SEDIMENTOLOGY AND METAMORPHISM OF A PROTEROZOIC VOLCANICLASTIC TURBIDITE SUITE THAT CROSSES THE BOUNDARY BETWEEN THE FLIN FLON AND KISSEYNEW BELTS, FILE LAKE, MANITOBA, CANADA

A Dissertation

Presented to

The Faculty of Graduate Studies

The University of Manitoba

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

by

ALAN HARVEY BAILES

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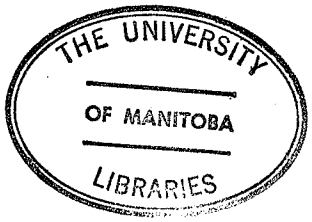

ABSTRACT

The Kisseynew sedimentary gneiss belt is near the southeast corner of the Churchill Province in Manitoba. It is a large, east-trending Proterozoic sedimentary basin composed largely of greywacke-, siltstone-, and mudstone-derived paragneisses and migmatites. It is bounded on the south by the Flin Flon volcanic-sedimentary belt. In the File Lake area, well preserved, weakly recrystallized pebbly greywacke, greywacke, siltstone and mudstone of the Aphebian Amisk Group of the Flin Flon volcanic-sedimentary belt have been traced northwards across a steep metamorphic gradient directly into migmatitic Kisseynew belt paragneisses.

The Amisk Group sedimentary rocks are mainly turbidites, with minor debris and fluidized sediment flow deposits. They are 1 km thick; consist almost entirely of volcanic detritus, which is mainly felsic in composition; and overlie a thick accumulation of Amisk Group mafic subaqueous flows. The felsic volcanic detritus is texturally and compositionally variable. This indicates a level of mixing which requires subaerial transport. The detritus was probably derived from easily eroded pyroclastic deposits of contemporaneous Amisk volcanoes, rather than by dissection of an older volcanic terrain by stream activity. This is indicated by: (i) only slight rounding of clasts; (ii) local intercalation of volcanic and sedimentary rocks; (iii) direct input of some strata into the sedimentary basin from their volcanic source without reworking; and (iv) absence of plutonic or metamorphic clasts.

The debris flow deposits have a restricted occurrence and are confined to the Flin Flon belt whereas the turbidites and fluidized sediment flow deposits are widespread and are part of a subaqueous sediment dispersal system developed around major stratovolcanoes of the

Flin Flon belt. A large portion of the detritus which entered the sediment dispersal system appears to have been channeled into subaqueous fans and transported into the adjacent Kisseynew sedimentary basin.

Several prograde metamorphic reactions have been identified in muscovite-bearing metasedimentary rocks and define a steep metamorphic gradient which increases from the Flin Flon volcanic-sedimentary belt into the Kisseynew sedimentary gneiss belt. These are:

chlorite + muscovite + garnet $\rightleftharpoons$ staurolite + biotite + quartz + H_2O;

chlorite + muscovite + staurolite + quartz $\rightleftharpoons$ sillimanite + biotite + H_2O;

muscovite + staurolite + quartz $\rightleftharpoons$ sillimanite + garnet + biotite + H_2O; and

muscovite + plagioclase + quartz + $H_2O \rightleftharpoons$ melt + sillimanite.

These and other reactions indicate that metamorphism in the File Lake area took place at moderate pressures ($\sim$ 3.5 kb) in a temperature gradient that increased from 400°C to 650°C.

The metamorphic gradient of 21°C/km is too steep to be accounted for by selective uplift of more deeply buried and metamorphosed strata in the Kisseynew belt. There was probably a higher geothermal gradient in the Kisseynew belt than in the Flin Flon belt. This could have been caused by lower thermal conductivity of the volcanic rocks and consequent impedance of upward movement of heat in the Flin Flon belt relative to the Kisseynew belt. This mechanism could explain why Precambrian volcanic belts are invariably much lower grade than associated sedimentary belts, and does not require special tectonic conditions for development of this difference.

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1. INTRODUCTION

1.1 Statement of Problem

The relationship between low grade, weakly recrystallized Aphebian Amisk and Missi Group sedimentary strata of the Flin Flon belt and high grade, strongly recrystallized paragneisses of the Kisseynew belt has been a source of controversy from the time they were first mapped by Bruce (1918). Attention was focused on this problem by Harrison (1951a), who recognized four main hypotheses concerning the relationship of the Kisseynew paragneisses to the stratigraphic succession in the Flin Flon belt. These hypotheses were:

1) paragneisses of the Kisseynew belt comprise rocks of various ages, probably including both Amisk and Missi Group strata, as well as some older and/or younger strata;
2) paragneisses of the Kisseynew belt are younger than the Amisk Group, lie conformably upon them, and are older than the Missi Group;
3) paragneisses of the Kisseynew belt are younger than the Amisk Group, lie unconformably upon them, and are probably equivalent to the Missi Group; and
4) paragneisses of the Kisseynew belt are separated from the Amisk and Missi Groups by a major fault, and their relative ages cannot be determined.

Harrison (1951a) tentatively suggested that paragneisses of the Kisseynew belt could be highly recrystallized deep-basin sedimentary facies equivalents of continental sedimentary deposits of the Missi Group. He also suggested that the boundary between the two belts was a major fault, which he termed the Kisseynew lineament. He based the fault hypothesis on a persistent lineament, marked by strong local shearing, which was parallel to the belt boundary and across which there appeared to be an abrupt change in metamorphic grade and local structural discordance. The fault interpretation was emphasized in a subsequent paper by Harrison (1951b) and was strongly supported by Kalliokoski (1953), who concluded that the Kisseynew belt had been "compressed and overturned in the south by a tectogene mechanism that was strong enough to shear the gneisses off the basement and thrust them over Amisk rocks" of the Flin Flon belt.

Other investigations (Robertson, 1951; Byers and Dahlstrom, 1954; Bailes, 1971, 1975; Froese and Moore, 1978) have demonstrated that both Amisk and Missi Group rocks can be traced into paragneisses of the Kisseynew belt and have shown that, although there is local faulting, the Kisseynew lineament is not a major fault structure and is simply the trace of the boundary between dissimilar rock types. Bailes (1971) suggested that there is a direct correlation between Amisk Group sedimentary rocks of the Flin Flon belt and Nokomis Group paragneisses of the Kisseynew belt and between Missi Group sedimentary rocks and Sherridon Group paragneisses. He also suggested that 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". One of the major objectives of this study has been

to investigate the validity of this hypothesis through a detailed sedimentologic study of the Amisk-Nokomis sedimentary rocks of the File Lake area.

The File Lake area is particularly amenable to a sedimentologic study of the Amisk-Nokomis Group rocks and to an analysis of the stratigraphic and metamorphic nature of the boundary between the Flin Flon and Kisseynew belts. This is because a sequence of weakly recrystallized, well preserved Amisk Group pebbly greywacke, greywacke, siltstone and mudstone can be traced across a steep metamorphic gradient from the Flin Flon belt into stratigraphically equivalent Nokomis Group migmatitic paragneisses of the Kisseynew belt.

1.2 Previous Work in the Study Area

The File Lake area has been mapped several times. It was mapped originally by Alcock (1920) and later by Stockwell (1935) at 1:126,720. Harrison (1949) mapped most of it at 1:63,360 and McGlynn (1959) mapped a small strip along the western edge that was not covered by Harrison. More recently, the author mapped the File Lake area at a scale of 1:25,000 (Bailes, 1978). This study is an offshoot of the latter mapping program.

This study is the first detailed sedimentological analysis of Amisk Group sedimentary rocks and their high grade Nokomis Group equivalents. Many aspects of their metamorphic paragenesis have been dealt with previously by Harrison (1949), Froese and Gasparrini (1975), Bailes and McRitchie (1978) and Froese and Moore (1978).

1.3 Location, Access and Field Work

The File Lake area is 260 km^2 and is bounded by latitudes $54^{o}47.5'$ and $54^{o}58'$ north and longitudes $100^{o}12.5'$ and $100^{o}31'$ west. It is 130 km northeast of The Pas and 20 km west of Snow Lake (Fig. 1).

There is no road access, but there are water and portage routes from Reed Lake, on Highway 391. The most convenient method of access is by float-equipped aircraft based at The Pas, Flin Flon or Wabowden. There is also rail access to Woosey Lake on CNR trains hauling ore from the Snow Lake mining area to the Hudson Bay Mining and Smelting Co. Ltd. refinery complex in Flin Flon.

Samples, photographs and geological data for this study were collected in the summers of 1970, 1971 and 1972, during mapping of the File Lake area by the author for the Manitoba Mineral Resources Division. The mapping was conducted by standard pace and compass traverses, spaced every 150 to 300 metres. The published geological map (Bailes, 1978; Fig. 2, in pocket) is at a scale of 1:25,000. Several short stratigraphic sections were measured and numerous coarse greywacke samples were collected in weakly recrystallized, well preserved Amisk Group metasedimentary rocks on Morton Lake. Several hundred field observations of megascopic metamorphic assemblages and numerous samples of Amisk Group metasedimentary rocks were collected in a zone from the south end of Morton Lake across the metamorphic gradient to the north boundary of the map-area, north of Corley Lake.

2. GEOLOGIC SETTING OF STUDY AREA

2.1 Regional Setting

The Churchill Province in northern Manitoba and northeastern Saskatchewan includes several belts of highly recrystallized and complexly deformed Aphebian sedimentary rocks (Fig. 1). The largest of these belts is the east-trending 300 km long and 150 km wide Kisseynew sedimentary gneiss belt. The Kisseynew belt comprises coarsely recrystallized migmatitic paragneisses in which only simple and tentative lithostratigraphic subdivisions have been made. It is bounded to the south by the Aphebian Flin Flon volcanic-sedimentary belt and to the north by the Aphebian Lynn Lake volcanic-sedimentary belt. Archean basement gneisses and granulites, which underlie Aphebian supracrustal rocks to northwest (Weber et al, 1975), are conspicuously missing in the Kisseynew, Flin Flon and Lynn Lake belts, although some late Archean to early Aphebian strata have been identified locally at the west end of the Flin Flon belt at Hanson Lake (Coleman, 1970) and at Pelican Narrows (K. Bell and J.M. Moore, personal communication, 1978).

The supracrustal and intrusive rocks of the Flin Flon, Kisseynew, and Lynn Lake belts have been dated by a variety of radiometric isotope techniques; Sangster (1978) contains a review of these studies. They indicate that the supracrustal rocks are between 1800 to 1900 Ma old and were deformed and metamorphosed before 1750 Ma.

The nature of the boundary of the Kisseynew belt with the Lynn Lake belt, to the north, has received little attention, but Zwanzig (1976) has suggested that paragneisses of the Kisseynew belt correlate with

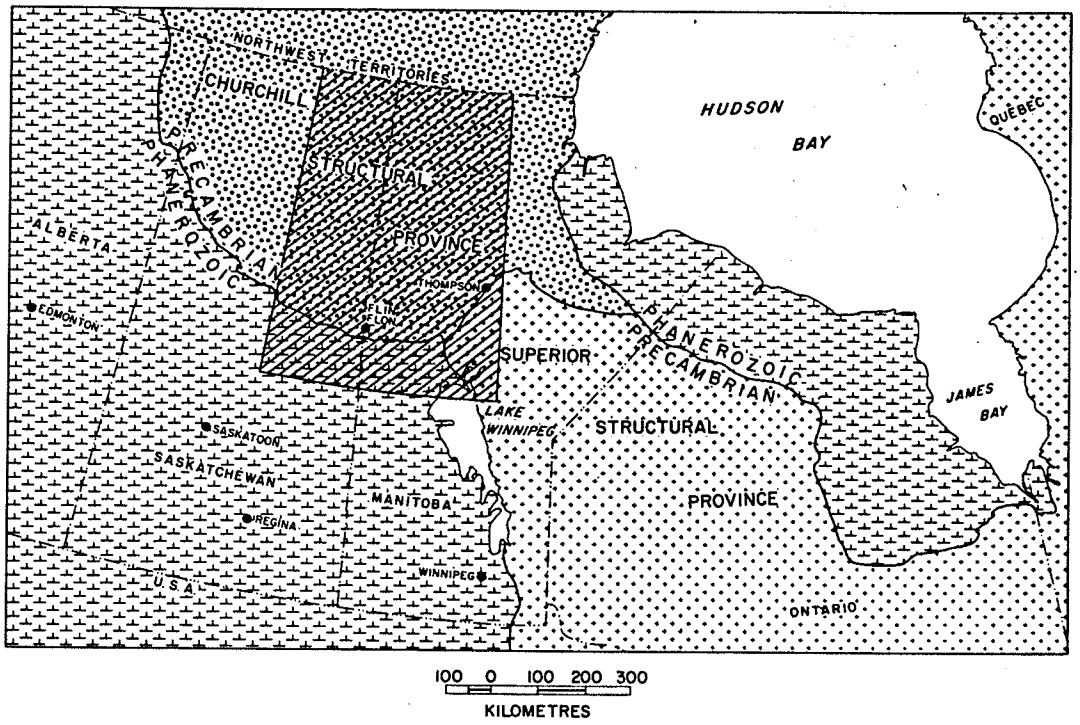
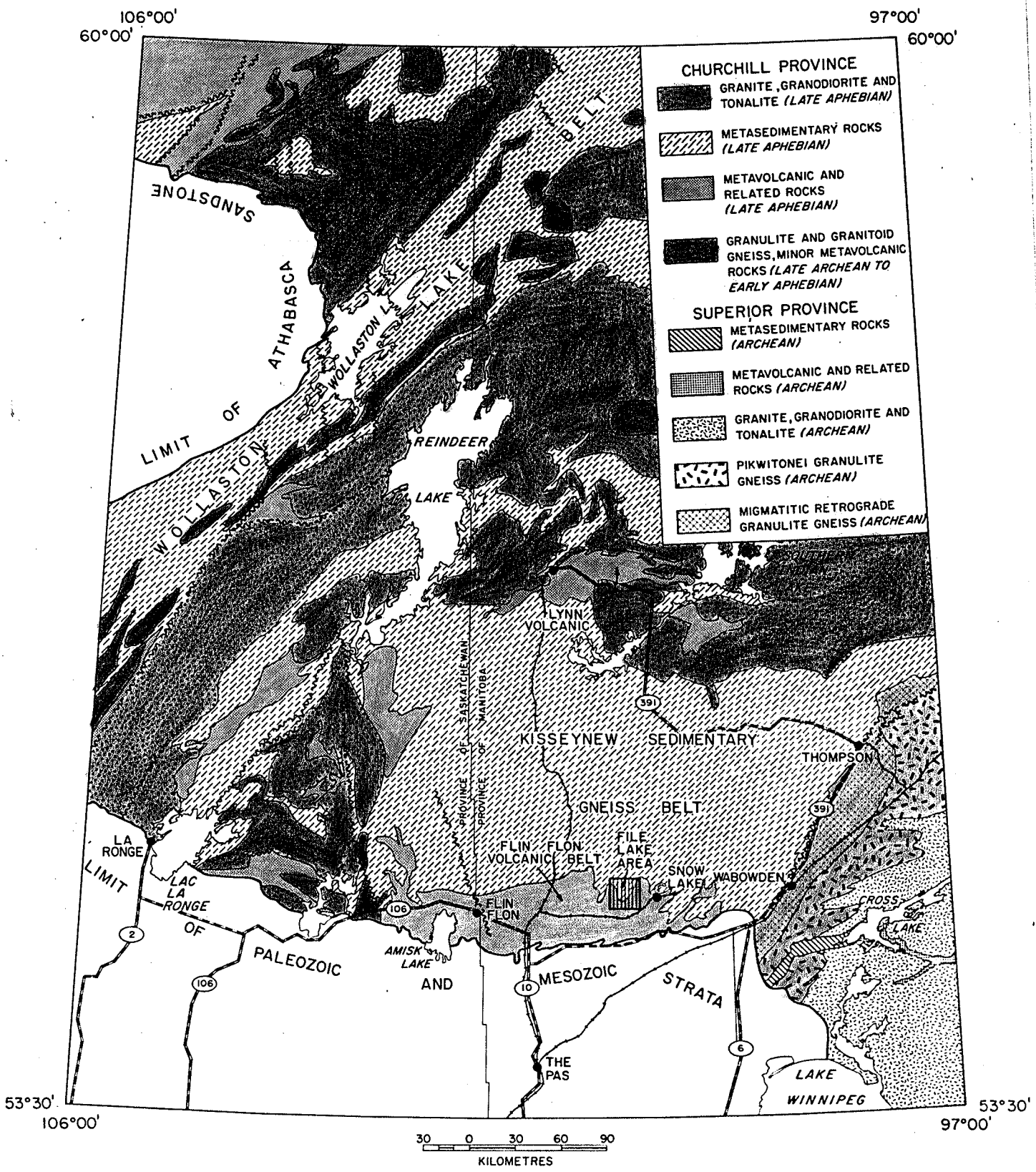


FIGURE 1: Main geological provinces in central Canada (above). Location of the File Lake area and generalized geology of the Churchill Province in western Manitoba and eastern Saskatchewan (opposite page).


106°00'
97°00'
60°00'
53°30'
CHURCHILL PROVINCE
GRANITE, GRANODIORITE AND TONALITE (LATE APHEBIAN)
METASEDIMENTARY ROCKS (LATE APHEBIAN)
METAVOLCANIC AND RELATED ROCKS (LATE APHEBIAN)
GRANULITE AND GRANITOID GNEISS, MINOR METAVOLCANIC ROCKS (LATE ARCHEAN TO EARLY APHEBIAN)
SUPERIOR PROVINCE
METASEDIMENTARY ROCKS (ARCHEAN)
METAVOLCANIC AND RELATED ROCKS (ARCHEAN)
GRANITE, GRANODIORITE AND TONALITE (ARCHEAN)
PIKWITONEI GRANULITE GNEISS (ARCHEAN)
MIGMATITIC RETROGRADE GRANULITE GNEISS (ARCHEAN)
SANDSTONE
LIMIT OF ATHABASCA
WOLLASTON LAKE
WOLLASTON LAKE BELT
REINDEER LAKE
LIMIT OF WOLLASTON
LYNN VOLCANIC
KISSEYNEW SEDIMENTARY GNEISS BELT
THOMPSON
LA RONGE
LIMIT OF PALEOZOIC AND MESOZOIC STRATA
LAC LA RONGE
FLIN VOLCANIC
FLON BELT
FILE LAKE AREA
SNOW LAKE
WABOWDEN
CROSS LAKE
FLIN FLON
AMISK LAKE
THE PAS
LAKE WINNIPEG
PROVINCE OF SASKATCHEWAN
PROVINCE OF MANITOBA
2
106
10
391
6
30 0 30 60 90
KILOMETRES