STRAIN ANALYSIS OF BOUDINAGE AND PTYGMATIC FOLDING IN THE LILY POND LAKE AREA, MANITOBA

A Minor Thesis

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by

BARRY MANCHUK

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ABSTRACT

Boudinage and ptygmatic structures can be observed within a vertical outcrop of amphibolite in the Lily Pond Lake area. Two well-developed joint directions facilitate measurement of the dimensions of the ptygmatic folds and boudinage structure in two directions. Their dimensional measurements are the basis of the interpretation of strain.

A study of the boudinage structure provided for extensional strain measurements from which the extensional strain axes of the strain ellipse were derived. A study of the ptygmatic structures provided for the amount of compressive strain the host rock had undergone and from which the compressive axis of the strain ellipsoid was derived.

The major axis of the strain ellipsoid strikes 062° with an extensional strain ratio of $\frac{3.50}{1.00}$ and the intermediate strain axis strikes 152° with an extensional strain ratio of $\frac{1.65}{1.00}$. The major and intermediate strain axes are in the plane of layering. The minor axis of the strain ellipsoid shows compression ratios ranging from $\frac{4.40}{1.00}$ to $\frac{7.70}{1.00}$ with a mean of $\frac{5.90}{1.00}$.

A predicted, compressional strain ratio of $\frac{5.77}{1.00}$ based

on the extensive-strain ratio data, compares favourably with the mean compressional ratio of $\frac{5.90}{1.00}$ derived from field observations.

ACKNOWLEDGEMENTS

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LOCATION AND ACCESS

The area of study is located in southeastern Manitoba, in the Whiteshell Provincial Park. Specifically, the area is located in the southwest corner of Tp. 19, Rge. 17E along Manitoba Provincial Highway 44, at Lily Pond Lake. Lily Pond Lake is approximately 8 miles from West Hawk Lake and 11 miles along Highway 44 from the east junction of the Trans-Canada Highway and Highway 44. The location of Lily Pond Lake is shown on the index map (Figure 1).

Convenient access from Winnipeg is via the Trans-Canada Highway to West Hawk Lake and then north on Highway 44 to Lily Pond Lake. West Hawk Lake is approximately 100 miles east of Winnipeg.

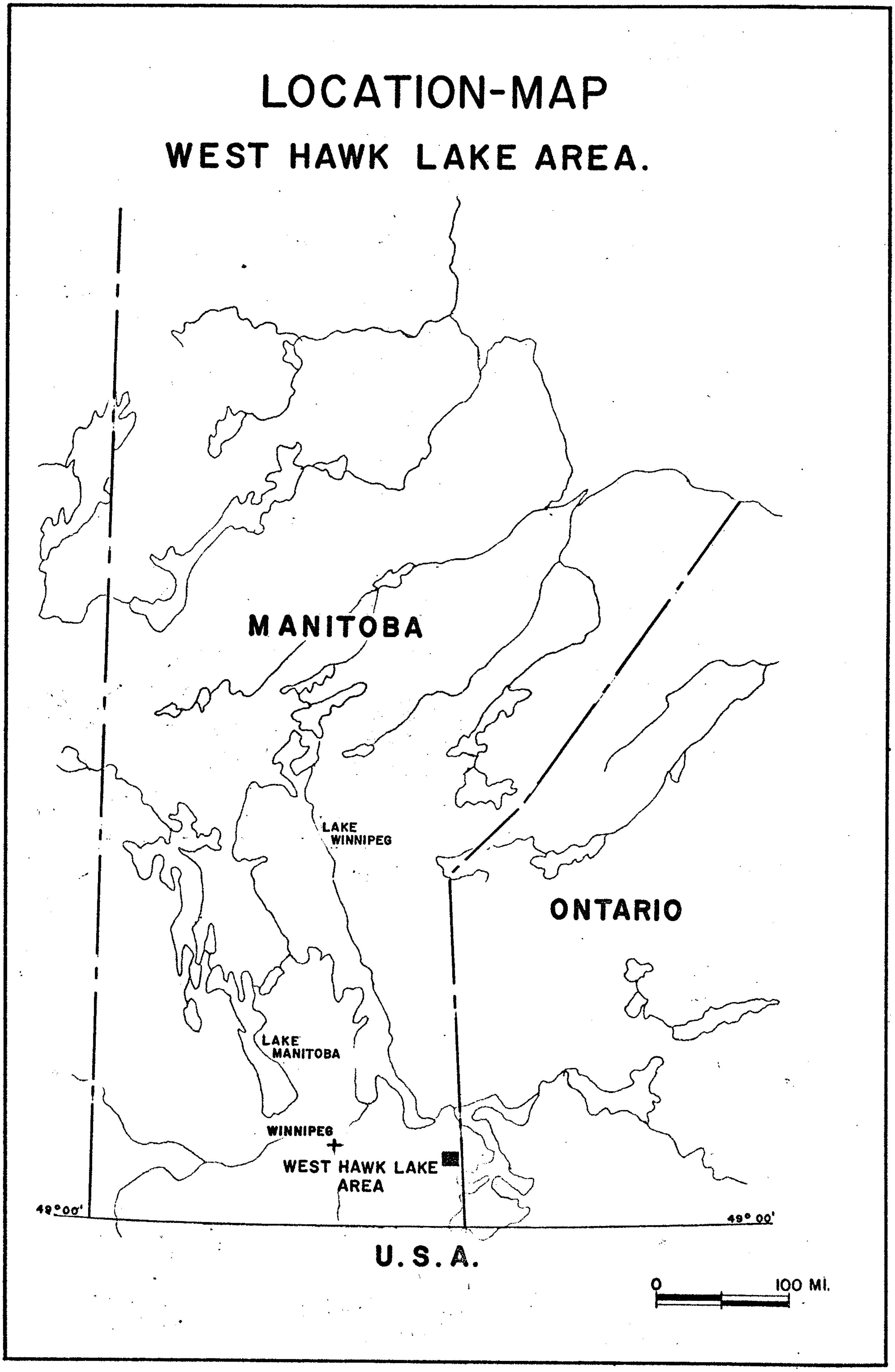

LOCATION-MAP
WEST HAWK LAKE AREA.
MANITOBA
LAKE WINNIPEG
ONTARIO
LAKE MANITOBA
WINNIPEG
WEST HAWK LAKE AREA
49°00'
49° 00'
U.S.A.
0
100 MI.

Figure 1

STATEMENT OF PROBLEM

This thesis presents the results of an analysis of boudinage and ptygmatic structures observed within a unit of amphibolitic rock exposed on the north shore of Lily Pond Lake, West Hawk Lake area, Manitoba (Figure 2).

At Lily Pond Lake boudinage and ptygmatic folds can be observed in a vertical outcrop which has two well-developed vertical jointing directions which facilitate measurements in two separate planes. Measurements of the boudinage and ptygmatic structures provide information on the amount of extensional and compressional strain that the host rock has undergone. Previous authors have indicated that ptygmatic folding and boudinage structure are a result of a single deformational event and there is no evidence to the contrary that the origin of these features is different at this location. Consequently, the compressional and extensional strain can be manifested by these features and related to a single strain ellipsoid. The purpose of this thesis is to determine the dimensions of the strain ellipsoid and ascertain its orientation.

GEOLOGY OF NORTHWEST CORNER
WEST HAWK LAKE AREA

LEGEND :

1 PINK QUARTZ MONZONITE

2 GREY PARAGNEISSIC GRANODIORITE

3 PINK PORPHYRITIC GRANODIORITE

4 ENGLISH RIVER GNEISSIC BELT TRANSITION ZONE

INTRUSIVE CONTACT

5 AGGLOMERATE

6 HORNBLENDE OLIGOCLASE SCHIST

7 METAVOLCANICS

8 METASEDIMENTS

SYMBOLS

SCHISTOSITY, GNEISSOSITY VERTICAL , INCLINED

BEDDING (VERTICAL , INCLINED)

ANTICLINE AXIS

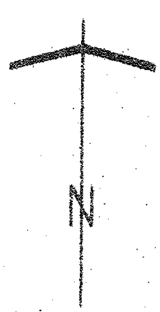
SYNCLINE AXIS

GEOLOGIC CONTACT (DEFINED, ASSUMED)

PROVINCIAL HIGHWAY

SECONDARY ROAD

TRANSMISSION LINE



DECLINATION 9° 20' E

0 1/2 1 MILE

PREVIOUS WORK

The first geological work done in the area surrounding Lily Pond Lake was by A.C. Lawson (1885) working for the Geological Survey of Canada. Lawson proposed that the volcanic-sedimentary sequence of the area be termed "Keewatin" after the type sequence to the east. The Manitoba Mines Branch published geological maps of the area in 1952 and 1954 on the basis of work done by Springer (1951) and J.F. Davies (1953), respectively.

M.Sc. student, A. Michalkow (1954), also worked in the area and prepared a map (scale 1 mile = 1 inch) which delineates the geology of the area for some 90 square miles surrounding Lily Pond Lake.

GENERAL GEOLOGY

Regional Geology

The accompanying geological map (Figure 2) presents the regional geological setting for the present study. The map is a compilation based on the published maps of Springer (1952) and Davies (1954); and on the unpublished maps of Michalkow (1954) and the students attending the University of Manitoba geological field school during the 1968 summer session.

The present author has not attempted to add to the regional geological picture but has drawn his information from the above reports and maps.

Springer (1952) writes:

> "All consolidated rocks in the area are of Precambrian age. The oldest rocks form a group of volcanic and sedimentary rocks, which are designated Keewatin ... These rocks have been intruded by a number of stocks and batholiths most of which are granodiorites."

The dominant geological feature which can be observed on the map (Figure 2) is a pink porphyritic granodiorite pluton which occupies the core of a shallow, east-plunging antiformal structure.

Above the pink porphyritic granodiorite core the following sequence of rocks can be observed:

i) a discontinuous band of amphibolite on the north flank of the antiform, north of Lily Pond Lake,

ii) a band of grey paragnessic granodiorite,

iii) a band of pink quartz monzonite.

A steeply west-plunging synform occurs to the south of the antiform (Figure 2). The north limb of the synform has been truncated by the rocks of the antiform. The rocks of the synform consist of an intercalated sequence of metasedimentary and metavolcanic rocks.

Local Geology

The narrow band of metavolcanic rocks (amphibolite) north of the antiform core contains the boudinage and ptygmatic structures investigated by the author (Figure 2). Structurally this band occurs on the north limb of the antiform, which is parallel to Highway 44 near Lily Pond Lake. This east-west trending unit dips approximately 20 to the north and forms a discontinuous cliff approximately 40 feet high forming three outcrops on the north side of Lily Pond Lake (Figures 3, 4, and 5).

The rocks of the antiform are significant to the study, in a spatial sense, therefore, the petrology of each unit is given below. Michalkow (1954) describes the pink quartz monzonite as a pink to greyish pink in colour, fine to medium grained, and massive to slightly gneissic. An average analysis shows 7.1 per cent quartz, 45.0 per cent plagioclase, 40.8 per cent potash feldspar, 0.6 per cent biotite, 4.5 per cent hornblende, 1.4 per cent magnetite, and 0.6 per cent apatite-zircon. Springer (1952) writes of the grey paragneissic granodiorite:

> "parallelism of the ferromagnesian minerals gives this rock a definite lineation. Average composition is 45 per cent oligoclase, 30 per cent quartz, 10 per cent microcline, 10 per cent biotite, and the remainder, accessory minerals. The granodiorite was probably formed by granitization of old sedimentary and volcanic rocks."

The narrow metavolcanic band consists of amphibolite which Michalkow (1954) has determined to be oligoclase hornblende schist. The boudinage and ptygmatic structures occur within this amphibolite unit. The amphibolite unit is overlain by the paragneissic granodiorite unit. Figure 6 shows the contact between the amphibolite and overlying paragneissic granodiorite.

The amphibolite unit pinches out in the easternmost and westernmost outcrops and attains its maximum thickness of approximately 35 feet in the central portion of the westernmost outcrop (Figure 5). On close inspection layering can be observed within the amphibolite. The layering is identified by mineralogical and textural changes and is interpreted as bedding. Although there is no completely diagnostic evidence the composition suggests that the amphibolite represents a bedded basic tuff unit. The bedding provided control for the injection of numerous granitic sheets concordant with the beds. The sheets were subsequently deformed to produce boudins but their concordant relationship with the host rock is still clearly visible (Figure 7).

Several granitic sheets were discordantly injected into the sequence and were deformed into ptygmatic folds. These discordant intrusions cut the bedding at shallow and steep angles. The pre-deformational attitudes of the discordant intrusion is unknown.

Several generations of granitic material are represented within the amphibolite. Figure 8 represents a close-up of a portion of a boudin and at least three ages of intrusion of granite can be identified. The proximity of the adjacent batholith which forms the core of the antiform and directly underlies the amphibolite unit suggests that the intrusive material may have been derived from the batholith. No systematic study of features observed within the younger intrusive material was carried out. Only deformational features related to older intrusive dikes and sills were studied by the author.

Boudinage Structure

The development of two sets of joints throughout the amphibolite unit has led to excellent exposures of the boudins in two planes.

All observations have led to the interpretation that

Figure 7. Boudins show concordant relationship with host rock.

Figure 8. Large (3 feet) boudin showing multiple generations of granitic material.

the boudins were formed by plastic necking prior to brittle failure. The resulting boudins are all lenticular in both of the observational planes (Figure 9). There are numerous examples of boudins in which necking has taken place but in which separation has not developed. Later discussion shows that the necking process prior to brittle failure is indicative of similar competencies within the host rock and the vein material. In a few places amphibolite boudins were also found (Figure 10).

Individual boudins observed in the Lily Pond Lake outcrops range from the order of 2 inches long to 20 feet long. Most of the boudins fall in the range 1 foot to 2 feet long with widths of approximately 1 inch to 2½ inches. Within any boudin layer the boudins are mostly the same size.

Evidence of deformation of the rock in which the boudins are resting is not visible everywhere. Where such evidence can be observed it is usually in the form of drag features in the host at the ends of boudins (Figure 11). These features are a result of greater amounts of slippage progressively away from the boudin-host contact.

Ptygmatic Folds

Although numerous ptygmatic folds can be observed in the Lily Pond Lake area, only five were suitable enough for strain measurements. The others were either discontinuous, too irregular or too poorly exposed for measurement.

Figure 9. Lenticular boudins.