell (112) mapped the Reindeer Lake area on a reconnaissance scale, the southeast part of his area lying about 30 miles west of Lynn Lake. He noted that some of the basic members in the complex there are altered volcanic rocks, and should probably be correlated with the Amisk.

Henderson's work in the Granville Lake area in 1932 established the presence of an unconformity between a group of basic volcanic rocks and some clastic sediments with a basal conglomerate. Norman (93) named these latter rocks the Sickle series, from their occurrence at Sickle Lake, and the name was adopted for the published maps (58, 73). The underlying volcanic assemblage was not named. Norman noted the similarity between the Missi at Flin Flon and the Sickle in the Granville Lake area, but remarked that a close correlation between the basic volcanic rocks in the Granville Lake area with those at Flin Flon and Amisk Lake was "not implied because their succession and possible subdivision are not known with any certainty". The main distinction lay in the fact that the Amisk succession (Wekusko of Wright and Stockwell) contains well-defined sedimentary members, whereas such were not recognized in the pre-Sickle assemblage. Although pebbles of granite and diorite are present in the Sickle conglomerate, no intrusive rock in the area could be shown to be older than the Sickle rocks. Their stratigraphic sequence is shown in the first column of Table III.

TABLE III

Granville-Lynn Lakes Region

Henderson, Norman, and Downie (58, 73, 93) Granville Lake area	Bateman (21) McVeigh Lake area	Allan, Crombie, Fawley, and Stanton (11, 12, 42, 64, 110, 111) Lynn Lake area
Granite and allied rocks Basic intrusions	Granite and allied rocks	Granite and allied rocks Basic intrusions Sheared granite-gneiss (may be older than Sickle)
Intrusive contact	*Intrusive contact*	*Intrusive contact*
Sickle series: conglomerate and clastic rocks; minor volcanic rocks	Sickle series: conglomerate and clastic rocks	Sickle series: conglomerate and clastic rocks; some basic lavas
Unconformity	*Unconformity*	*Unconformity*
	Sheared granitic rocks Basic intrusions	
	Intrusive contact	
Pre-Sickle: basic volcanic rocks, minor rhyolite and trachyte	Wasekwan series: basic volcanic and interbedded sedimentary rocks	Wasekwan series: basic volcanic and interbedded sedimentary rocks

In 1940, Bateman (18, 21) mapped the McVeigh Lake area, a few miles south of Lynn Lake, on a scale of 1 inch to 1,500 feet. His stratigraphic succession is shown in the second column of Table III. The basal assemblage of rocks, part of the pre-Sickle group, he termed the Wasekwan series, and included in it a considerable thickness of interbedded sedimentary rocks, whereas Henderson, Norman, and Downie, mapping on a broad scale, had been unable to distinguish positively any sediments in this group. Bateman also designated some basic and acidic intrusions as pre-Sickle because their alteration and deformation were similar to those of Wasekwan rocks but different from those of the Sickle series. However, no definitely unconformable contacts between intrusions and Sickle rocks are exposed in the area mapped.

No further geological mapping was done in the region until systematic mapping of Lynn Lake area and its extensions was begun by Allan in 1946. A composite geological succession compiled from the work of Allan (11, 12), Crombie (42), Fawley (64), and Stanton (110, 111) is shown in the third column of Table III. They also recognized the presence of considerable quantities of sedimentary material in the pre-Sickle (Wasekwan) assemblage. Although it is considered probable that some of the granitic rocks are pre-Sickle (12, p. 9; 110, p. 10), the Manitoba Mines Branch geologists show these rocks as post-Sickle because no positive evidence for a pre-Sickle age had been obtained. However, Fawley (64, p. 8) found an altered hornblende gabbro that is definitely pre-Sickle, and Allan stated recently[1] that the Sickle conglomerate "appears to lie upon an eroded granite surface and contains granite pebbles; and as, conversely, it is intruded by granite, two distinct ages of granitic intrusion are indicated".

G. M. Wright[2] made a reconnaissance 4-mile map of the Uhlman Lake area, to the east of Granville Lake, in 1948. Near Rat Lake are good exposures of Sickle-type sedimentary rocks, and to the north, at Karsakuwigamak Lake, altered sedimentary rocks are, apparently, interbedded with basic flows. Owing to the scale of mapping and the scarcity of outcrops, no evidence was found to establish the relations between these Sickle-type rocks and the basic flows. Also in 1948, Gadd (67) mapped the Brochet area, which joins the Granville Lake area to the north, on a reconnaissance 4-mile scale. The volcanic and sedimentary rocks in this area are too highly altered to compare with Sickle or Wasekwan rocks to the south, but probably represent both series.

All these rock types were seen by the writer in 1948, and he is in accord with Norman's suggestion (93, p. 27) that the Sickle series should be correlated with the Missi strata at Flin Flon, and, further, believes that the Wasekwan should be correlated with the Amisk rocks at Flin Flon and elsewhere.

Gods, Island, and Oxford Lakes Region

The central part of this region is at Gods Lake, about 300 miles east of Flin Flon, and the area to be discussed is much larger than the Flin Flon and Reed-Wekusko regions combined. Very few detailed studies have been made, and most of the geological mapping has been in the form of track surveys, or for publication on a scale of 1 inch to 4 miles.

History of Mapping

Bell and his associates in the years 1878-79-80 made the first track surveys through these lakes (25, 26, 27). Apparently no other geologist examined this region until Dobbs (56) made a reconnaissance trip down

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[1] Allan, J. D. (1950): Lynn Lake Nickel Area, Manitoba; Trans. Can. Inst. Min. Met., vol. 53, pp. 357-362.

[2] Geol. Surv., Canada; map in preparation.

Gods River and up some of its tributaries. In 1910, Brock (29) took some geological notes on a trip down Hayes River with Earl Grey, then Governor General of Canada, and about the same time McInnes (88) made reconnaissance maps of parts of the region. In 1919, Bruce conducted a reconnaissance survey of the Knee Lake area (36), followed, in 1925, by Wright (138), who extended the mapped areas in 1927 and 1931 (140, 146). In 1925, Merritt (91) mapped an area about Bigstone and Fox Rivers north of Oxford and Knee Lakes, and since then many investigations have been made (55, 59, 68, 75, 89, 90, 105, 122), but few of them in detail.

Stratigraphic Studies

Until Bruce's investigations (36) in 1919, the terms Keewatin, Huronian, and Laurentian were used, based on lithological appearance rather than stratigraphic mapping. Bruce did not name any rock groups, but divided the volcanic and sedimentary rocks at Oxford and Knee Lakes into two parts, the lower consisting mainly of sedimentary and the upper mainly of basic volcanic rocks; so far as he was able to determine, the two are conformable. They are intruded by a rock called quartz-porphyry, descriptions of which are similar to those of intrusions mapped in later years as 'quartz-eye' granite. These are all intruded by granite and allied rocks.

Wright extended Bruce's mapping in 1925, and studied the rocks about Oxford Lake in somewhat more detail. His succession (138), also unnamed, was much the same as that of Bruce (36), except that some basic dykes were regarded as pre-granite and some diabase as post-granite.

In the same year, Merritt (91) mapped an area to the north of Wright's and there, in contrast with Bruce and Wright, he found that the basic lavas are older than the sedimentary rocks, but conformable with them. Most of these rocks are altered to schists and gneisses of high-rank metamorphism, intruded by granite and, later, by pegmatite and diabase.

In 1927, Wright (140) mapped the area about Island Lake on a scale of 1 inch to 4 miles, and established the sequence shown in the first column of Table IV. A basal group, similar to that noted at Oxford and Knee Lakes, was called the Hayes River group because of its distribution in the area drained by Hayes River. The lowest known members of this group are sedimentary, and they grade upwards, through a zone where sedimentary and volcanic rocks alternate, to basic volcanic rocks and derived schists. These rocks were overlain unconformably by a series of sedimentary rocks found only on some islands of Island Lake, and which, therefore, were called the Island Lake series. Although the contact between the Hayes River group and Island Lake series is not exposed, the basal conglomerate of the Island Lake formations contains numerous pebbles of the Hayes River rocks, and there is a marked structural discordance between the two. Pebbles of granite are common in the Island Lake series, but no granite body of definite pre-Island Lake age could be identified. Although no granite was found cutting Island Lake rocks, vein quartz is found in them, and it is presumed that some at least of the granite in the area is post-Island Lake series. Small bodies of an old granite porphyry are described, and are similar to 'quartz-eye' granite, which is cut by the younger batholithic granite. Diabase dykes are the youngest rocks in the area.

Table IV

Gods, Island, and Oxford Lakes Region

Wright (140) Island Lake area	Wright (146) Oxford House area	Wright (147) Gods-Island-Oxford area	Horwood (75) Cross Lake area	McMurchy (90) Island Lake area
Diabase	Diabase	Diabase	Diabase	Diabase
Intrusive contact	*Intrusive contact*	*Intrusive contact*	*Intrusive contact*	*Intrusive contact*
Granite and allied rocks	Granite and allied rocks	Granite and allied rocks	Granite and allied rocks	Granite and allied rocks
Granite porphyry	*Intrusive contact*	Quartz and feldspar porphyry	Basic intrusions	*Intrusive contact*
Basic intrusions	Basic intrusions	Basic intrusions		Basic intrusions
Intrusive contact	*Intrusive contact*	*Intrusive contact* Island Lake series: grit, conglomerate, quartzite (Proterozoic)	*Intrusive contact*	*Intrusive contact*
		Unconformity		
Island Lake series: grit, conglomerate, quartzite	Oxford sediments: slate, greywacke, quartzite, arkose, conglomerate	Oxford sediments: slate, greywacke, quartzite, arkose, conglomerate	Cross Lake series: arkose, quartzite, conglomerate	Island Lake series: grit, arkose, greywacke, quartzite, slate, conglomerate
Unconformity	*Unconformity* 'Quartz-eye' granite ?? *Intrusive contact??*	*Unconformity*	*Unconformity*	*Unconformity*
Hayes River group: lavas and sedimentary rocks	Hayes River lavas and sedimentary rocks	Hayes River lavas and sedimentary rocks	Hayes River group: lavas and sedimentary rocks	Hayes River group: lavas and sedimentary rocks
			Unconformity ??	
			Tonalite	

While Wright was conducting his examination of the Island Lake area, Greer (68) mapped an area to the west. He considered that the volcanic and sedimentary rocks were interbedded and that the bulk of the sedimentary strata was older than the bulk of the volcanic members. All were placed in the Hayes River group.

In 1931, Wright extended his previous work in the Oxford Lake area to include Gods Lake and some lakes a few miles to the south. The stratigraphic sequence resulting from this work (146) differs from that in the Island Lake area in that the rocks unconformably above the Hayes River group were called "Oxford sediments" because they are abundant at Oxford Lake, and a 'quartz-eye' granite was thought to be, perhaps, older than the Oxford sediments because pebbles similar to it were found in the basal Oxford conglomerate. The sequence is shown in the second column of Table IV. Wright also remarked that it was possible for some of the sedimentary rocks mapped with the Hayes River group at Island Lake to be of Oxford age.

The results of Wright's investigations in northeastern Manitoba were summarized (147) in 1932, and his combined stratigraphic succession is shown in the third column of Table IV. Wright considered that the Island Lake series, which is exposed only at Island Lake, is much younger than the more widespread Oxford sedimentary rocks, because the rocks in it are much less deformed, are not intruded by bodies of granite, and the structural break between Oxford and Hayes River rocks is much less marked than that between Island Lake and Hayes River rocks. He further observed (147, p. 449) that "No evidence was noted to prove granites of more than one age in northeast Manitoba—", apparently having reconsidered the evidence for a pre-Oxford 'quartz-eye' granite.

In 1931 and 1932, Horwood mapped the Cross Lake area in the southwest part of the Gods-Island-Oxford region, and in 1935 published a paper summarizing the stratigraphy of the area (75), his succession being shown in the fourth column of Table IV. His sequence differs most markedly from the others in that he believed the tonalite, a rock widespread in the area, to be the basement rock on which the Hayes River rocks lie. However, a critical appraisal of his evidence, as published, leads the writer to believe rather that the so-called tonalite is largely the product of granitization and intrusion, and is, therefore, much younger than Hayes River rocks. Horwood considered that there is a small angular unconformity between Hayes River rocks and overlying Cross Lake series, and that these younger rocks are the equivalent of the Oxford sedimentary assemblage.

In 1936, Johnston made a reconnaissance map of the Norway House area (81) south of Cross Lake, and noted that the basal assemblage consists of interbedded volcanic and sedimentary strata. Although these rocks are not named, they include those mapped as the Hayes River group by Greer (68) in 1928.

Also in 1936, Tanton (122) made a brief examination of exposures near the headwaters of Hayes River, and referred the interbedded lavas and sedimentary rocks to the Hayes River group. He noted that they were cut by granite and allied rocks, and by some basic intrusions.

Downie (59) mapped the Stull Lake 4-mile area, which extends east from Gods Lake across the Ontario boundary, in 1936. He followed Wright's terminology and assigned the basal assemblage of volcanic and sedimentary rocks to the Hayes River group, and the younger strata of predominantly sedimentary origin to the Oxford group. No intervening granite was postulated, nor was any diabase noted. However, a body of basic intrusive rock east of Stull Lake, in Ontario, was considered to be younger than the granite of the area and perhaps equivalent to the diabase of other areas.

McMurchy (90) mapped the Island Lake area in 1938 more completely than Wright had done, but still on a 4-mile scale. His stratigraphic sequence is shown in the last column of Table IV. He concluded that the Island Lake series and the Oxford strata are of the same age, and that some of the sedimentary rocks that Wright had mapped as part of the Hayes River group are actually part of the Island Lake series. He classed all formations younger than the Hayes River group as Island Lake series and did not use the term "Oxford". Although granite pebbles are abundant in the Island Lake series, he could find no evidence that any particular granite is pre-Island Lake, but did believe that some basic intrusions might be.

In 1938 also, the Bigstone Lake area, a few miles west of Island Lake, was mapped in some detail by McIntosh (89), who regarded most of the rocks as part of the Hayes River group of the Island Lake area. Some isolated belts of sedimentary rocks were classed provisionally as part of the Island Lake series, but McIntosh thought that some, at least, of these bodies might be Hayes River in age. These rocks are cut by granite and, finally, by dykes of diabase.

In 1946, Springer (105) mapped the Knee Lake area, north of Gods Lake, on a 4-mile scale, and classed all the sedimentary and volcanic rocks in the area as Hayes River. He noted that the volcanic rocks are cut by a sheared quartz-porphyry having bluish phenocrysts of quartz—('quartz-eye' granite?)—and regarded it as possibly older than the fresher, massive granite of the area. All these rocks are cut by diabase dykes.

Finally, in 1947, Dix (55) mapped the area about the Gods Lake mine on a scale of 1 inch to 1 mile. He used the terms Hayes River and Oxford to designate his rock units, and, except that no diabase occurs in the area mapped, his stratigraphic succession is similar to Wright's (146). However, in contrast with Bruce (36) and Wright (140, 146, 147), who placed sedimentary members at the base of the Hayes River group, Dix regarded the volcanic members as the oldest rocks, at least in the vicinity of the mine.

Summary

Wright (147) regarded the Island Lake series as younger than the Oxford, but McMurchy (90), who mapped an area where both series are exposed, regarded the two as contemporaneous and designated them the Island Lake series. However, Wright (147) had already defined the Island Lake series as Proterozoic in age and unconformably above the Oxford sediments of Archæan age. Thus, if the two are actually part of the same succession and Archæan in age, as indicated by McMurchy, the whole group should be called the Oxford. Unless later, more detailed work proves that the so-called Island Lake series, as mapped by Wright, rests unconformably above Oxford rocks, all formations in this area that were deposited on the Hayes River rocks should be mapped as part of the Oxford succession. The Cross Lake series was considered by Horwood

(75) to be equivalent to the Oxford group, but the name could be retained for local terminology until mapping shows that the two are the same, at which time "Cross Lake" can be dropped. The stratigraphic sequence for the Gods, Island, and Oxford Lakes region, compiled from all these works, is shown in the third column of Table VI.

Correlation with Flin Flon

The Hayes River group, as the basement rocks of the Gods, Island, and Oxford Lakes region, should obviously be correlated with the Amisk rocks of the Flin Flon region, and the Oxford group is the equivalent of the Missi. No pre-Oxford granite has been recognized that corresponds with the pre-Missi, Cliff Lake granite porphyry, although Wright (146) at one time did consider that a similar rock at Oxford Lake was, perhaps, pre-Oxford. The diabase dykes of this region apparently have no equivalent at Flin Flon, but otherwise the post-Oxford intrusive sequences are similar.

Thicket Portage Region

Thicket Portage, at mile 186 on the Hudson Bay railway, is a name used here to designate a narrow strip of territory extending about 60 miles southwest and 90 miles northeast at that station (*See* Figure 1). The region is very incompletely mapped, but some rock-unit relationships have been tentatively established.

History of Mapping

Part of the region lies along the routes covered by Bell and his associates in 1878-79-80 (25, 26, 27). Tyrrell (129) mapped some of the region in 1896, his work being followed by McInnes (86) and O'Sullivan (94) in 1906. Spurr (108) made some geological notes as a result of examination of mineral prospects in the area. Alcock (5) studied part of the area in more detail in 1920, and in 1928 Birse (28) made a geological survey of part of the area. In 1930, Wright (144, pp. 113-124) followed Grass River to Thicket Portage, and Dawson (46, 47) mapped areas about Split and Partridge Crop Lakes in 1939 and 1941. All these surveys were on reconnaissance scales.

Stratigraphic Studies

Bell (25, 26, 27) and Tyrrell (129) referred all rocks in the region to the Laurentian or Huronian systems, and McInnes (88), in his compilation report, to the Keewatin, Huronian, and Laurentian. O'Sullivan (94) named no rock units.

Alcock (5) named no rock units in the Ospwagan (Pipe) Lake district, but his stratigraphic sequence shows grey gneiss at the base, succeeded by basic volcanic rocks and derived schists. These are cut by batholithic granite, and all are cut by dykes of gabbro and diabase. Birse (28) noted only a narrow fringe of greenstone on Mystery Lake, the rest of the rocks being granite and its derivatives. Wright (144) was chiefly concerned with mineral deposits, and his comments on stratigraphy are necessarily local. However, he did note apparent interbeds of sedimentary and volcanic rocks, and the succession of intrusive rocks described by Alcock.

Dawson (46, 47) separated the rocks into groups, of which the oldest, pre-Assean Lake group consists of gneisses and schists, some limy rocks, and sheared conglomerate. These are overlain, possibly unconformably, by the Assean (Stony) Lake group of predominantly clastic sediments, with some intercalated lavas. These are much fresher in appearance than the pre-Assean Lake rocks, and the contact between them is so sharp and irregular that it suggests an unconformity. Dawson includes in his pre-Assean Lake assemblage a grey gneiss, or tonalite similar to that mapped by Horwood (75) at Cross Lake as the basement rock, and in at least one place the tonalite cuts the pre-Assean Lake sedimentary members. A 'quartz-eye' granite-gneiss intrudes pre-Assean Lake rocks, but was not found in the Assean Lake. All are intruded by gneissic granite, followed by basic dykes, and finally by massive granite and pegmatite.

As both the pre-Assean Lake and Assean Lake rocks are mainly sedimentary, it is difficult to correlate them with rocks in other areas. It is possible that only the sedimentary members of the Hayes River (Wasekwan, Amisk) groups are preserved in this area as pre-Assean gneisses and schists, and that the Assean Lake rocks are equivalent to Oxford (Sickle, Missi) strata. On the other hand, the contact between pre-Assean Lake and Assean Lake may be a metamorphic contact, in spite of the sharp lithological distinction between the two. The descriptions of pre-Assean Lake gneisses are very similar to those of Kisseynew gneisses near Sherridon and north of Flin Flon (19, 23, 71, 141, 144), and the two groups of gneisses may be continuous. The writer believes that the Kisseynew gneisses[1] were formed comparatively late in the Precambrian history of northern Manitoba, and if the pre-Assean gneisses are to be correlated with the Kisseynew, the time of metamorphism is post-Assean Lake, and degree of metamorphism is no criterion of age. It is possible, therefore, that the Assean Lake and pre-Assean Lake rocks form one series, and, if so, that it is probably equivalent to Oxford (Missi, Sickle) strata in age.

Other Regions of Northern Manitoba and Adjacent Parts of Saskatchewan

Widely separated areas in other parts of northern Manitoba have been mapped on reconnaissance 4-mile scales, and correlations of their rocks with those in other areas are even more tentative than those discussed so far.

At Churchill, on Hudson Bay, some beds of quartzite form a broad syncline[2] plunging to the south, and in places the beds dip as steeply as 70 degrees. These rocks were called the Churchill quartzite by Bell (26, p. 20), who noted their similarity to the Proterozoic gold-bearing strata of Nova Scotia. In 1893 and 1894, Tyrrell (127) examined these rocks and regarded them as equivalent to the "Athabasca" sandstone in Saskatchewan, and to the Keweenawan of Lake Superior. He noted (p. 91) that "The Churchill rock has been much more disturbed and altered than the Athabasca conglomerate, but that may be due to quite local conditions". Alcock examined these rocks in 1915, and considered them to be older than the regional granite, although the two were not found in contact (1, p. 135). He apparently based his conclusion on the high angles of dip of the quartzite. Williams (133) studied the area in 1947, but did not classify the Churchill quartzites as to age. However, he did note that they are

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[1]*See* Part II of this report.

[2]Owen, E. B.: Geol. Surv., Canada, personal communication, 1949.

somewhat metamorphosed, and apparently regarded them as older than the granite. Owen made a brief study of the rocks there in 1948, and noted the presence of some beds of calcareous sandstone. With Bell and Tyrrell, he regards the rocks as Late Precambrian. A study of these rocks on air photographs shows a well-formed cleavage and contorted bedding, features that were probably missed in reconnaissance mapping, as the bedding is very obscure. Hence, it may be that the Churchill quartzites are of Archæan age, in spite of calcareous sandstone beds, although definite classification as such must necessarily be deferred until detailed mapping has been done.

Near Great Island, in Seal River, Johnston reported (76) that a series of volcanic rocks is overlain unconformably by slates and quartzites. The volcanic members are cut by granite, and both volcanic and sedimentary rocks are cut by basic dykes. Relations of the sedimentary strata to the granite are unknown. West of Great Island, a group of gneisses form the bedrock, and these are very similar to Kisseynew gneisses. The rock units are not named, but might be classed, provisionally, as Amisk-type, Missi-type, and Kisseynew-type.

Some of the names used to designate rock units in northern Manitoba have been applied to similar successions in Saskatchewan, but for the most part the rock-unit names there are referred to the succession at Lake Athabasca[1].

Weeks (131, 132) mapped an area west from, and including most of, Reindeer Lake. No names were applied to the rock units, which consist mainly of gneisses of sedimentary and volcanic origin that Stockwell (112) referred to the Kisseynew and Wekusko (Amisk) rocks of the Flin Flon region. The area immediately south of Weeks's area was mapped by Alcock (9, 10), and he also refrained from applying rock names. However, he noted that the basal assemblage of interbedded volcanic and sedimentary rocks is similar to the Wekusko group of northern Manitoba. The description of the gneisses leaves little doubt that they are Kisseynew types. Satterly (102) mapped the Pelican Narrows area northwest of Flin Flon and immediately south of Alcock's area. He remarked that the oldest group of rocks, which consisted mainly of basic lavas, was "believed to be equivalent to the Amisk series". The sedimentary members of the complex, now highly altered to gneisses and schists, were correlated with the Kisseynew. Allen (13) mapped the southeast corner of the Pelican Narrows area on a scale of 1 inch to 1 mile, but did not correlate the rocks there with any other area. However, the description of them, and the fact that they are continuous with Kisseynew gneisses to the south and east, leave no doubt that they are part of the same complex. DeLury[2] mapped an area west of Amisk Lake on a reconnaissance scale, but applied no names. However, he divided the rocks into a basal volcanic group, an upper group of sedimentary types that included basal conglomerate, and a group of gneisses that may be the oldest rocks in the area. These groups should probably be correlated respectively with the Amisk, Missi, and Kisseynew.

[1]Alcock, F. J. (1936): Geology of the Lake Athabaska Region, Saskatchewan; Geol. Surv., Canada, Mem. 196.

[2]DeLury, J. S. (1925): Wapawekka and Deschambault Lakes Area, Saskatchewan; Geol. Surv., Canada, Sum. Rept. 1924, pt. B, pp. 23–50.

The term 'Wekusko group' was carried into central Saskatchewan by McLarty[1] where the volcanic and sedimentary rocks of the Lac la-Ronge area are so designated. They are partly altered to gneisses and schists, which are not named, but are probably Kisseynew. Keith[2] followed McLarty's nomenclature when mapping a part of this area in more detail, but included the gneisses and schists in the Wekusko group.

Southeastern Manitoba

As considered here, southeastern Manitoba includes the Precambrian rocks east of Lake Winnipeg to the Ontario boundary, and from the International Boundary north to latitude 53 degrees (*See* Figure 1). Most of the detailed geological studies have been concentrated in the Rice Lake-Beresford Lake gold area, but they are being extended both north and south from there by officers of the Manitoba Mines Branch.

History of Mapping

The first reports of this area of Precambrian rocks, and of any such in the province, were those made by Bell (24) and Selwyn (103) as a result of track surveys in 1873, from Lake Superior to Lake Winnipeg and Fort Garry respectively. Low (83), in 1886, and Tyrrell (128), in 1890 and 1891, explored some of the rivers east of Lake Winnipeg. Apparently no further examinations were made of these rocks until Moore (92), accompanied by Wallace (130), made micrometer and track surveys of part of the Rice Lake-Beresford Lake area in 1912. In 1916, Dresser (60) studied some of the gold deposits in that area, and from that year to 1930 examinations and geological studies were made in the region every year. De Lury made many examinations, but only a few are listed here (48, 49, 50, 51, 53) because most of them were concerned with economic aspects and had little bearing on stratigraphy. In 1917 and 1918, Bruce (33, 35) examined briefly some prospects in the south part of the region, and Marshall (84) examined many deposits farther north. In the twenties, McCann (85), Cooke (41), Burwash (40), and Rickaby (97) each spent one season mapping in the region, and Wright (134, 135, 136, 137, 139, 143) spent several. Wright's work was continued in the thirties (148, 149, 150), at which time Stockwell also mapped several areas (115, 116, 117, 118, 119, 120). In 1936, a large area east of Lake Winnipeg was mapped on a reconnaissance 4-mile scale by Geological Survey parties under the direction of Johnston (77, 78, 79, 80, 81). In 1947, officers of the Manitoba Mines Branch commenced systematic 1-mile mapping in the region (100, 101, 106).

Stratigraphic Studies

Bell (24), Low (83), Selwyn (103), and Tyrrell (128) all referred the rocks to the Laurentian or Huronian, largely on the basis of lithology. However, when Moore (92) mapped an area in 1912, he introduced local names for the rock units. The oldest assemblage, consisting mainly of volcanic rocks, was named the Rice Lake series and was considered the equivalent of the Keewatin. The Wanipigow series, consisting of sedimentary formations, was thought to be Huronian and, therefore, uncon-

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[1]McLarty, D. M. E. (1936): Lac la-Ronge Sheets, Saskatchewan; Geol. Surv., Canada, Maps 357A and 358A.

[2]Keith, M. L. (1940): MacKay Lake, Saskatchewan; Geol. Surv., Canada, Map 592A.

formably above the Rice Lake series, although no positive evidence for such relations was found. All these rocks were cut by the Manigotagan granite. In 1916, Dresser (60) followed the same classification as Moore, but a year later Marshall (84) named the oldest rocks "Keewatin", although he retained the name of Wanipigow for the presumed younger sedimentary assemblage.

Farther south, at Falcon Lake, Bruce (33, 35), in 1917 and 1918, called the lavas "Keewatin" and the granite "Laurentian", names that were extended from the work of Parsons (95) on the Ontario side of the provincial boundary in 1910 and 1911. De Lury (48) followed the same procedure in 1917; in 1918 (49) he applied no names, and in the following 2 years (50, 51) he reverted to Bruce's terminology.

McCann (85) studied a copper-nickel deposit at Maskwa River in 1920, and stated: "The greenstone schists are probably of Keewatin age, and are correlated with the Rice Lake series farther north". The next year Cooke (41) mapped an area that included parts of the areas mapped by Moore (92) and McCann (85). He found evidence to show that the Rice Lake series, of volcanic origin, was overlain conformably by the Manigotagan sedimentary rocks, and he designated the whole succession as the Rice Lake series (Table V), and probably Keewatin in age.

Also in 1921, Burwash (40) mapped the geology along the Manitoba-Ontario boundary between Winnipeg and Bloodvein Rivers, and used the terminology established by Moore. Extending this work farther north in 1922, Rickaby (97) used the terms Keewatin and Laurentian.

In 1922, 1923, and 1924, Wright mapped considerable areas in southeast Manitoba (134, 135, 136), but did not name the rock units, because he found sedimentary rocks both younger and older than the volcanic members, and in places rocks of both types are intercalated. However, in 1925, he published a general summary of the geology of the region (137). In his stratigraphic column, the lavas and sedimentary rocks were divided into three series (second column, Table V); the oldest, Manigotagan series, consisted mainly of argillaceous rocks conformably overlain by the intermediate Wanipigow series of quartzose sedimentary rocks, and these, in turn, were conformably overlain by the Rice Lake series of lavas and pyroclastic rocks. Thus, Cooke's stratigraphic sequence (41) was inverted. However, in 1927, Wright (139) modified this concept on the map of the Beresford and Rice Lakes area. The rocks were all named the Rice Lake series, and were separated into 'phases', as shown in the third column of Table V. The oldest, Manigotagan phase, was provisionally placed in the Rice Lake series. It was represented as overlain by unnamed volcanic rocks, succeeded by the Beresford Lake phase of intercalated sedimentary and volcanic rocks, which was overlain conformably by the Wanipigow phase of quartzose sedimentary rocks. The same year De Lury (52) published a general account of economic geology in southeastern Manitoba, but justifiably refrained from naming any rock units.

In 1929 some more of the mineral deposits in southeast Manitoba were mapped by Wright (143), and he again separated the Rice Lake series into three phases. However, this time he included the previously unnamed volcanic rocks in the Beresford Lake phase.

Wright's final published statement on this region was made in 1932 when all available information on some 45,000 square miles from Winnipeg

TABLE V

Southeastern Manitoba

COOKE (41)	WRIGHT (137)	WRIGHT (139)	STOCKWELL (115)
			San Antonio formation: conglomerate, arkose, quartzite
			Unconformity
Granite Gabbro Diabase dykes Acidic dykes Granite	Diabase Granite and related rocks Acidic dykes Granodiorite and related rocks Basic intrusions	Diabase Acidic dykes Granite and related rocks Basic intrusions	Acidic and basic dykes Quartz diorite 'Quartz-eye' granite Basic intrusions
Intrusive contact	*Intrusive contact*	*Intrusive contact*	*Intrusive contact*
Rice Lake series: tuffaceous sediments *Conformable contact* Lavas and breccias	Rice Lake series: basic volcanic rocks; some rhyolite, greywacke Wanipigow series: greywacke, arkose, conglomerate Manigotagan series: argillite, slate, derived schists and gneisses	Rice Lake series: Wanipigow phase: greywacke chert, quartzite, arkose Beresford Lake phase: acidic volcanic rocks, iron formation; intercalated sedimentary rocks Basic volcanic rocks; some rhyolite and sedimentary rocks Rice Lake series (?): Manigotagan phase: sedimentary rocks; derived schists and gneisses	Rice Lake series: basic and acidic volcanic rocks; some sedimentary rocks

River north to latitude 51°15′ was summarized in Memoir 169 (148). In addition, he published two maps (149, 150) of the south part of the area. The Rice Lake series included all the sedimentary and volcanic rocks in the area, and was divided into three phases, the previously unnamed volcanic rocks being included in the Beresford Lake phase. The phases appear to have been separated on the basis of lithology, rather than structure, and on the maps of the south part of the area no divisions of the Rice Lake series are shown.

In 1936, Johnston (77, 78, 79, 80, 81) mapped a large area east of Lake Winnipeg, from the north part of the area described by Wright (148) north to Norway House. No names were applied to any rock units, most of which are varieties of granitic intrusions.

Stockwell commenced mapping the main gold-producing part of the region in 1936. As a result of his detailed studies around the San Antonio mine in 1936, he concluded (115) that, in addition to the sedimentary rocks that are part of the Rice Lake series, there are other sedimentary rocks that overlie that series with marked structural unconformity. These younger strata were named the San Antonio formation, and in the area examined no bodies of granite or other intrusive rocks were found to cut them. In his table of formations (fourth column, Table V) this formation is shown as the youngest rock in the area, but with the qualification (p. 4) that "........ it should be borne in mind that the relations of these sediments to the quartz diorite and related dykes are unknown".

At the same time Lord mapped a small area, in great detail, about the Gunnar mine at Beresford Lake, and the next year Stockwell extended the study, in somewhat less detail, to include the Central Manitoba and Oro Grande mines. Results of these studies were published in Memoir 219 (116). The volcanic and sedimentary rocks were mapped as the Rice Lake series, and were those included by Wright (148) in the Beresford Lake phase. No rocks of the San Antonio formation occur in the area.

Stockwell continued mapping in this region in 1938 and 1939, and, as a result, three 1-mile maps were published (118, 119, 120) that include the areas previously studied in detail. On these maps all the sedimentary and volcanic rocks, except the San Antonio formation (120), are mapped as a conformable succession called the Rice Lake group, and although they include rocks of the three phases distinguished by Wright, Stockwell could find no sound basis for separation. The San Antonio formation is shown in the legend (120) as it is in Table V, no further evidence of its age having been found.

Springer (106, 107), as a result of 1-mile mapping in 1947 and 1948 south of that done by Stockwell, classified the rocks as the Rice Lake series, and separated them into an older volcanic group conformably overlain by a sedimentary group, a classification adopted the following year[1].

In 1947, Russell (100) mapped an area north of Beresford Lake on a 1-mile scale, and refers simply to the "Sedimentary-Volcanic series", in which most of the volcanic rocks are regarded as older than most of the sedimentary rocks. However, in continuing the work the following year, the volcanic and sedimentary strata were included in the Rice Lake group (101).

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[1]Springer, G. D. (1950): Cat Lake-Winnipeg River area; Mines Branch, Dept. Mines and Nat. Res., Manitoba, Pub. 49-7.

Davies (45) in 1948 mapped the Wanipigow Lake area, which includes a small part of the area previously mapped by Stockwell (120), and made the same reservations regarding the relative age of quartz diorite and the San Antonio formation. The next year he mapped the area that adjoins it on the east, the southern part of which also includes some of the area mapped by Stockwell. Here he regarded the quartz diorite as essentially contemporaneous with the granite, and stated that the San Antonio formation lies unconformably on the granite.[1]

Correlation with Flin Flon

The rocks variously termed the Rice Lake series and Rice Lake group should probably be correlated with the Amisk rocks at Flin Flon, although the Rice Lake contains more sedimentary strata than the type Amisk. Descriptions of the San Antonio formation are the same as those of some facies of the Missi series, but the formation is much less widely exposed. However, a tentative correlation with the Missi appears in order, a classification with which Stockwell is inclined to agree.[2] One major distinction between the San Antonio and Missi lies in their relations to the intrusive rocks of their respective areas. At Rice Lake it is difficult to prove that any particular granitic intrusion is younger than the San Antonio formation, whereas in the Flin Flon region it is difficult to determine which granitic bodies are older than the Missi rocks.

SUMMARY OF STRATIGRAPHIC NOMENCLATURE

A stratigraphic sequence for each of the main regions in Manitoba and adjacent parts of Saskatchewan is shown in Table VI. The Flin Flon region is regarded as the standard, because it was there that the first stratigraphic mapping was undertaken (31). Subsequently, almost all geologists who have studied areas in that region have followed Bruce's terminology wholly or in part, and the most recent work follows it closely (121). The names employed in the Reed-Wekusko region are not quite the same, but they will be modified, or dropped, as geological investigations are carried towards or from the Flin Flon region. Names applied in the other regions are those established for those regions, and until more positive correlation can be made with the Flin Flon region they should be retained. However, named rock units should be defined so that later investigators in particular areas will use them with the same meaning.

Amisk-Wasekwan-Hayes River-Rice Lake

The Amisk series was defined by Bruce (31) as a complex of very ancient, rather basic, volcanic rocks with some intrusive equivalents, and which forms the oldest recognized series. In his latest detailed examination, Stockwell (121) followed this definition, but added some acidic volcanic rocks to the Amisk succession, as Alcock (7) had done. The main shortcoming of this definition is that no sedimentary rocks are included. However, the Amisk rocks at Flin Flon have been traced both east and west to localities where clastic sedimentary members are interbedded with the

[1]Davies, J. F. (1950): Geology of the Wanipigow River Area; Mines Branch, Dept. Mines and Nat. Res., Manitoba, Pub. 49-3.

[2]Personal communication.

TABLE VI

Comparative Precambrian Stratigraphy in Manitoba

	FLIN FLON	REED-WEKUSKO	GODS, ISLAND, and OXFORD LAKES	GRANVILLE-LYNN LAKES	SOUTHEASTERN MANITOBA
Proterozoic			Diabase		Diabase (?)
			Intrusive contact		
Archæan or Proterozoic	Kaminis granite Boundary intrusions Granite and allied rocks Basic intrusions	Granite and allied rocks Basic intrusions 'Quartz-eye' granite?	Granite and allied rocks Basic intrusions	Granite and allied rocks Basic intrusions	
	Intrusive contact	*Intrusive contact*	*Intrusive contact*	*Intrusive contact*	*Intrusive contact* (?)
	Missi series: clastic sedimentary rocks; local volcanic rocks; derived schists and gneisses	Missi series: clastic sedimentary rocks; some volcanic rocks; derived schists and gneisses (includes Snow?, Laguna?, and post-Laguna; some pre-Laguna)	Oxford group: conglomerate, arkose, quartzite, grit, slate; derived schists (includes Cross Lake and Island Lake series)	Sickle series: conglomerate, quartzite, arkose, greywacke; some volcanic rocks	San Antonio formation: conglomerate, arkose, quartzite
	Unconformity	*Unconformity*	*Unconformity*	*Unconformity*	*Unconformity*
Archæan	'Quartz-eye' granite	'Quartz-eye' granite (?)	'Quartz-eye' granite (?)	Granite-gneiss ??	Granite and basic rocks
	Intrusive contact	*Intrusive contact ??*	*Intrusive contact ??*	*Intrusive contact ??*	*Intrusive contact*
	Amisk series: mainly basic volcanic rocks; some acidic lavas; some clastic sedimentary rocks (includes Wekusko group of Wright)	Amisk series: mainly basic volcanic rocks; some acidic flows; some clastic sedimentary rocks (includes part of Wekusko group of Alcock, and part of pre-Laguna of Armstrong)	Hayes River group: mainly basic volcanic rocks; some acidic lavas; local abundance of clastic sedimentary rocks	Wasekwan series: mainly basic volcanic rocks; some acidic lavas; local abundance of clastic sedimentary rocks	Rice Lake series: interbedded volcanic and sedimentary rocks

volcanic assemblage (22, 39, 61, 82, 151, 155) and, therefore, the Amisk should be regarded as a conformable succession consisting predominantly of basic volcanic rocks with interbeds of acidic volcanic and clastic sedimentary rocks in varying proportions, and forming the oldest recognized assemblage of the region. This definition should apply also to the Wasekwan and Hayes River successions. All three can be correlated roughly with the Keewatin of Ontario on lithological grounds, and on the fact that all are usually regarded as basal assemblages, though not necessarily of the same age.

Missi-Sickle-Oxford-San Antonio

Bruce (31) divided a group of clastic sedimentary rocks into the Upper and Lower Missi series, possibly separated by an unconformity. However, more recent and more detailed investigations (39, 154) have shown that the Lower Missi comprises clastic sediments that are interbedded with Amisk volcanic strata and, therefore, should be considered as part of the Amisk. Thus Bruce's Upper Missi only is now classed as Missi, and was defined (31) as mainly rather coarse clastic sedimentary rocks, with interbeds of conglomerate, that lie with angular unconformity on the Amisk strata. Similar relations and lithology characterize the Sickle and Oxford series, the Cross Lake series, which was considered to be equivalent to the Oxford (75), and, perhaps, the Assean Lake rocks of Dawson (46). However, Missi strata are indicated as consisting wholly of clastic sedimentary rocks in the type localities of Flin Flon (31, 121) and Amisk Lake (31, 151). But if the Snow group of File Lake map-area (70, 72), and the younger rocks east of Wekusko Lake (65), are to be correlated with the Missi, then some volcanic rocks are intercalated with Missi strata[1].

Volcanic interbeds are found in the Sickle series (58, 73), but none is reported in the Oxford group or Island Lake series, or in the San Antonio formation. It is suggested that the definition of the Missi series be modified to include local accumulations of volcanic rocks, a definition that would apply equally well to the Sickle.

Missi strata were further considered to be later than the Cliff Lake granite prophyry (31). Alcock (7) regarded this granite as post-Missi, as did Tanton (124), but detailed studies by Stockwell (121) have resulted in good evidence for its pre-Missi age. At Amisk Lake, Wright (151, 152) considered that a granite on Lookout Island, and probably also on Missi Island, was pre-Missi, but Tanton (123) presented evidence to indicate that it is post-Missi in age, a conclusion with which the writer is in accord. However, the writer also agrees with Bruce (31) and Stockwell (121) that the Cliff Lake granite prophyry is pre-Missi, and also noted pebbles of similar rock in the Missi conglomerate on Lookout Island. Thus, in the Flin Flon area at least, a pre-Missi granite can be recognized in place. A similar relation (146), later reconsidered (147), was postulated by Wright between the Oxford series and a 'quartz-eye' granite at Oxford Lake. A pre-Sickle granite was designated by Bateman (21) at McVeigh Lake, and Allan (12) and Stanton (110) believe there is a good possibility that some of the granite mapped by them as post-Sickle may actually be pre-Sickle. In the Rice Lake area, Stockwell (115) has shown that the San Antonio formation is younger than some, if not all, of the granitic rocks of

[1]This problem is further considered in the discussion of age of the Kisseynew gneisses in Part II of this report.

the area. Thus, the Missi-Sickle-Oxford-San Antonio strata can roughly be considered the equivalents of the Timiskaming rocks of Ontario and Quebec, and the 'quartz-eye' granite can be regarded as Laurentian.

Wekusko Group

The term 'Wekusko group' was introduced in 1920 by Alcock (4, p. 16) to designate a complex of volcanic and sedimentary rocks in the Reed-Wekusko region. He regarded the whole group as a series of flows and contemporaneous sediments, but considered the possibility that later, more detailed work might alter this concept (2), as it has done (16, 62, 65, 70, 72, 104, 109, 114). In 1931, the term 'Wekuskoan' was employed by Wright (144, p. 8) "to include all the sedimentary and volcanic strata of the [mapped parts of the northwestern Manitoba] that are older than the Missian sediments". However, 'Wekuskoan' did not come into general use, and geologists, including Wright, used the term 'Wekusko group' to designate assemblages of volcanic and sedimentary rocks that might include strata of widely different ages (98, 113, 151, 152, 153, 154), and that usage of the term was carried a considerable distance west in Saskatchewan[1]. It is, therefore, recommended that the term 'Wekusko' be used for all presumably pre-Missi assemblages of volcanic and sedimentary rocks whose relative ages are not reasonably well established.

Laguna Series

The term Laguna series was proposed by Armstrong (16) to designate a series of rocks on the east side of Wekusko Lake, and which were, presumably, younger than more altered rocks on the opposite side of the Lake. Laguna rocks were believed to be overlain unconformably by sedimentary beds and lava flows of post-Laguna age, but detailed investigation to the east by Frarey (65) have led him to regard the Laguna and post-Laguna rocks as a conformable succession, probably equivalent to the Missi series, lying unconformably on the pre-Laguna of Armstrong. Thus, if the term 'Laguna' is to be used at all, it should be considered equivalent to the Missi, and the 'pre-Laguna' equivalent to the Amisk. However, detailed mapping to the west discloses that part of the pre-Laguna is equivalent to the Snow group (70, 72), which is of uncertain age, but may be Missi. Thus, the latest studies indicate that part of the pre-Laguna, and all of the Laguna and post-Laguna rocks, possibly are of Missi age. It is, therefore, suggested that the term 'Laguna' be abandoned.

Snow Group

The name 'Snow group' was introduced by the writer (70) to designate a group of rocks that have some structural and lithological affinities with the Missi, but also differ from it in many respects. Its introduction to formational nomenclature was intended as a temporary expedient, with the idea that as soon as mapping was carried farther west to join with that at Flin Flon, the name could be dropped or its definition modified to suit the later information.

Cross Lake Series

The Cross Lake series includes some sedimentary rocks at Cross Lake that rest unconformably on the Hayes River group. Horwood (75)

[1]Keith, M. L. (1940): MacKay Lake Area, Saskatchewan; Geol. Surv., Canada, Map 592A.
McLarty, D. M. E. (1936): Lac la-Ronge Sheets; Geol. Surv., Canada, Maps 357A and 358A.

regarded these rocks as the equivalent of the Oxford group at Oxford Lake, and the lithology and structural relations of the two groups are similar. However, their two type areas are separated by about 80 miles of virtually unmapped country, and until more definite evidence of contemporaneity is obtained the name 'Cross Lake' may be useful locally.

Island Lake Series

The Island Lake series was named by Wright (140) in 1928, and in 1932 he used the term for the same series of rocks, but defined it as one that is Proterozoic in age and unconformable above the Oxford group (147). In 1938, McMurchy (90) concluded that the Island Lake series was part of the Oxford group, and used the name to designate rocks that had previously been mapped as both Oxford and Island Lake strata (140, 146, 147). However, McMurchy regarded the assemblage as Archæan and, because Wright had previously defined the Island Lake rocks as Proterozoic, it is recommended that the term be dropped until, or unless, it can be shown that the rocks mapped by Wright as the Island Lake series are actually Proterozoic.

Assean Lake Group

These rocks, named by Dawson (46, 47), are in an area that is separated from other mapped regions, and hence their relative age is unknown. However, as soon as reasonable correlation can be made with other regions the term 'Assean Lake' should be abandoned.

Conclusions

It is recommended that the terms Amisk, Hayes River, Wasekwan, and Rice Lake be retained for the basal rocks in the regions for which these terms have been defined, and that the terms Missi, Oxford, Sickle, and San Antonio be retained for the rocks unconformably above the basal strata in their respective regions. When it becomes possible to make more exact correlation between regions, only the names having priority of definition should be retained. In order of seniority the terms are: Rice Lake, Amisk, Missi, Hayes River, Oxford, Sickle, Wasekwan, and San Antonio. However, as the Rice Lake and San Antonio rocks are separated from all the others by 175 miles or more of granitic rocks, it is hardly probable there will be any need to dispose of their names. It is recommended, further, that 'Island Lake' be retained only if it can be shown that the rocks so named are younger than Oxford strata and, hence, of Proterozoic age. 'Wekusko group' should be applied only where strata of widely different ages may be included in the rocks so designated. Snow group, Cross Lake series, and Assean Lake group are local designations that should be abandoned if reasonably sound correlations can be made with any of the eight names suggested as standards. The term 'Laguna' should no longer be used. As all mapping in the parts of northern Manitoba and Saskatchewan will be an extension of areas already mapped, it should not be necessary to introduce any new series or group names into the literature, unless it becomes apparent that some of the standard terms are useless, as defined. However, as more areas are mapped in detail it will probably be necessary to modify the definitions of the terms as used in this report.

'GROUPS' AND 'SERIES'

According to a standard adopted by the Geological Survey of Canada, 'series' is the total assemblage of sedimentary and volcanic rocks formed during a geological epoch, as, for example, Upper Devonian series. An exception is made in the unfossiliferous Precambrian rocks where any conformable succession of sedimentary and/or volcanic strata, bounded by significant faults or unconformities, may be termed a series, although its status as representing an epoch cannot be demonstrated—for example, Bruce series. A 'group', on the other hand, is a succession of sedimentary or/and volcanic rocks, with broad lithological characteristics, which has either been subdivided or is believed to be capable of subdivision into two or more formations or even smaller groups. As commonly used in Precambrian areas, it may even be separable into series, but should not include any recognized significant intervals of non-deposition, as, for example, the Wekusko group.

According to these definitions, it seems reasonable to use the term 'series' with the local names of Amisk, Missi, Sickle, Wasekwan, and Rice Lake. However, in referring to Amisk, Wasekwan, and Rice Lake rocks as series, a further modification of the definition is needed. These rocks are the oldest known in their respective regions, and, consequently, are nowhere present in their entirety. Owing to later batholithic intrusions, the floor on which these ancient rocks were deposited has not been recognized in any area so far mapped. However, the upper limits of these three series are marked by unconformities, and sufficient detailed work has been done on them to indicate, with reasonable assurance, that the Amisk, Wasekwan, and Rice Lake strata each form one conformable succession. The Missi and Sickle strata have a well-defined floor marked by unconformable relations with Amisk and Wasekwan rocks, but their upper limits are not known with any certainty. However, as they are each believed to represent a continuous succession of strata, they should also be called series.

The Oxford and Hayes River rocks pose a slightly different problem. The Hayes River, like the Amisk and Wasekwan, are basal assemblages and their top is marked by an unconformity. However, very little detailed work has so far been done on them, and, as pointed out by Wright (**140**, p. 73; **147**, p. 445), some of the rocks classed as Hayes River may actually be Oxford, and it is still possible that the rocks called Island Lake by Wright (**147**) rest unconformably above the Oxford. Hence, the Hayes River and Oxford rocks should be classed as groups.

The San Antonio strata have been termed a formation, which is a lithologically distinctive product of essentially continuous sedimentation containing no apparent evidence of an appreciable break in deposition and, in its simplest form, composed dominantly of one general kind of rock. The San Antonio is of restricted occurrence; it forms a lithological map-unit, composed of feldspathic quartzite, arkose, and conglomerate, the last forming the basal member. Were these rocks more widespread they, like the Missi, Sickle, and Hayes River sedimentary rocks, would probably be found to be associated with a wider variety of rock types. They should probably be regarded as a part of a series, now largely eroded, that corresponds to the Missi.

ARCHÆAN AND PROTEROZOIC

The two main divisions of Precambrian time, as applied to the rocks of the Canadian Shield, are Archæan (Early Precambrian) and Proterozoic (Late Precambrian). The rock assemblages of these two groups[1] are separated by a major unconformity, and the Proterozoic rocks, in most places, are relatively little disturbed and altered. However, in parts of Canada, Proterozoic strata were mountain built, and it is customary to regard folded rocks of such age as early Proterozoic.

On lithological grounds, the Churchill quartzites were regarded by Bell (26, p. 20) and Tyrrell (127, p. 91) as equivalent to rocks now considered to be late Proterozoic. Alcock (1) regarded these rocks as probably early Precambrian, but Owen[2] thought that they are more probably Proterozoic, and they are so shown on the Geological Map of Manitoba (850A) published by the Geological Survey of Canada in 1946. A study of air photographs taken in 1948 shows that these rocks are quite strongly folded, in spite of their fresh appearance in the hand specimen. Hence, if the Churchill quartzites are Proterozoic, they should be regarded as early Proterozoic in age.

Wright (147, p. 442), in 1932, defined the Island Lake series as Proterozoic and the Oxford group as Archæan, but McMurchy (90) considered the Oxford and Island Lake rocks as the same unit, and Archæan in age.

Except for the Churchill quartzites and the Island Lake rocks, no other strata in Manitoba have ever been assigned to the Proterozoic. However, in recent years, the younger, predominantly sedimentary formations that comprise the San Antonio, Missi, and Sickle rocks have been designated on Geological Survey maps as Archæan or Proterozoic (74). It has been impossible, so far, to prove that these rocks are not Proterozoic, though on the basis of lithology and metamorphism they are more probably Archæan. They are tightly folded, and in many places and over large areas are altered to gneisses and schists representing a high degree of dynamothermal metamorphism, features not commonly displayed by known Proterozoic strata. It seems probable that the only strata of Proterozoic age between the Athabaska sandstone in northwestern Saskatchewan and Proterozoic strata on the north side of Lake Superior are those at Churchill, and even there the classification is tentative.

CORRELATION OF FLIN FLON WITH PRECAMBRIAN OF ONTARIO

It has been customary to correlate the Amisk series at Flin Flon with the Keewatin of Ontario (37, 53, 123, 145, 147, 155), largely on lithological grounds. The Missi strata are commonly correlated with the Timiskaming, as both are successions consisting mainly of clastic sedimentary rocks, which lie unconformably above the predominant volcanic rocks. Similarly, the Cliff Lake granite porphyry can be regarded as equivalent to the Laurentian of Ontario, and the other intrusions as Algoman. As no younger Precambrian rocks are known in the Flin Flon region, none is equivalent to the Huronian or Keeweenawan, although the quartzites at Churchill may be Huronian.

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[1]This is an alternate use of the word 'group', and applies to all the rocks that formed during a geological era.
[2]Owen, E. B.: Geol. Surv., Canada, personal communication, 1949.

Part II

PROBLEMS OF THE KISSEYNEW GNEISSES[1]

INTRODUCTION

Rocks classed as Kisseynew gneisses occupy a rather narrow belt that extends across west-central Manitoba and east-central Saskatchewan (Figure 2). Other, similar gneisses lie several miles to the north and are separated from the Kisseynew by a broad zone of granitic rocks that holds abundant inclusions of gneiss. It is suggested that the term Kisseynew complex be applied to the rocks comprising both belts of gneisses and the intervening granite, and this report is concerned mainly with the southern belt of gneisses. Most of the detailed mapping has been concentrated in the area about the Sherritt Gordon mine, and Sherridon map-area (19, 23) is proposed as the type area for the Kisseynew gneisses.

The writer has spent parts of six field seasons studying the gneisses in various localities, and the following account is an attempt to clarify some of the problems of their origin and stratigraphic position—problems that are the subject of some controversy.

History of Mapping

Apparently, the first geologist to note the Kisseynew gneisses was Dowling (57, pp. 26-39). In 1899, he traversed them while descending File and Burntwood Rivers and again in passing from Athapapuskow Lake to Churchill River by way of Pineroot and Kississing Rivers. However, Bell (25, 26) and Tyrrell (129) in the seventies and eighties mapped areas of gneisses that are very probably part of the same complex.

It was not until 1918 that Bruce (31) designated these gneisses as "Kisseynew", from their exposures about Kisseynew Lake[2], north of Flin Flon. Since that time, most geologists who have studied the Flin Flon and Reed-Wekusko regions have had to contend with them: some have named them Kisseynew; some have left them unnamed; others have included them as part of the Wekusko group, Missi series, or other local assemblages; and all have found them difficult to interpret.

Distribution

Bruce (31) mapped gneisses of the Kisseynew complex north of Flin Flon, near latitude 55 degrees in 1918, and 9 years later[3] learned that they extended at least to Sherridon. In 1928, Wright (141) showed that they occupied the basin of Kississing Lake, and later (144, 151) mapped them both east and west of previously known areas. Gneisses classed as Kisseynew are now known to extend from longitude 99°30′ to longitude

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[1]In Part II, stratigraphic names are used as defined in Part I.

[2]Kisseynew is a Cree Indian word meaning "It is cold"—a somewhat incongruous designation for high-rank metamorphic rocks, or 'hot' gneisses.

[3] Private report.

104° (*See* Figure 2), and probably extend much farther, for similar gneisses, mapped by McInnes (88) as Grenville (?), and by Dawson (46, 47) as pre-Assean Lake rocks, lie farther west and east respectively.

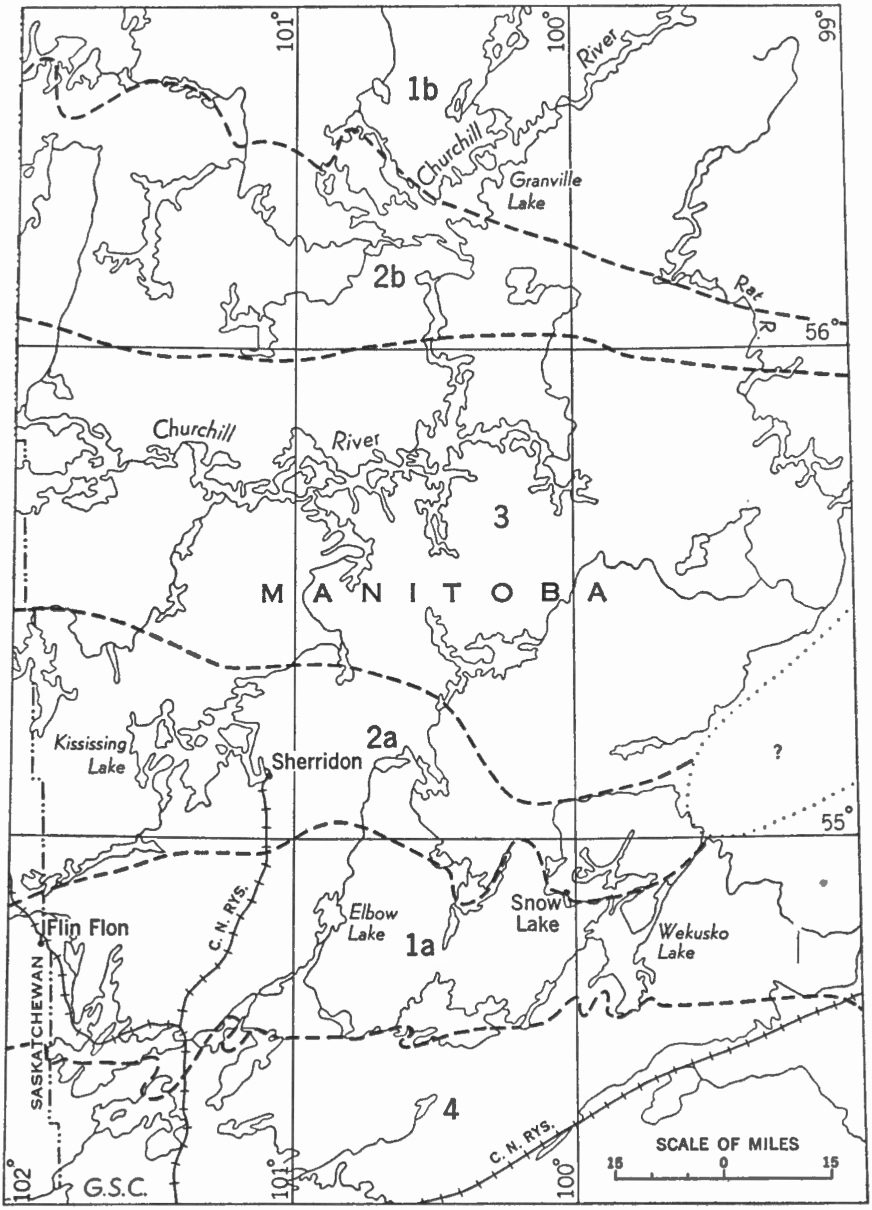

Figure 2. Sketch-map, showing distribution of rock units in west-central Manitoba: 1a, Amisk and Missi strata (southern area); 1b, Wasekwan and Sickle strata (northern area); 2a, Kisseynew gneisses (southern area); 2b, Kisseynew-type gneisses (northern area); 3, complex of granite and gneiss; 4, Palæozoic rocks.

Northwards from Sherridon, the gneisses grade across a broad zone into rocks consisting mainly of granite, but containing large inclusions of altered sedimentary rocks; this zone extends north to about latitude 56 degrees, where the predominantly granitic rocks pass gradually into foliated gneisses that are identical in all respects with those termed Kisseynew. These gneisses are irregularly distributed for many miles to the north and occupy a band parallel with that of the Flin Flon region.

Description

The large number of lithologic varieties that comprise the Kisseynew gneisses virtually preclude an adequate description. Most of them are gneisses, but locally low-grade metamorphic types are represented, so that all grades of regional, or dynamothermal, metamorphism can be distinguished. Thermal effects are superimposed on the regionally metamorphosed rocks, and in many places metasomatism has produced rocks near granite in composition. The rocks vary from black hornblende gneiss to white quartzite; from grey or brown garnet gneiss to pink and red granitic gneiss; from fine-grained argillite to coarse-grained staurolite and garnet gneiss containing crystals as much as 6 inches in length. The lithology varies both across and along the formational trend, due in part to lensing out of particular members or to variation in degree of metamorphism and granitization. In addition, intricately folded structures add further difficulties to geological mapping. A few of the marker formations that have been used with some success in the gneisses are staurolite and sillimanite gneiss and schist, hornblende-plagioclase gneiss, quartzite, cordierite-anthophyllite gneiss, hornblende-carbonate gneiss, garnetiferous-hornblende gneiss, and garnet-feldspar-quartz gneiss. In general, the appearance of the Kisseynew gneisses is similar to that of the Grenville gneisses in Ontario and Quebec, except that crystalline limestone is much less abundantly associated with the Kisseynew than with the Grenville gneisses.

ORIGIN

Bruce (31, pp. 28-29) noted the extreme heterogeneity of the Kisseynew gneisses, but regarded them as variations of two end products, one composed mostly of sedimentary materials, and the other of intrusive origin, but modified by the assimilation of the intruded rocks. To the south, he noted (p. 27) that garnetiferous gneiss graded into "a richly hornblendic quartz schist which resembles more nearly the volcanics than it does the gneisses". He assumed, therefore, that this basic gneiss was part of the Amisk group, although it is metamorphosed in the same manner as some of the basic gneisses termed Kisseynew.

No further published studies were made of these gneisses until 1928, when Wright (141) made a reconnaissance survey of the basin of Kississing Lake and prepared a more detailed map of the area about the newly discovered Sherritt Gordon mine. This work showed that the gneisses in this area are part of the same complex that Bruce mapped at Kisseynew Lake, and that they show the same great range in appearance and mineral composition. Wright classed them (pp. 79-82) as variations of gneissic quartzite, quartz-biotite-garnet gneiss derived from impure sandstone, and hornblende-bearing garnet gneiss derived from clayey arkose; he also described several varieties of granitized gneiss. He stated (p. 81) that "no lava flows or other rocks that might be considered to represent highly metamorphosed lavas were noted amongst the Kisseynew gneisses in the basin of Kississing Lake".

In 1930, Wright (142) described the rocks of two localities near Sherridon where crystalline limestone occurs, and discussed the rocks in some detail. He pointed out that the Kisseynew gneisses resemble the Grenville gneisses of southeastern Ontario, and that the presence of crystalline limestone in both regions enhances their similarity.

Bruce and Matheson (38) published the first detailed account of the mineral and chemical composition of some of the Kisseynew rocks. They studied specimens mainly from the rocks enclosing the Sherritt Gordon orebodies, and found that recrystallization had obliterated the original textures and structures that might have provided evidence of origin. The dark grey to black hanging-wall gneiss was found to consist mainly of amphibole, subordinate oligoclase or andesine, and subsidiary quartz, garnet, and, locally, chlorite and biotite. The foot-wall quartzite consists mainly of quartz, with subordinate to subsidiary plagioclase, biotite, garnet, magnetite, apatite, and chlorite. Other bands of gneiss were examined, and essentially the same suites of minerals were found in different proportions. Studies were made of garnets from acidic and basic gneisses and from a contact zone in a vein, and in all instances they were found to be closely related varieties of almandine. From these studies it was concluded (p. 124) that the gneisses were all derived from sediments.

In 1938, Tanton (124) mapped the Flin Flon area on the standard 1-mile scale, the north part of the area including the west end of Kisseynew Lake. He did not use the term Kisseynew, but classified the gneisses broadly into micaceous and hornblendic types. The micaceous varieties were considered to be sedimentary in origin, and some relict conglomerates were found in them, but no statement as to origin was made for the hornblendic types. A similar classification was adopted by Allen (13) when mapping the Mari Lake area to the northwest in 1939.

Derry (54), in 1942, stated that the acidic and intermediate gneisses near the Sherritt Gordon mine were clearly derived from sediments, but he regarded the basic gneisses there as probably derived from intercalated basic lavas.

In 1941, Bateman mapped the north part of the Mikanagan Lake area, which includes the central part of Kisseynew Lake. He mapped (22) the south border of the Kisseynew gneiss as an unconformable contact, with Kisseynew gneiss resting on hornblende gneisses and schists that were derived from Amisk volcanic rocks. Some hornblende gneiss exposed about 4 miles north of the contact appeared to represent an anticline, and was presumed to be a metamorphosed part of the older volcanic succession to the south, exposed as through a window in the Kisseynew gneisses. However, this minor anticline is composed of rocks altered in the same manner as other basic rocks known to be part of the Kisseynew.

Two years later, Bateman and Harrison mapped the Sherridon area on a standard 1-mile scale (20, 23), Bateman mapping the northern two-thirds and Harrison the southern one-third. In addition, Bateman (19) studied the area about the Sherritt Gordon mine in somewhat more detail.

As a result of these studies it was concluded that most, if not all, of the basic gneisses in the Sherridon map-area were igneous in origin. Those in the southern part of the area were considered to be derived from basic volcanic rocks and minor, probably related, intrusions. In the northern part of the area Bateman (19, 23) regarded the basic gneisses as divisible into several lithologic units. The basic garnetiferous gneiss that forms the hanging-wall of the Sherritt Gordon orebodies, considered by Wright (142) and by Bruce and Matheson (38) to be derived from sedimentary beds, and in which Wright had described what he regarded as crystalline limestone, was mapped by Bateman as an altered basic volcanic rock because remnants of pillow lavas were thought to be present. North of the mine, another band of hornblende-bearing gneiss was mapped as altered pyroclastic rock, perhaps partly intrusive. Northeast of the mine, near Found and Cree Lakes, some basic gneisses were mapped as part of the Cree Lake intrusive group, and were thought to represent anorthositic rocks, metagabbro, pyroxenite, and peridotite. Bateman noted, however (20, p. 3), that the rocks mapped as anorthosite had been considered by Stockwell to be altered limy sediments, but Bateman stated that "actually, the present mineral assemblage of these rocks might be derived from the metamorphism of either impure limy quartzites or anorthositic rocks; and it is possible that either one or both types are present". These 'anorthosites', according to Bateman, consist mainly of plagioclase, with more or less pyroxene, hornblende, carbonate, titanite, and scapolite. Narrow lenses of calcite and rusty weathering carbonate were believed to be the result of widespread hydrothermal alteration.

In 1947, the writer mapped the Kississing area (71), which includes Sherridon map-area, on a reconnaissance 4-mile scale, and several narrow bands of limy rocks were encountered in the course of the work. In places these limy bands were found to grade imperceptibly along strike into hornblende-rich gneisses. Later in the field season, 3 days were spent at Sherridon examining some of the rocks around the Sherritt Gordon mine, and some doubt arose as to the correctness of interpreting the Cree Lake intrusive rocks as igneous in origin. Consequently, a few days at the close of the field season were spent by the writer and J. F. Davies in making a detailed study of these rocks. Davies collected specimens and made a petrographic study of them for his Master's thesis at the University of Manitoba (44). At the same time Antrobus (15) made a similar study for his Master's thesis at McGill University, using a suite of specimens collected by Stockwell. Both concluded that most of the Cree Lake intrusive rocks are altered sedimentary rocks that contained more or less lime. In 1948, the writer re-examined other basic gneisses near Sherridon and concluded that, with two exceptions, all are derived from more or less limy sedimentary material, and are, therefore, members of the Kisseynew gneisses. One of the exceptions is a rock mapped by Bateman (19, 23) as pyroxenite, the other is the common hornblende-plagioclase gneiss of Sherridon map-area.

As a check on field and petrographic studies, analyses were made of composite chip samples of three basic gneisses, thought to be of sedimentary origin, and of the common hornblende gneiss thought to be derived from basic igneous rocks. The results are shown in Table VII.

TABLE VII

Comparative Analyses of Kisseynew and Other Rocks

—	I[1]	II[1]	III[1]	IV[1]	V	VI
SiO_2	40·65	53·36	51·20	47·29	47·36	53·40
Al_2O_3	18·86	15·92	17·66	12·85	11·32	23·96
Fe_2O_3	0·33	1·02	0·40	0·80	3·77	0·91
FeO	2·60	6·49	9·38	10·14	8·76	3·02
CaO	21·64	12·57	8·64	11·55	10·54	9·85
MgO	1·27	3·17	6·50	11·78	12·37	1·88
Na_2O	2·17	1·51	1·66	1·08	2·58	4·17
K_2O	2·10	1·40	0·48	0·32	1·76	0·80
H_2O+	0·95	1·16	2·17	1·20	1·00	0·62
H_2O-	0·19	0·18	0·11	0·10	0·08	0·07
TiO_2	0·63	0·56	0·30	0·78	1·19	0·77
MnO	0·50	0·26	0·07	0·15	0·15	....
P_2O_5	0·29	0·48	0·51	0·46	0·55	0·18
CO_2	7·89	2·19	0·58	1·20	0·35	0·42
C	0·71	0·36	0·40	0·56	0·23[2]	....
	100·68	100·63	100·06	100·26	100·01	100·06

I. Composite of chip samples, Sherridon area (19, 23, map-unit 11).
II. Composite of chip samples, Sherridon area (19, 23, map-unit 2).
III. Composite of chip samples, Sherridon area (19, 23, map-unit 4).
IV. Composite of chip samples, Sherridon area (19, 23, map-unit 5).
V. Epidiorite from Scotland; Guppy, E. M., and Thomas, H. M.: Chemical Analyses of Igneous Rocks, Metamorphic Rocks, and Minerals; Geol. Surv., Great Britain (1931), p. 109; anal. 422.
VI. Composite sample of gabbroic anorthosite, Willsboro quadrangle, New York; Buddington, A. F. (1939): Adirondack Igneous Rocks and their Metamorphism; Geol. Soc. Am., Mem. 7, p. 44, table 10, and p. 19.

The first three analyses are of progressively less limy rocks, the fourth of the basic gneiss of igneous origin. The chips for analysis I, Table VII, were taken from exposures of the rock mapped as anorthosite and gabbroic anorthosite (19, 23); those for analysis II, from gneiss mapped as hornblende-plagioclase gneiss and pyroclastic breccia (19, 23); and those for analysis III, from gneiss mapped as hornblende-plagioclase-garnet gneiss

[1]Analyst, R. J. C. Fabry, Geological Survey of Canada.
[2]Cr_2O_3 (Ni, Co)O, BaO.

(19, 23). An analysis of gabbroic anorthosite from the Adirondacks (No. VI, Table VII) shows little similarity with analysis I. Chips for analysis IV, Table VII, were taken from the common hornblende gneiss (19, 23), and analysis V is that of an epidiorite intrusive rock. The similarity between the two analyses is obvious and both are similar to analyses of basalts. From field, petrographic, and chemical studies, therefore, it is concluded that some bands of hornblende-bearing gneisses in the Sherridon area are derived from rocks that were sedimentary, with varying amounts of free lime, but that other such gneisses have been derived from basic lavas or intrusions. This conclusion is further substantiated by discovery of amygdules in basic gneiss along the outlet of Kisseynew Lake (66, 71) and by pillowed structures (*See* Plate I A, frontispiece) in Nokomis Lake area (98); by discovery of limy bands in the Nokomis Lake and Moody Lake areas (98, 99), and in other parts of the Kississing area (71). Farley[1] had concluded earlier that some of the gneisses near Sherridon were altered, limy, sedimentary rocks. The general conclusion of earlier years, that all the gneisses are of sedimentary origin (31, 38, 141, 144), may have been reached because of the stratiform foliation, or banding, commonly present in gneisses derived from basic lavas and/or intrusions (*See* Plate I B, frontispiece).

Most of the Kisseynew gneisses are believed to have been derived from sedimentary strata. In many localities, bedding is well preserved, and locally crossbedding has been noted (66, 82). The most compelling evidence, however, comes from File Lake map-area (70, 72) where relatively little altered sedimentary and igneous rocks of the Snow group grade northwards into Kisseynew gneisses, and probably are equivalent to the lower part of the Kisseynew succession as established by Robertson (98, 99). In other areas, where primary features have not been preserved, assemblages rich in cordierite, lime-silicate minerals, garnet, quartz, staurolite, and sillimanite suggest a sedimentary origin. It is concluded, therefore, that the bulk of the gneisses that have a stratiform structure are derived from sedimentary rocks, some of which were calcareous enough to be classed as impure limestone, but that some of the basic gneisses are altered basic flows, tuffs, and related intrusions. No acidic volcanic rocks have been recognized, perhaps because the characteristic extreme alteration would have produced a rock indistinguishable from a granitic gneiss. The assemblage of rocks, before alteration, can be indicated as follows: argillite, greywacke, arkose, and sandstone, with local conglomerate and limestone facies. Some basic lavas and pyroclastic rocks were interstratified with them, and all were intruded by basic dykes and sills.

AGE RELATIONS

The position of the Kisseynew gneisses in the stratigraphic succession of the Flin Flon and Reed-Wekusko regions is a problem that is still not solved, but four main hypotheses have been advanced by various geologists as follows:

1. The Kisseynew gneisses are a complex of different ages, probably including both Amisk and Missi strata, as well as some older and/or younger formations (2, 72, 102, 112, 124, 154).

[1]Farley, W. J.: personal communication, 1947.

2. The Kisseynew gneisses are younger than Amisk rocks, conformable with them, and older than Missi strata (4, 31, 141, 144).
3. The Kisseynew gneisses are younger than Amisk, lie unconformably above them, and are probably the equivalent of the Missi (22, 23, 72).
4. The Kisseynew gneisses are separated from the Amisk and Missi rocks by a major fault and, therefore, the relative ages cannot be determined by methods now practical.[1],[2]

Kisseynew Gneisses Include Rocks of Different Ages (?)

Bruce, the first geologist to map the Kisseynew gneisses as such, appears to have been undecided about their age. He stated (31, p. 29) that the Kisseynew included rocks of different ages, but concluded (31, p. 30) that the complex was "the upper part of a great formation of which the Amisk group forms the lower part".

Alcock (2) described both sedimentary and volcanic rocks of the Wekusko group that have been altered to gneisses, and that are now known to be part of the Kisseynew complex.

Satterly (102) mapped the Pelican Narrows area, Saskatchewan, which is almost completely underlain by a complex of gneisses and schists, and regarded the sedimentary members as Kisseynew. However, he considered that the volcanic members were Amisk, although he stated (p. 31) that the basic lavas are now largely altered to hornblende schists and amphibolites, rocks characteristic of Kisseynew gneisses.

As a result of surveys made in the Amisk Lake area, a few miles west of Flin Flon, in 1932 and 1933, Wright and Stockwell (151, 153, 154) apparently considered that alteration to the gneisses increased gradationally from south to north, and affected both Wekusko (Amisk) and Missi strata.

In 1938 Tanton (124) extended the mapping about Flin Flon, and part of his area is underlain by Kisseynew rocks. However, he did not name the gneisses, but stated that they are presumably derived from the older rocks in the region as well as from formations of different ages exposed in the map-area.

In the File Lake area, Harrison (70, 72) was unable to place a definite boundary between rocks of the Snow group and Kisseynew gneisses, as there is a complete gradation between them. Rocks known to be Amisk were also found altered to gneisses, and similar relations were observed by Kalliokoski[3] at Weldon Bay. As a result of investigations along and near the transition zone to Kisseynew gneisses, the writer believes that the bulk of the Kisseynew rocks represent a lithologic succession originally distinct from Amisk strata and, perhaps, even from Missi rocks. Some Amisk rocks have undoubtedly been converted to similar gneisses, and locally the Missi approaches the extreme alteration of the Kisseynew (14), but these occurrences are of limited areal extent near the Kisseynew contact. In most places, the transition from relatively unmetamorphosed volcanic and sedimentary rocks to gneisses takes place abruptly, or

[1]Kalliokoski, J. (1950): Weldon Bay, Manitoba; Geol. Surv., Canada, Paper 50–5.

[2]Harrison, J. M. (1951): Possible Major Structural Control of Ore Deposits in the Flin Flon-Snow Lake Mineral Belt, Manitoba; Trans. Can. Inst. Min. Met., vol. 54, pp. 4–8.

[3]Personal communication, 1950.

within a few hundred feet. The main exception is the area west of Flin Flon and north of Amisk Lake, where Amisk and Missi strata are altered to gneisses indistinguishable from the Kisseynew (151, 153, 154).

Kisseynew Gneisses are Older than Missi, but Conformably Above the Amisk (?)

This relationship appears to have been Bruce's final conclusion (31, p. 30) for the area north and northeast of Flin Flon. In that, he was followed by Wright for areas southwest (141, p. 78) and southeast (144, p. 14) of Sherridon.

Part of the area mapped by Bruce was subsequently remapped by Bateman (22), who regarded the contact as unconformable and the Kisseynew as the younger rocks.

Wright (141, p. 78) referred specifically to the area about Weldon Bay when he stated that the Amisk-Kisseynew contact is transitional and marked by an alteration of lava flows and quartzitic sedimentary rocks across a strike width of about ½ to 1 mile. Kalliokoski mapped the area in more detail in 1948 and 1949, and concluded[1] that the contact there was along a fault zone, that the rocks mapped as lavas and sediments by Wright are intrusive, and that their present fine grain is due to crushing along the fault zone. Wright (144, p. 14) had also postulated a conformable contact farther east, at Loonhead Lake, where Harrison (70; 72, pp. 45-46) found evidence of faulting at the contact.

Armstrong (16) showed a gradational contact between his typical pre-Laguna succession of Wekusko map-area and the gneisses to the north. However, just west of his area it is known that the gneisses are separated from the volcanic rocks by the Snow Lake fault (70), which, if extended eastward, should follow the south contact of the Kisseynew assemblage. Further evidence of this relation can be seen on air photographs in the west part of the Wekusko map-area where there is a distinct structural discordance between the two rock units.

It seems, therefore, that conformable relations between Amisk and Kisseynew rocks is an hypothesis open to serious question, although Kalliokoski[2] intimates that the Kisseynew may be pre-Missi. This suggestion is based mainly on the fact that a few pebbles of gneiss have been reported in Missi conglomerate. However, Amisk rocks include abundant gneisses, some of sedimentary origin, that are almost certainly pre-Missi in age.

Kisseynew Gneisses are Unconformably above Amisk, and Equivalent in Age to Missi Strata (?)

This hypothesis was first suggested by Bateman and followed by Harrison (22, 23, 72). As a result of studies made in the northern part of Mikanagan Lake area in 1940 (22), Bateman designated the gneisses as Kisseynew, and stated that they probably rest unconformably on volcanic rocks (Amisk), for several members of the volcanic succession were missing at the contact, and he found no evidence of a fault. Thus the Kisseynew probably equals the Missi in age. In 1943, Bateman mapped

[1]Op. cit., pp. 9–10.

[2]Geol. Surv., Canada, Paper 50-5, p. 12.

the northern two-thirds of the Sherridon area and Harrison mapped the south part (20, 23). Bateman (20, 23) noted that some of the gneisses near Sherridon appeared to be more altered varieties of gneisses outside the map-area, at Weldon Bay, and pointed out that these Weldon Bay rocks "are strikingly similar to parts of the Missi series near Flin Flon". Highly altered jasper conglomerate observed in the southwest part of the Sherridon area appeared to be the metamorphic equivalent of a rock similar to Missi conglomerate seen on Whitefish Lake (22), and, thereby, lent further indirect support to Bateman's suggestion that the Kisseynew represents altered Missi rocks. The idea was carried east to File Lake map-area, where Harrison suggested (72, p. 5) that the Snow group of rocks might be the equivalent of the Missi, although Snow and Amisk rocks are separated by a major fault, and although there are many lithologic dissimilarities between Snow and Missi strata.

Rocks of the Snow group grade northwards into gneisses that are now known to be a continuation of the Kisseynew gneisses at Sherridon, so it is important to establish their relations to Missi strata. It is not possible to obtain direct evidence, for Snow rocks are separated from Amisk and Missi by major faults, but the differences in lithology appear to be significant. Missi rocks are all clastic, contain interbedded conglomerate, and show such features as crossbedding, ripple-marks, rill-marks, and scour, all of which are characteristic of 'platform', or epeirogenic, deposits.[1] Rocks of the Snow group, on the other hand, contain interbedded volcanic strata, and the basal formation consists of grain-graded argillite and greywacke, an association considered to be characteristic of geosynclinal deposits.[2] However, the youngest rocks of the Snow group are arkose and greywacke of the platform type, and northwest of File Lake pass stratigraphically upwards to the interbedded quartzites, limy sedimentary gneisses, and basic igneous rocks of the Kississing area (23, 71, 98, 99). This association also indicates a 'platform' type of deposit, and probably represents changing conditions in the depositional basin, but the deposits are marine, whereas the Missi rocks appear to be continental. Buckham (39) pointed out that the Missi strata appear to have been deposited in intermontaine basins and, therefore, that the areal extent of individual deposits is small. Thus, on purely theoretical grounds, it might be argued that Missi rocks represent the marginal continental facies of sediments that were deposited in a sinking basin, the basin deposits now represented by Snow rocks and Kisseynew gneisses (*See* Figure 4A). Conditions in the basin probably changed so that, as time went on, arkoses, sandstones, and limy rocks, characteristic of shallow waters, were deposited in the later stages of sedimentation. Kisseynew gneisses were formed owing to deep burial of these sediments, and later mountain building, with their attendant heat, stress, and metasomatism. Missi rocks, on the other hand, accumulated in small basins away from the main locus of deformation and, in the main, were not metamorphosed to the same degree. However, under certain conditions, such as a more shelving floor in the basin of deposition, or a less rugged source area, Missi-type rocks may have been deposited near the shoreline, and when the basin deposits were mountain-built some Missi-type rocks were highly

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[1]Pettijohn, F. J. (1949): Sedimentary Rocks; Harper's Geoscience Series; espec. table 134, p. 455.
[2]Pettijohn, F. J.: op. cit., p. 455.

altered. Or, locally, extreme alteration associated with the mountain building may have extended farther into the shoreward area to produce gneisses from the Missi rocks, as, for example, in the area north of Amisk Lake (151, 153).

Kisseynew Gneisses Are Separated from Amisk and Missi Rocks by a Major Fault (?)

It has recently been suggested[1],[2] that the south contact of the Kisseynew gneisses is marked by a major fault, or fault zone. Known Missi rocks do not occur at this contact, but lie varying distances to the south in small basins in Amisk volcanic rocks, and are not known to occur north of the presumed fault.

Faulting at the contact between Amisk rocks and rocks that form part of the Kisseynew gneisses (Snow group) was first recognized in File Lake map-area (70, 72), where a broad zone of strongly sheared rocks separates the two groups. In 1947, Frarey (65) mapped a fault that separates Kisseynew-type rocks from others in the Crowduck Bay area, and, as a result of studies in 1948 and 1949, Kalliokoski[3] and Robertson[4] found that Kisseynew rocks in the Weldon Bay and Nokomis Lake areas, respectively, are separated from Amisk rocks by shear zones. Kallioski also suggested that these faults might be parts of a major fault that extends approximately east from Weldon Bay to Snow Lake, and that the presumed fault might extend westward through Mikanagan Lake area (22). In many places the Kisseynew rocks immediately north of the fault are folded into elongated domes or anticlines whose long axes are parallel with the fault, and which are overturned to the south, features that suggest thrusting from the north. A study of air photographs and geological maps revealed that a lineament, or composite of lineaments, follows closely the contact between Kisseynew gneisses and Amisk volcanic rocks[5]. The lineament persists eastward with a few interruptions from a point about 25 miles west-northwest of Flin Flon to a point at least 10 miles northeast of Wekusko Lake, a distance of about 110 miles (Figure 3). In some places the lineament is barely discernible, perhaps because the fault zone and consequent lineament have been obscured by later granitic intrusions. The faults at Weldon Bay, and Nokomis, Loonhead, File, Snow, and Osborne Lakes are all parts of this lineament, and the fact that faults have been indicated at these places suggests that the lineament marks a continuous fault.

Added evidence[6] that this Kisseynew lineament marks a fault is provided in Mikanagan Lake area (22). There, an elongated dome in the Kisseynew is overturned to the south, and its south limb is in contact with the north flank of an elongated dome of Amisk volcanic rocks. No syncline has been found between the two anticlinal structures, so it appears that the contact is along an unconformity or a fault. According to Bateman (22) it is an unconformity. However, the presumed younger rocks, the

[1]Kalliokoski, J. (1950): Weldon Bay, Manitoba; Geol. Surv., Canada, Paper 50-5.

[2]Harrison, J. M. (1951): Possible Major Structural Control of Ore Deposits in the Flin Flon-Snow Lake Mineral Belt, Manitoba; Trans. Can. Inst. Min. Met., vol. 54, pp. 4-8.

[3]Op. cit., pp. 9-10.

[4]Robertson, D. S.: Geol. Surv., Canada, personal communication, 1949.

[5]Harrison, J. M. (1951): op. cit.

[6]Most of the suggestions presented here are a composite of ideas derived from discussions with J. Kalliokoski.

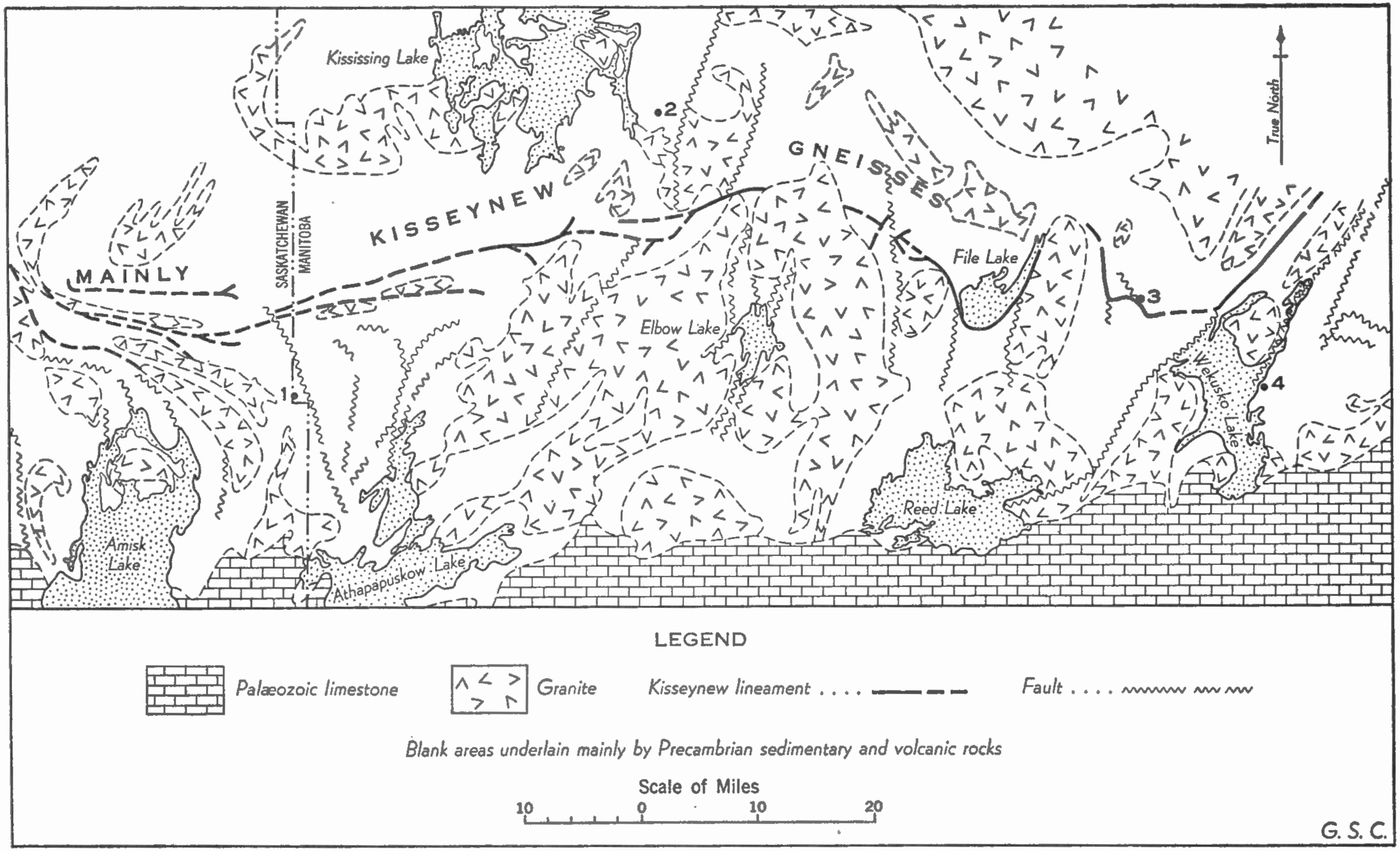

Figure 3. The Kisseynew lineament and associated faults in the Flin Flon-Snow Lake area, Manitoba: 1, Flin Flon; 2, Sherridon; 3, Snow Lake; 4, Herb Lake.

Kisseynew, are overturned to the south so that they lie face down on the north-dipping flank of the Amisk dome, a position impossible to achieve except by faulting.

A major structural discordance between Amisk and Kisseynew strata is shown in a regional way by the trends of formations. Amisk structures trend about north, except near the Kisseynew lineament where they flare east and west to produce a trumpet-shaped structure as viewed on maps. The southern edge of the Kisseynew strata lies athwart the mouth of this trumpet.

The type of mineral deposit found in this part of Manitoba also appears to change abruptly at the lineament. Some years ago, Stockwell[1] prepared a map to show mineral deposits, and drew a line to mark the boundary between pyrrhotite-rich sulphide deposits in the north and pyrite-rich sulphide bodies in the south. This line follows closely the position of the lineament as determined from field studies and air photographs.

In summary, the facts that the Kisseynew-Amisk contact is marked by a persistent lineament, that there is an abrupt change in degree of alteration at or near the contact, that there is a pronounced discordance between regional structures of Amisk and Kisseynew strata, that the types of mineral deposit are different on different sides of the lineament, that the structural relationships in at least one place can only be explained by a fault, and that heavy shearing has been found at several places along it, all suggest that the Kisseynew lineament marks a major fault, or fault zone. The fact that other geologists have not recognized this lineament as a fault may be due to granitization of the faulted rocks during, or after, deformation. Faults of several ages are known in the File Lake area (72, p. 45) and at Flin Flon (121), and later granites are especially common from Weldon Bay westward. It is possible, too, that mylonitized granitic rocks may have been mapped as Kisseynew gneisses.

If it be assumed that the Kisseynew lineament marks a fault, there is contradictory evidence regarding the direction of movement. As pointed out by Kalliokoski[2], regional structures in the Kisseynew gneisses suggest that the fault marks a thrust from the north and northeast. However, minor structures within the fault zone at Snow Lakes (72, p. 45) indicate that the north side has moved down, that is, that faulting was normal, and at Loonhead Lake (72, pp. 45-46) they indicate thrusting from the south. At both Loonhead and File Lakes the shear zone dips south at moderate to steep angles. Likewise, at Nokomis Lake, Robertson found minor structures that indicated that the north side moved down with respect to the south side. It may be that, if the lineament marks a continuous zone, movement may have occurred at more than one time, and that the fault may itself have been deformed by later folding[3].

Summary

Age relations are, at present, so far from being established for the Kisseynew gneisses that it is unwise to attempt to correlate them with

[1]Stockwell, C. H.: personal communication, 1949.

[2]Weldon Bay, Manitoba; Geol. Surv., Canada, Paper 50-5, 1950.

[3]The lineament was examined from Weldon Bay to the Saskatchewan boundary in 1950 by D. S. Robertson. In his report to the Geological Survey he states that no evidence was found for a continuous fault, although sheared rocks are present locally. North of Flin Flon the contact between Amisk and Kisseynew strata is regarded by him as completely gradational.

other rocks in the general region. If they are a complex of different ages, no correlation can ever be made, except locally. If they are comformable with Amisk strata, but older than Missi, they have no known equivalents, except possibly local patches of sedimentary rocks that have been classed with the Amisk at Amisk and Athapapuskow Lakes, and near Elbow Lake. If they rest unconformably on the Amisk, they are probably equivalent, at least in part, to the Missi rocks, but more highly metamorphosed. If they are separated from Amisk and Missi strata by a major fault, their age relative to these groups cannot be determined by methods now practicable. However, if they were thrust over Amisk rocks from the north, they are probably older than Amisk, but there is contradictory evidence regarding this relative movement. If it be assumed that the Kisseynew gneisses represent a generally more highly altered, deep-basin facies, equivalent in age to local, continental deposits of Missi rocks, the contact may be a fault along, or near, an unconformity. In this view, the Kisseynew rocks would owe their present, strongly metamorphosed state to thermal and metasomatic alteration accompanied by intense deformation, probably orogenic in origin. Such movements would buckle the predominantly sedimentary rocks into a mountain range, probably accompanied by faulting near the margins of the basin. It is interesting to note that gneisses, similar in all respects to the Kisseynew, lie north of the predominantly granitic rocks into which the Kisseynew gneisses of Sherridon grade, and that the gneisses there are, in part at least, separated from Wasekwan and Sickle rocks by a shear zone (111). Perhaps this shear, and the lineament to the south, represent the present boundaries of the former depositional basin. The two contacts are about 100 miles apart. If the gneisses mapped as pre-Assean by Dawson (46) to the east, and the gneisses mapped much farther west, in Saskatchewan, are part of the Kisseynew, the basin had a length of at least 250 miles. Figure 4, part B of which is modified from Peach and Horne[1], represents diagrammatically how such a basin might be faulted into its present position.

[1] Peach, B. N., and Horne, J. (1930): Chapters on the Geology of Scotland; Oxford Univ. Press, London, Fig. 27, p. 224.

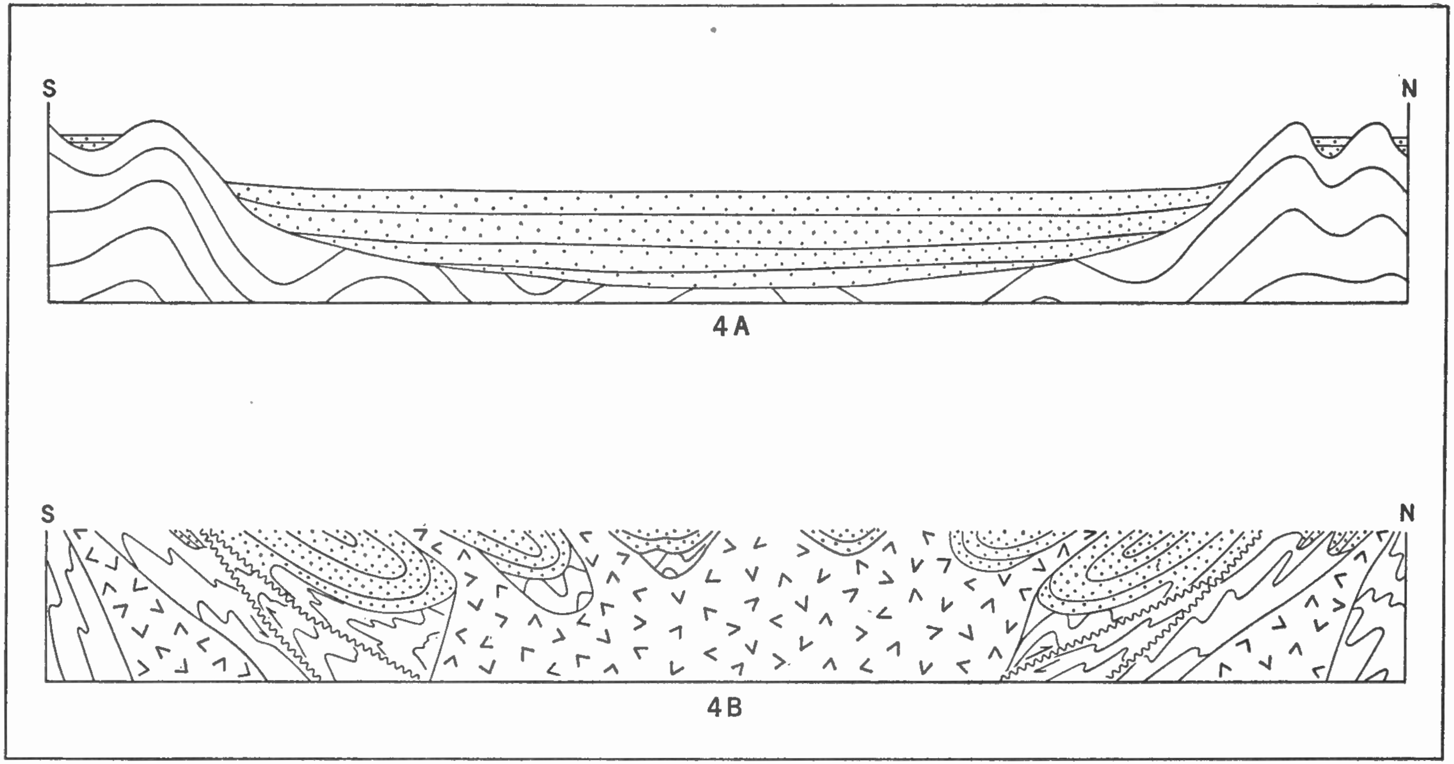

Figure 4. Illustrating hypothetical relations of the Kisseynew complex to the Amisk and Missi (and Wasekwan and Sickle) rocks: 4A, at time of deposition of sedimentary strata (stippled), assuming that continental Missi are of the same age as marine Kisseynew rocks; 4B, after folding and thrusting approximately along unconformable contact between Amisk and Kisseynew rocks; intrusions of granite are abundant in both rock facies, but are especially common in the Kisseynew; central area mainly granite. Length of sections about 150 miles; vertical scale exaggerated.

Part III

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