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MANITOBA
DEPARTMENT OF MINES AND NATURAL RESOURCES

MINES BRANCH
GEOLOGICAL PAPER 1/71

PRELIMINARY COMPILATION OF THE GEOLOGY OF THE SNOW LAKE-FLIN FLON SHERRIDON AREA

BY

A. H. BAILES

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TABLE OF CONTENTS

TABLES

FIGURES

MAPS

INTRODUCTION

LOCATION

The area covered by the geological compilation map comprises approximately 5,000 square miles of west central Manitoba, bounded by latitudes 54°30′ and 55°30′ north and longitudes 99°33′ and 101°50′ west. It is an important copper-zinc mining district.

PREVIOUS WORK

This compilation is based on 1 inch to 1 mile geological maps prepared by the Geology Division of the Manitoba Mines Branch and the Geological Survey of Canada. Most of the mapping by the Geological Survey of Canada (references with single asterisks) was carried out during the period 1941 to 1959. Investigations by the Manitoba Mines Branch (references with double asterisks) date from 1957, with most of the work having been carried out since 1964. Detailed mapping of the Herb (Wekusko) Lake and Flin Flon-Mandy areas has been done by Stockwell (1937 and 1960); of the Snow Lake area by Russell (1957); and of the Chisel Lake area by Williams (1966).

Davies *et al.*, (1962) contains an excellent review of the geology and mineral resources of the Snow Lake-Flin Flon-Sherridon area and briefly outlines the status of geophysical and geological exploration for mineral deposits up to 1962. Development of a system of stratigraphic nomenclature for rocks of this area has been summarized by Harrison (1951b).

PURPOSE OF THE GEOLOGICAL COMPILATION

The present compilation was initiated in 1969 for the eastern part of the region, during investigation of the regional setting of the Guay Lake-Wimapedi Lake area, then being mapped by the writer. The compilation was subsequently extended to encompass all the one inch to one mile maps of the Snow Lake-Flin Flon-Sherridon region. Portions of this region were previously compiled by Davies *et al.* (1962). However, this, the first compilation of the entire area, includes a more complete subdivision of the geological units.

The compilation is intended only as a preliminary interpretation. It is not meant to replace the existing maps but rather to provide a regional picture of the geological setting of the individual areas, and to bring out regional variations in the geology. However, many of the problems of correlation are not yet fully appreciated, understood or studied in the field.

This paper gives a brief description of the geological units shown on the compilation map, and presents the views of the writer concerning the geological history of this region.

METHOD OF COMPILATION

The compilation was prepared from one inch to one mile geological maps of the region and reduced to one inch to four miles for publication.* A photogeological interpretation of the area was made prior to compiling the geological maps. This interpretation provided an appreciation of the air photo expression of the different rock units, together with information on the style of deformation, and consequently assisted in correlating the geology.

A comprehensive Table of Formations (Table 1) was constructed to include the most widely recognized and accepted rock-stratigraphic units. These units were subsequently compiled from the existing geological maps. The stratigraphy of the Kisseynew sedimentary gneisses is adapted from Robertson's (1953) classification. The subdivision of the Flin Flon-Snow Lake volcanic and sedimentary rocks is based on the work of Harrison (1949b) in the Snow Lake area, modified by the more recent work of Russell (1957) and Williams (1966). The granites associated with the volcanic belt are subdivided on the basis of mapping by McGlynn (1959) in the Elbow-Heming Lakes area.

ACKNOWLEDGEMENTS

I am greatly indebted to the staff of the Hudson Bay Mining and Smelting Company Limited and the Hudson Bay Exploration and Development Co., Limited who have been very co-operative in supplying information about mining properties in the Snow Lake-Flin Flon-Sherridon region, and who have been of assistance on numerous occasions. I. Haugh critically read the manuscript and offered many helpful and constructive comments.

*Note: Prints of the geological compilation map at a scale of 1 inch to 2 miles (excluding the air photo lineaments) can be purchased from: Geology Division, Manitoba Mines Branch, 900 Norquay Building, 401 York Avenue, Winnipeg 1, Manitoba.

GENERAL GEOLOGY

GENERAL STATEMENT

The Precambrian rocks of the Snow Lake-Flin Flon-Sherridon region comprise two broad easterly trending belts of rocks of differing lithology, degree of deformation and grade of metamorphism. These belts are referred to as the Flin Flon-Snow Lake greenstone belt (in the south) and the Kisseynew metasedimentary gneiss belt (in the north). The southern belt is composed of greenschist to lower almandine-amphibolite facies volcanic and sedimentary rocks. The northern belt comprises complexly deformed middle to upper almandine-amphibolite facies sedimentary gneisses and associated granitic rocks. The two belts are in fault contact from north of Flin Flon to a point east of File Lake. Further to the east, in the vicinity of Snow Lake, the two belts are gradational into one another across a zone of steep metamorphic gradients with little or no faulting.

The Flin Flon-Snow Lake greenstone belt and the Kisseynew sedimentary gneiss belt have been considered separately, both in the text and in the geological compilation. This division into two separate sequences is in some areas arbitrary. It is, however, necessary to facilitate description of the geology.

FLIN FLON-SNOW LAKE GREENSTONE BELT

The development of a system of stratigraphic nomenclature for the volcanic and sedimentary rocks of the Flin Flon-Snow Lake greenstone belt has been adequately covered by Harrison (1951b) and by Davies *et al.* (1962) and will not be repeated here. The belt comprises four main sequences (from oldest to youngest): the Amisk Group; the Post-Amisk Intrusive Group; the Missi Group; and the Post-Missi Intrusive Group (Table 1). This subdivision closely follows that developed by Bruce (1918a) during his early reconnaissance studies of the Amisk-Athapapuskow Lake district. The terms 'Amisk' and 'Missi' were first established by Bruce for the volcanic and sedimentary groups respectively from their type localities at Amisk Lake and Missi Island in Amisk Lake, Saskatchewan.

The Amisk Group is composed of a thick sequence of volcanic strata ranging from basalt through to rhyolite, with intercalated volcaniclastic sediments. The Amisk volcanism began with widespread extrusion of thick sequences of mafic flows (A1a). These flow rocks are commonly pillowed, indicating submarine extrusion. Unit A1b consists of mafic to intermediate pyroclastic rocks, which include agglomerate, tuff and ash deposits. The mafic lavas and pyroclastic rocks of unit A1 commonly have small, mafic, fine-grained, and probably comagmatic intrusions associated with them. These small intrusions have not been distinguished from the other rocks of unit A1 on the geological compilation map.

TABLE 1 — Table of Formations

PLEISTOCENE AND RECENT — Clay, silt, sand

UNCONFORMITY

PALEOZOIC — Argillaceous limestone, calcareous sandstone

UNCONFORMITY

PRECAMBRIAN

KISSEYNEW SEDIMENTARY GNEISS BELT

POST-SHERRIDON INTRUSIVE GROUP

K6 Pyroxenite, gabbro

K5 Pink granodiorite gneiss, derived in part from unit K3

K4 White quartz monzonite and granodiorite, derived in part from unit K1

INTRUSIVE CONTACT

SHERRIDON GROUP

K3 Siliceous paragneisses derived from a monotonous sequence of arkosic to quartzitic sedimentary rocks, possibly equivalent to unit A6. Includes undifferentiated material transitional into unit K5

? DISCONFORMITY ?

NOKOMIS GROUP

K2 Hornblende-plagioclase gneiss

K1 Intermediate garnetiferous paragneisses derived from a repetitious sequence of greywacke and argillite, possibly equivalent to unit A3. Includes migmatitic and granitoid phases

BASEMENT GROUP

K0 Variable sequence of granitized gneisses

FLIN FLON-SNOW LAKE GREENSTONE BELT

POST-MISSI INTRUSIVE GROUP

A8 Intrusive rocks of variable composition related to unit A7

A7 Granodiorite and quartz diorite, generally gneissic. Large portions represent metasomatically granitized material

INTRUSIVE CONTACT

MISSI GROUP

A6 Arkose, greywacke, quartzite. Basal conglomerate common

UNCONFORMITY

POST-AMISK INTRUSIVE GROUP

A5 Gabbro and diorite often with ultrabasic phases. Commonly differentiated. Includes rocks of several ages and diverse origins

A4 "Quartz-eye" granite

INTRUSIVE CONTACT

AMISK GROUP

A3 Argillite, greywacke, tuff. Turbidites common in eastern region

A2 Rhyolite, dacite, quartz porphyry. Includes acidic crystal tuff and siliceous, carbonate-rich tuff

A1 Mafic to intermediate volcanic rocks: (a) pillowed varieties, and (b) fragmental varieties. Includes many small related intrusions.

As the Amisk volcanism progressed it became: (1) gradually more acidic, (2) increasingly localized to smaller centres of extrusion, and (3) more fragmental. The resulting acidic volcanic rocks of unit A2 are highly variable. They include dacitic and rhyolitic flow rocks, and their pyroclastic equivalents; acidic tuff deposits of various types; and some of the tuffaceous, cherty and carbonate-rich sedimentary rocks. Certain intrusive quartz porphyries, which possibly represent feeders for the acidic extrusive material, have been included in unit A2.

Argillitic and tuffaceous sediments of unit A3 were probably derived by erosion of pyroclastic deposits. They occur at various levels throughout the volcanic sequence, but are more commonly associated with the later acidic volcanic phases. The sedimentary rocks of unit A3 can be subdivided into two general categories: (i) volcaniclastic sediments consisting of thin beds of tuffaceous siltstones and greywackes; and (ii) turbidite greywacke and siltstone sequences which form thicker and more widespread deposits than (i). The two categories of unit A3 have not been distinguished on the geological map.

The Post-Amisk Intrusive Group includes "quartz-eye" granite (A4) and mafic intrusive rocks (A5). These rock types generally show a close spatial relationship to one another, and are possibly comagmatic. The intrusions of unit A4 range in size from small irregular masses, like those east of Wekusko Lake, to stocks over twenty-five square miles in area, such as the intrusion south of Elbow Lake. The large sill-like body of "quartz-eye" granite, mapped by Harrison (1949) south of Snow Lake, has been included with the acidic volcanic rocks of unit A2 on the compilation map, on the basis of a detailed study of this body by Williams (1966). Harrison's "quartz-eye" granite was mapped as a sedimentary rock by Russell (1957) and subsequently classed as an acidic pyroclastic tuff by Williams (1966). More recent mapping by N. Russell (1970, personal communication) indicates that this body is, at least in part, intrusive. The mafic intrusive rocks (A5) are of diverse origin and of different ages, all post-Amisk. Many of these intrusions contain ultramafic phases, some of them are noticeably differentiated e.g. the Chisel Lake intrusion.

The Amisk Group and Post-Amisk Intrusive Group are unconformably overlain by a relatively clean, detrital sequence of arkose, greywacke, and quartzite, forming the Missi Group. Pebble or boulder conglomerate beds, with recognizable clasts of the Amisk and Post-Amisk Intrusive rocks, are located at or near the base of this unit. Cross-bedding is characteristic of the Missi rocks. The contact of the Missi Group with the lower units is usually disconformable (although locally shows some angular discordance).

The Post-Missi Intrusive Group comprise large granitic bodies, often of batholithic dimension, which fall into two general categories: (1) unit A7; gneissic intrusive rocks of granodiorite composition which are generally conformable with the surrounding units; and (2) unit A8; intrusive, generally non-foliated rocks of variable composition comprising acid to basic varieties which intrude unit A7.

KISSEYNEW METASEDIMENTARY GNEISS BELT

The metasedimentary gneisses of the northern belt were named the Kisseynew gneisses by Bruce (1918a) after their type exposures at Kisseynew Lake. These rocks have been derived mainly by regional metamorphism and granitization of sedimentary rocks. Widespread and intense granitization has converted large proportions of the paragneisses to migmatitic and granitoid rocks.

Bateman and Harrison (1946) subdivided the paragneisses of the Sherridon area into the Pre-Sherridon Group, the Sherridon Group and the Post-Sherridon Group. Robertson (1953), who mapped to the east of the Sherridon area, subsequently identified a complicated refolding pattern in the area, which revealed that the Post-Sherridon group was in fact equivalent to the Pre-Sherridon Group. Robertson retained the term Sherridon Group but introduced the Nokomis Group to replace the Pre-Sherridon and Post-Sherridon Groups of Bateman and Harrison. He placed the Sherridon Group, which occupies synformal structures, above the Nokomis Group in the stratigraphic column.

Recent mapping by Kornik (1968) and Bailes (1969b) has confirmed Harrison's (1951b) view that the Snow Group sedimentary rocks of the File Lake area are the stratigraphic, though less metamorphosed, equivalents of the Kisseynew gneisses. In the File Lake-Snow Lake area, primary bedding features show that the Sherridon Group paragneisses do, in fact, overlie the paragneisses of the Nokomis Group.

In the present compilation, the Kisseynew sedimentary gneiss belt has been subdivided into: the Basement Group; the Nokomis Group; the Sherridon Group; and the Post-Sherridon Intrusive Group (Table 1).

The Basement Group (KO) has been recognized only in the eastern part of the belt (Bailes, 1969a), where it comprises a sequence of layered granitoid gneisses, previously mapped as granites. Basement Group gneisses are not similar to any of the Nokomis Group, but portions of the Basement Group are similar to highly granitized Sherridon rocks. Basement Group gneisses, however, are readily divisible into three units while no systematic subdivision of Sherridon rocks (unit K3) has been recognized. It is therefore suggested that the Basement Group gneisses are not merely selectively granitized portions of the Sherridon and/or Nokomis Groups, but are actually a highly granitized sequence of older "basement gneisses". These gneisses (unit KO) occupy the cores or large structural domes, which may have been caused by large scale interference folding and/or diapiric intrusion of remobilized masses of the "basement gneisses".

The Nokomis Group consists of two units, K1 and K2. Unit K1 comprises a thick monotonous sequence of fine-grained plagioclase*-quartz-biotite-garnet-(staurolite)-(sillimanite)-(cordierite)-(graphite) gneisses derived from a repetitive sequence of argillaceous sediments and greywacke. The alumina-rich gneisses of unit K1 vary mineralogically and texturally with increase in grade of metamorphism from south to north. For example, around Wekusko, Snow, File and Duval Lakes, portions of unit K1 are rich in staurolite. The staurolite dies out to the north, however, because (1) the upper stability limit of staurolite is exceeded due to the increasing metamorphic grade; and (2) the argillaceous layers, in which the staurolite preferentially occurs, are less abundant. The most typical variety of unit K1 consists of thinly bedded meta-greywacke characterized by mauve pyralspite garnet porphyroblasts, and a penetrative biotite foliation parallel to the original layering. Partial melting and migmatization of unit K1 has occurred in response to an increase in metamorphic grade. In northern portions of the Kisseynew sedimentary gneiss belt this process has reached a level where it is virtually impossible to distinguish between the granitic rocks of unit K4 and granitized portions of unit K1.

Unit K2 is not exclusive to the Nokomis Group. It is a lithologic rather than a strictly rock-stratigraphic unit (like units K1 and K3) and includes all basic hornblende-plagioclase (amphibolite) gneisses in the Kisseynew belt regardless of their stratigraphic position. The hornblende-plagioclase gneisses occur as conformable thin layers (commonly

*Note: The minerals are listed in order of decreasing abundance. Minerals in brackets are not present in all assemblages.

less than 50 feet thick) which are laterally continuous over considerable distances. They characteristically occur at, or near, the Nokomis-Sherridon contact. Although some of the hornblende-plagioclase gneisses probably represent metamorphosed basic volcanic horizons, most of them appear to have been derived from sedimentary rocks by a process described by Orville (1969), in which calcareous horizons react with the adjacent pelitic sediments during metamorphism. The metamorphism of calcareous horizons to hornblende-plagioclase gneisses in the Batty Lake area has been described by Robertson (1953). Mineral assemblages in unit K2 are dominated by hornblende and plagioclase, but also include varying amounts of diopside, orthopyroxene, quartz, calcite, scapolite, sphene, clinozoisite and apatite.

The Nokomis Group is overlain conformably by the Sherridon Group, although in places the two groups are possibly separated by a disconformity. The Sherridon Group, unit K3, comprises a monotonous sequence of fine to medium-grained quartz*-plagioclase-potassium feldspar-biotite-(hornblende)-(sillimanite)-(magnetite)-(garnet) gneisses, derived from a sequence of arkose and quartzite. Primary features in this unit, other than bedding, have been destroyed by recrystallization and the development of a strong penetrative foliation parallel to the layering. Quartz-sillimanite-(muscovite) nodules commonly occur in the Sherridon gneisses, particularly in the more quartzose phases of this unit. The effects of partial melting are less evident in the Sherridon gneisses, in which migmatitic phases are not as well developed as in the Nokomis gneisses (unit K1). Large portions of the Sherridon gneiss have been subjected to potassium metasomatism and recrystallization, to produce homogeneous granitoid phases which are transitional into the granitic material of unit K5.

Robertson (1953) concluded that a distinct change in the character of sedimentation occurred between deposition of the Nokomis and Sherridon Groups. This conclusion was based on the difference in rock types between the two sequences and on the occurrence of limestones and orthoquartizites at their contact. Recent studies by the writer of primary sedimentary features in the File Lake area, have indicated a marked contrast in sedimentary environment and mode of deposition of the Nokomis and Sherridon sequences. The presence of turbidites in the Nokomis Group may be taken to imply a relatively deep water environment with an adjacent elevated land mass. The Sherridon Group of finely laminated quartzitic and arkosic sedimentary rocks is more characteristic of sedimentation in a shallow water and/or fluvial deltaic environment. Limestones and orthoquartzites at the Nokomis-Sherridon contact are most prominent in the Batty Lake and Sherridon areas (Robertson, 1953 and Davies, 1948). They suggest that a stable, shallow water environment, with a limited supply of detrital material, prevailed for a significant time interval prior to deposition of the Sherridon sequence. Robertson (1953) further suggested that the discontinuous character of these calcareous and orthoquartzitic rocks might be the result of partial erosion of an originally more extensive unit.

A post-Sherridon metamorphic and tectonic event generated the Post-Sherridon Intrusive Group (units K4-K6) by metamorphic differentiation and mobilization of portions of the Nokomis and Sherridon sequences. Unit K4 is a white gneissic quartz monzonite and granodiorite that is gradational into migmatic and granitoid varieties of unit K1. Unit K5, a homogeneous sequence of pink granodiorite gneisses is similarly transitional into granitoid phases of unit K3. Some of the pyroxenite and gabbro bodies of unit K6 are spatially associated with amphibolite horizons of unit K2 and were possibly derived from the latter by the process of metamorphic differentiation and metasomatism described by Sorensen (1953).

*Note: The minerals are listed in order of decreasing abundance. Minerals in brackets are not present in all assemblages.

STRATIGRAPHIC CORRELATION BETWEEN THE KISSEYNEW METASEDIMENTARY GNEISS BELT AND THE FLIN FLON-SNOW LAKE GREENSTONE BELT

Previous stratigraphic correlations between the Flin Flon-Snow Lake greenstone belt and the Kisseynew gneiss belt have been unsatisfactory for several reasons: (i) the two belts are generally in fault contact so that there is little direct evidence on which to compare the two sequences; (ii) the boundary between the two belts parallels latitude $55^{o}00'$ which is the line of division between individual map-areas at both the 1 inch to 1 mile and 1 inch to 4 mile scales. Thus geologists mapping in this region have been preoccupied with either one or other of the two sequences; and (iii) most hypotheses were prepared prior to completion of the 1 inch to 1 mile mapping of this region. Harrison (1951b) outlined the four main hypotheses, advanced by various geologists, concerning the relation of the Kisseynew gneisses to the stratigraphic succession in the Flin Flon-Snow Lake greenstone belt. These hypotheses are as follows:

(i) The Kisseynew gneisses comprise rocks of different ages, probably including both Amisk and Missi strata, as well as some older and/or younger formations;

(ii) The Kisseynew gneisses are younger than the Amisk rocks, and conformable with them, but older than the Missi Group.

(iii) The Kisseynew gneisses are younger than the Amisk Group, lie unconformably above them, and are probably equivalent to the Missi Group;

(iv) The Kisseynew gneisses are separated from Amisk and Missi rocks by a major fault, and therefore, the relative ages cannot be determined.

Each of these statements is valid for the individual area for which it was postulated, but none holds true for the entire Snow Lake-Flin Flon-Sherridon region. For example a fault structure, as in hypothesis (iv), or series of fault structures, is present along only part of the contact between the Flin Flon-Snow Lake greenstone belt and the Kisseynew gneiss belt. West of Flin Flon and east of Snow Lake, the fault structure horsetails and dies out, such that the Amisk and Missi strata then become gradational into gneisses of the Kisseynew sequence. Thus the fault hypothesis is untenable for the Snow Lake area.

Harrison (1951b) favoured equating the Kisseynew sedimentary gneisses with the Missi Group, as in hypothesis (iii). He believed Kisseynew sedimentary rocks to be the marine geosynclinal equivalents of the Missi Group, which he suggested were continental deposits (Figure 1). However recent work by the writer in the Guay Lake-Wimapedi Lake area and the File-Morton Lakes area, suggests that the lower sequence of the Kisseynew sediments (unit K1) is equivalent, at least in part, to the Amisk sediments (unit A3). In these areas, units K1 and A3 comprise greywacke-argillite turbidite sequences which are lithologically similar. Northeast of Wekusko Lake units K1 and A3 appear to be stratigraphically equivalent, although further mapping in this area is needed before this can be stated with any certainty.

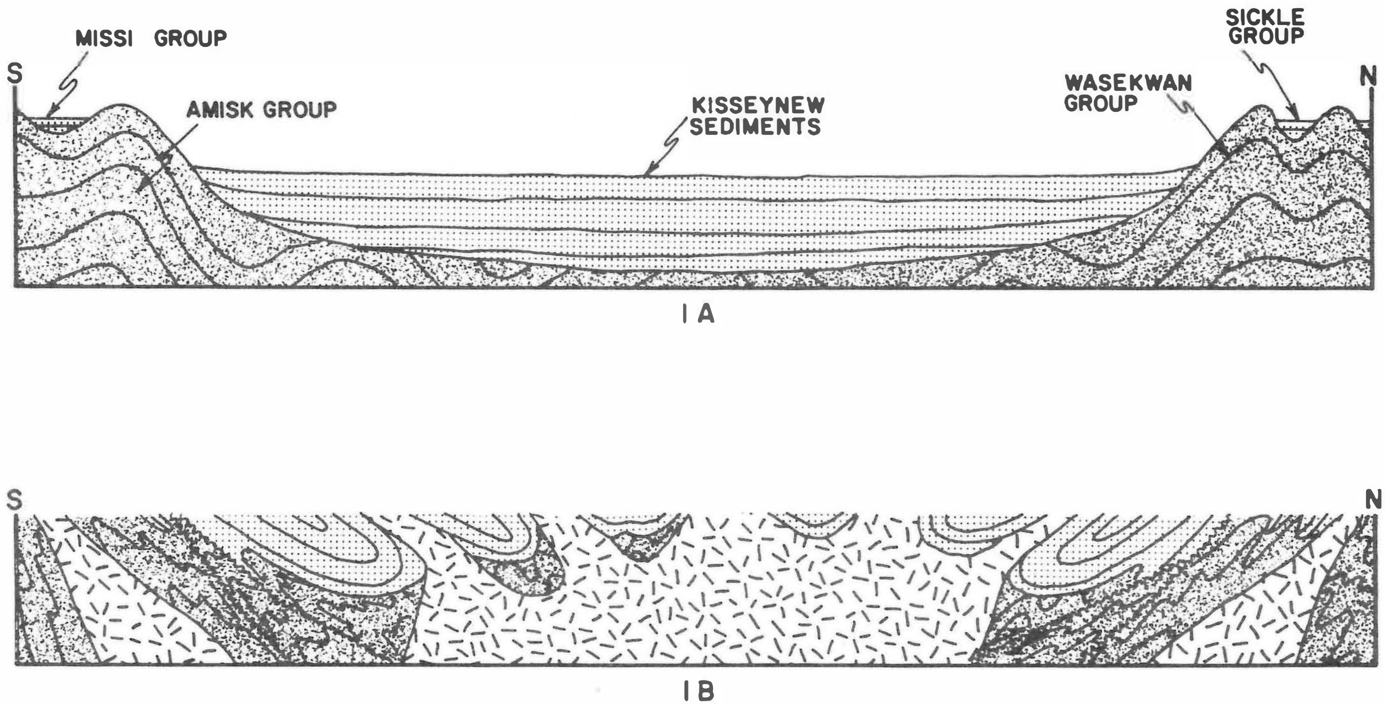


FIGURE 1

Hypothetical relations of the Kisseynew complex to the Amisk and Missi rocks, modified from Harrison (1951): 1A Relationship of the Kisseynew sediments to the Missi-Sickle Groups and the Amisk-Wasekwan Groups prior to deformation and metamorphism; 1B Relationship of the Kisseynew metasedimentary gneisses to the Missi-Sickle Groups and the Amisk-Wasekwan Groups after deformation, metamorphism and intrusion by granitic rocks. Length of sections about 150 miles; vertical scale exaggerated.

The writer favours hypothesis (i), which suggests that the Kisseynew gneisses are a complex of different ages including strata equivalent to both the Amisk and Missi Groups. It is the opinion of the writer that the Nokomis is the stratigraphic equivalent of the Amisk Group sediments, while the Sherridon gneisses are equivalent to the Missi Group. Figure 2 illustrates the hypothetical relationship of the Kisseynew sedimentary gneiss belt to the Flin Flon-Snow Lake greenstone belt at various stages during their development. Assumptions used in the preparation of Figure 2 are as follows:

(1) The Precambrian crust is assumed to have been thin and tectonically mobile.

(2) The early Amisk volcanism was submarine.

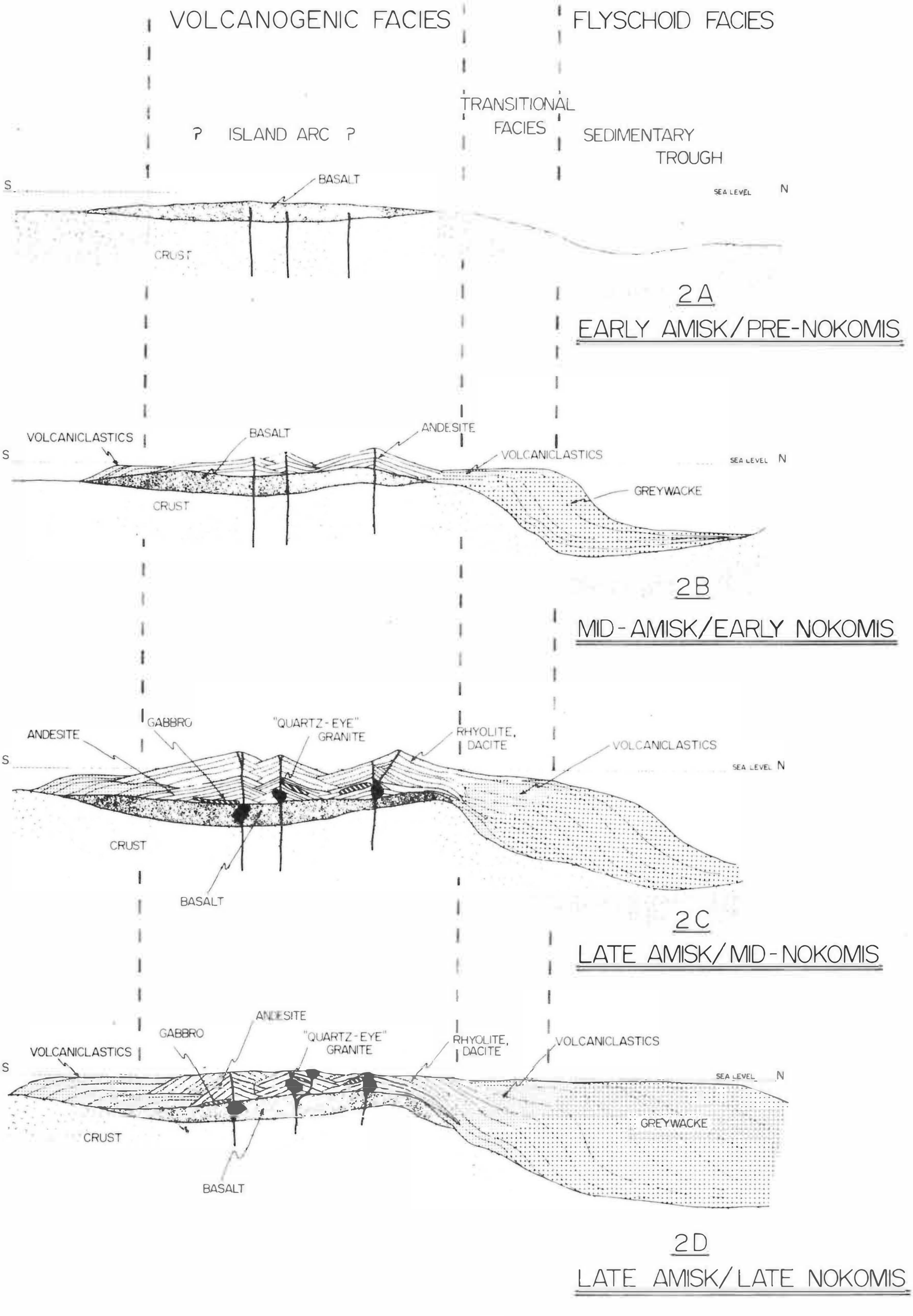
(3) The Nokomis sequence accumulated in a relatively deep water environment, likely a trough, by submarine dumping of clastic material, mostly derived from the adjacent Amisk volcanic deposits.

(4) At the end of Nokomis time the sedimentary basin was largely filled and the adjacent source area, interpreted as the Amisk volcanic belt, was an area of low relief.

(5) The Nokomis period was terminated by orogenic, or perhaps epeirogenic, disturbances which elevated the Flin Flon-Snow Lake greenstone belt. Clastic material derived from the uplifted portions of the Amisk volcanic belt were deposited in continental and/or shallow water environments forming the Missi and Sherridon sequences.

(6) The thick Kisseynew sedimentary deposits were deformed and intensely metamorphosed by a post-Sherridon orogeny, which thrust the Kisseynew gneisses towards the Flin Flon-Snow Lake greenstone belt.

The interpretation of the history of the Snow Lake-Flin Flon-Sherridon region as presented in Figure 2 is highly speculative. However, its presentation here may stimulate and suggest areas of investigation for future geological studies in this region.


VOLCANOGENIC FACIES
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TRANSITIONAL FACIES
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VOLCANICLASTICS
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GABBRO
"QUARTZ-EYE" GRANITE
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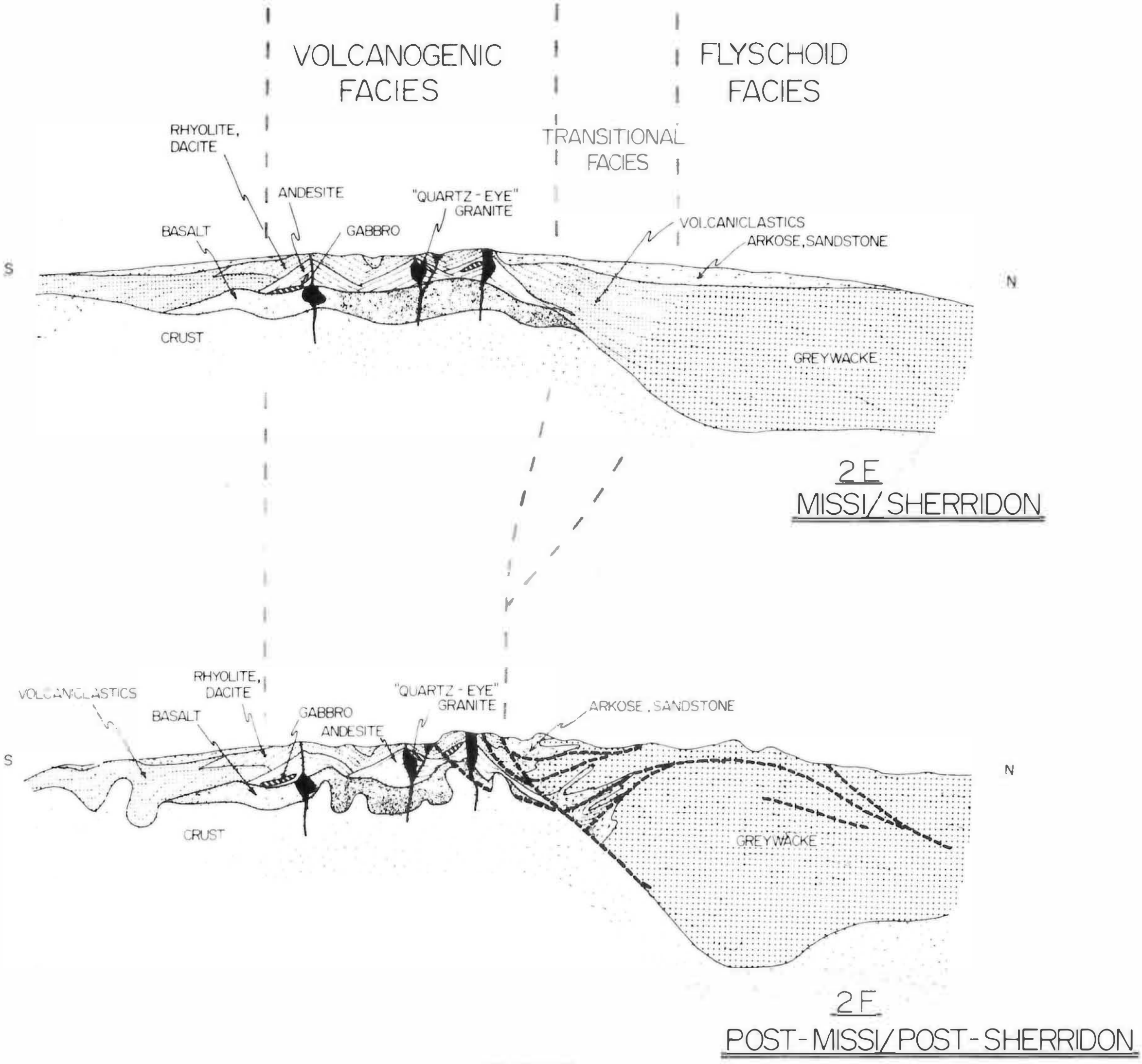

FIGURE 2

Hypothetical relationship of the Flin Flon-Snow Lake greenstone belt to the Kisseynew sedimentary gneiss belt at various stages during their development. Sections are about 60 miles long, with considerable vertical exaggeration.

	FLIN FLON-SNOW LAKE GREENSTONE BELT	KISSEYNEW SEDIMENTARY GNEISS BELT
A. EARLY AMISK/ PRE-NOKOMIS	Mafic submarine volcanism	Trough structure initiated
B. MID AMISK/ EARLY NOKOMIS	Mafic to intermediate volcanism. Fragmental varieties common	Periodic submarine slumps and turbidity currents from narrow shelf area, adjacent to volcanic belt, deposited flyshoid sediments in trough.
C. LATE AMISK/ MID-NOKOMIS	Intermediate to acidic volcanism with large proportions being fragmental. Gabbroic and granitic intrusions of Post-Amisk Intrusive Group emplaced.	Large volumes of turbidite sediments deposited in subsiding trough.
D. LATE AMISK/ LATE NOKOMIS	Volcanic activity minimal. Volcanic pile reduced to an area of low relief.	Trough largely infilled, forming a shallow coastal plain adjacent to the volcanic belt.
E. MISSI/SHERRIDON	Crustal, perhaps orogenic, movements elevated portions of the volcanic belt. Clastic sediments deposited in local intermontane basins.	Fluvial deltaic deposits, derived from elevated portions of volcanic belt, cover the earlier turbidite deposits.
F. POST-MISSI/ POST SHERRIDON	Large batholithic granitic bodies emplaced causing considerable deformation.	Intense metamorphism and deformation.

METAMORPHISM AND DEFORMATION

The major metamorphic and tectonic event(s) post-dated deposition of the Missi and Sherridon Groups. The intensity of deformation and grade of metamorphism is highest in the Kisseynew sedimentary gneiss belt and decreases southwards into the Flin Flon-Snow Lake greenstone belt. Within the Kisseynew gneisses, upper almandine-amphibolite facies metamorphism was prevalent and was accompanied by anatexis and granitization. In places lower granulite facies assemblages were developed. The structures of the Kisseynew belt are dominated by tight, nearly isoclinal, easterly trending folds which are overturned to the south. This suggests that the sedimentary rocks were pushed out from an orogenic centre, towards the Flin Flon-Snow Lake greenstone belt (Figure 2F). The late syntectonic anatectic granites of the Post-Sherridon Intrusive Group and granitized masses of the Basement Group, appear to have intruded and domed the earlier tight overturned folds, causing extremely complicated refolding patterns.

The Flin Flon-Snow Lake greenstone belt is less deformed and metamorphosed than the Kisseynew gneisses. In the greenstone belt greenschist facies metamorphism prevailed, although lower almandine-amphibolite facies was reached in portions of the Snow Lake district. Much of the deformation in this belt was caused by emplacement of the Post-Missi Intrusive Group. These intrusions appear to be syntectonic, equivalent in age to the Post-Sherridon Group.

K-Ar dates of rocks from the Snow Lake-Flin Flon-Sherridon region range from 1610 to 1960 million years (Table 2). On the basis of these K-Ar dates and the presence of northeasterly structural trends, the main deformation and metamorphism of this region has been considered to be Hudsonian. However, two factors suggest that the culmination of metamorphism and deformation in this region may have taken place at an earlier date, possibly during the Kenoran orogeny:

1) Foliation and/or layering trends in the Kisseynew gneisses (see air photo interpretation on geological compilation map), major tectonic units (such as the Flin Flon-Snow Lake greenstone belt and the Kisseynew gneiss belt), and aeromagnetic trends (Kornik and MacLaren, 1966) in the Snow Lake-Flin Flon-Sherridon region have a dominantly easterly trend. Superior trends are characteristically to the east while normal Churchill trends are generally considered to be northeasterly.

2) Rb-Sr whole rock dating by Coleman (1970) of rocks from the Hanson Lake area, forty miles west of Flin Flon gave a date of 2,521 million years for Amisk-type metavolcanic rocks, and a date of 2,446 million years for granitic rocks which intruded the metavolcanic rocks. Pegmatites from the area gave an age of 1,799 million years.

Further studies on the structural and metamorphic geology of this region, and additional Rb/Sr whole rock analyses and dates are clearly needed to determine the time, extent, and intensity of orogenic events that affected the rocks of the Snow Lake-Flin Flon-Sherridon region. If a well defined Kenoran event can be proved for this region, it will be necessary to re-examine the significance of the present Churchill-Superior boundary. It may prove impossible to define a sharp boundary between the regions affected by the Kenoran and Hudsonian orogenic events.

TABLE 2

Isotopic Age Determinations
Snow Lake-Flin Flon-Sherridon Region

Unit No. / Reference	Location	Description	Material Dated	Method Used	Age (m.y.)
A2 (Moore *et al.*, 1960)	Stail Lake lat: 54°51'N long: 99°56'W	Quartz-biotite gneiss, thought to be sedimentary in origin by Russell (1957) and an altered volcanic rock by Harrison (1949)	biotite	K-Ar	1760
A4 (Wanless *et al.*, 1964)	Cliff Lake lat: 54°48'N long: 101°50'W	Medium-grained altered granitic rock with eyes of quartz. Rock shows considerable evidence of crushing.	muscovite	K-Ar	1620
A6 (Lowden *et al.*, 1962)	Hat Lake lat: 54°46'N long: 99°32'W	Medium-grained metamorphosed impure quartzite.	biotite	K-Ar	1770
A6 (Lowden *et al.*, 1962)	Hat Lake lat: 54°46'N long: 99°32'W	Same as above.	muscovite	K-Ar	1620
A7 (Lowden *et al.*, 1961)	Reed Lake lat: 54°39'N long: 100°16'W	Medium-grained grey muscovite granite from dyke cutting Amisk Group	biotite	K-Ar	1745
A7 (Lowden *et al.*, 1962)	Reed Lake lat: 54°39'N long: 100°16'W	Same as above.	muscovite	K-Ar	1775
A8 (Wanless *et al.*, 1964)	Wekusko Lake lat: 54°43'N long: 99°59'W	Massive, non-foliated tan biotite quartz monzonite.	biotite	K-Ar	1960±60
A8 (Wanless *et al.*, 1964)	Phantom Lake lat: 54°42'N long: 101°52'W	Medium-grained, massive, pink porphyritic granodiorite	biotite	K-Ar	1865±65
K1 (Lowden *et al.*, 1961)	Kisseynew Lake lat: 54°57'N long: 101°41'W	Medium-grained grey paragneiss	biotite	K-Ar	1735
K4 ? (Wanless *et al.*, 1964)	Crowduck Bay lat: 54°52'N long: 99°43'W	Quartz-microcline-mica pegmatite	muscovite	K-Ar	1790±60
K4 ? (Wanless *et al.*, 1964	Crowduck Bay lat: 54°52'N long: 99°42'W	Quartz-microroline-mica pegmatite	biotite	K-Ar	1610±50
A1 - A2 (Coleman and Gaskarth, 1970)	Hanson Lake area, Saskatchewan	Metavolcanic rocks of the Amisk Group	whole rock	Rb-Sr isochron	2521±60
? (Coleman and Gaskarth, 1970)	Hanson Lake area, Saskatchewan	Granitic rocks intruding the Amisk Group	whole rock	Rb-Sr isochron	2446±16
? (Coleman and Gaskarth, 1970)	Hanson Lake area, Saskatchewan	Late pegmatites	whole rock	Rb-Sr isochron	1799±2

COPPER-ZINC SULPHIDE MINERALIZATION

Copper-zinc sulphide deposits are found within the Flin Flon-Snow Lake greenstone belt and the Kisseynew sedimentary gneiss belt. The more important Cu-Zn sulphide deposits of the Snow Lake-Flin Flon-Sherridon region, are shown on the geological compilation map. The deposits can be grouped into three broad categories: (i) those occurring in the Amisk Group of the Flin Flon-Snow Lake greenstone belt; (ii) those occurring in hornblende-plagioclase gneiss horizons at, or near the contact of the Sherridon and Nokomis Groups of the Kisseynew gneisses, and (iii) those occurring in rocks transitional between the greenstone and sedimentary gneiss belts.

Category (i) – Flin Flon-Snow Lake greenstone belt

These deposits are finer grained, richer in zinc, and more irregular in shape than deposits of the other two categories. They are also larger in size, but have a lower grade. The host rocks are acidic intrusive, extrusive, pyroclastic and tuffaceous volcanic rocks of unit A2 of the Amisk Group. The association of the Cu-Zn sulphide deposits with centres of acidic volcanism, is evident from their distribution on the geological compilation map. The ore shoots are almost invariably concordant with the host rocks, and commonly have chloritic and sericitic footwall alteration zones.

The deposits are of volcanic exhalative, volcanic replacement and syngenetic sedimentary origins.

Category (ii) – Kisseynew sedimentary gneiss belt

These deposits are coarse-grained, copper-rich and high grade. They are generally smaller and more stratiform than the deposits of the other two categories. The host rocks are the hornblende-plagioclase gneiss horizons of unit K2.

The sulphide mineralization is interpreted as syngenetic sedimentary. It is preferentially localized in hornblende-plagioclase gneiss horizons at the contact between the Nokomis and Sherridon sequences. The sedimentary environment which appears to have existed during the terminal stages of deposition of the Nokomis sequence, was one characterized by low relief of the volcanic belt, or source area, and infilling of the sedimentary basin until it consisted of numerous, disconnected, shallow water basins. It is suggested that carbonate-rich sediments and the syngenetic sulphide deposits were deposited in these basins before the deposition of arkosic sediments of the Sherridon Group.

Category (iii) — Transitional

These deposits, which are typical of the estern portions of the region, share many characteristics of the two previous categories. They are coarse-grained, copper-rich, high-grade, and linear tabular, and resemble the deposits of the Kisseynew gneisses. The host rocks, however, are metavolcanic and metasedimentary rocks of the Amisk Group. The mineralization, as with the first category of deposits, is associated with the acidic phases of volcanism, particularly acidic tuffs and acidic volcaniclastic sediments. The deposits may be volcanic exhalative, volcanic replacement, and/or syngenetic sedimentary in origin.

The sulphide deposits have been coarsely recrystallized and their host rocks converted to gneisses by high grade metamorphism. Many of these host rocks contain spectacular metamorphic assemblages rich in aluminosilicate minerals. The Anderson Lake deposit, for example, has a footwall zone with large quantities of kyanite in chlorite and sericite schists. Staurolite, garnet and cordierite are present in the host rocks and interspersed with the sulphide minerals of the Anderson Lake deposit.

The sulphide orebodies of the Snow Lake-Flin Flon-Sherridon region, particularly those of categories (ii) and (iii), have been complexly deformed and metamorphosed since their formation, and ore shoots are structurally controlled. A knowledge of the structural geology of the Snow Lake-Flin Flon-Sherridon region, and specifically of the area around an individual sulphide deposit, is necessary for efficient mining of the deposit. For example, recognition of the structural control of the Chisel Lake orebody, and application of structural analysis to tracing ore shoots, has proved to be fundamental to mining this deposit (Martin, 1966).

The presence of copper-zinc sulphide deposits within paragneisses and granitic rocks of the Kisseynew belt, disproves the former view that Precambrian metamorphic sedimentary terrains are unfavourable for finding sulphide ore deposits. Nevertheless, the Flin Flon-Snow Lake greenstone belt is relatively more favourable for finding copper-zinc sulphide deposits than the Kisseynew gneiss belt. The metasedimentary belt is more difficult to explore with standard airborne and ground geophysical equipment, because it contains a higher proportion of barren graphitic conductors relative to mineralized conductors (Koffman *et al.*, 1962). Thus, for an equivalent exploration expenditure, the greenstone belt will yield more numerous (and generally larger) sulphide deposits than the metasedimentary gneiss belt. However, if the geology and genetic associations of sulphide orebodies can be established in well mapped sedimentary gneiss terrains, the more favourable geophysical anomalies can often be identified, and the statistical chance of finding a mineralized conductor increased substantially. The presence of sulphide orebodies in the Kisseynew sedimentary gneisses indicates that high grade metamorphism did not disperse the sulphide mineralization. On the contrary they appear to have been concentrated by metamorphism.

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