STRUCTURAL GEOLOGY OF THE LONG LAKE AREA MANITOBA

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ABSTRACT

At Long Lake Manitoba the Rice Lake greenstones have had a complex structural and metamorphic history. A period of isoclinal folding (D_1) and greenschist facies metamorphism were the earliest events. They were followed by open cross folding (D_2) accompanied by dynamic metamorphism and retrogression of biotite to chlorite. A period of minor kink folding (D_3) was the last event.

The development of folds during D_1 is not well understood. During D_2, folds were produced by passive slip parallel to a well developed axial plane foliation (S_2) which strikes west and transects the axial surfaces of the early folds. The apparent direction of tectonic transport during D_2 was parallel to mineral lineations (L_2) and slickensides (L_2') which pitch steeply to the east or west in the plane of S_2. Volcanic fragments elongated in these directions and flattened in the plane of S_2 are interpreted as possible evidence for near-vertical elongation and north-south shortening of the rock mass during D_2.

The last period of deformation (D_3) resulted in a conjugate set of kink folds and a series of small concentric folds in the foliation (S_2). These folds were probably produced by flexural slip on S_2 parallel to a set of horizontal slickensides (L_3).

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CHAPTER I

INTRODUCTION

This study represents a geometric and kinematic analysis of the diastrophic structures of the metamorphosed Archean sedimentary and volcanic rocks in the Long Lake area of Manitoba. The geometric analysis is based on field mapping and on the interpretation of the orientation data from various types of s-surfaces and various types of lineations. The kinematic analysis is based on the character of the surfaces of deformation and the lineations, on the microscopic fabric of the rocks and on the shape and orientation of deformed fragments.

Location

The map-area is located about 15 miles southeast of Bissett, Manitoba and covers about 4 square miles of Township 22, Ranges 15 and 16, at the east end of Long Lake (Fig. 1).

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geology. Mr. F. H. A. Campbell was very helpful in discussing the stratigraphy with the writer.

Course of Investigation

Six weeks of field work was done in the fall of 1967 and three weeks in the fall of 1968 under the auspicies of the Manitoba Mines Branch. Laboratory work was done during the winter months of 1967 and 1968 at the University of Manitoba and at the Mines Branch. Mapping was carried out to the scale of 16 inches to 1 mile on enlargements of air photos Nos. A 18881-218 and -220. No correction for distortion was made on the final maps. Structural data was recorded in the field on a computer oriented field data sheet (Haugh et al., 1967) and contoured stereograms were prepared using the computer. Oriented specimens of all rock types were collected throughout the map area and important structural features were photographed or sketched. In the laboratory a number of specimens were cut perpendicular and parallel to prominent s-surfaces and lineations. Thirty-two oriented thin sections were prepared and examined.

General Geology

The Long Lake map-area is located on the southern flank of the Rice Lake greenstone belt in the Superior structural province of the Canadian Shield. The belt is composed of the Rice Lake Group of metamorphosed Archean

sedimentary and volcanic rocks, which extend northwest from the Ontario-Manitoba boundary to Manigotogan on Lake Winnipeg (Fig. 1). The Greenstones are flanked by granitic rocks on the northeast and by the English River granites and gneisses on the southwest (Dwibedi, 1966). The Rice Lake Group has been intruded by numerous dykes and sills of basic and intermediate plutonic rocks. A quartz diorite batholith is located one half mile north of Long Lake (Paulus, 1968).

In the Long Lake area all rock units belong to the Rice Lake Group. They consist of meta-sedimentary rocks and metamorphosed volcanic rocks (both clastics and flows) which have been intruded by dykes and sills of quartz diorite, quartz-feldspar porphyry, gabbro and diabase. The eastern part of Long Lake is in the centre of the map-area and all rock units trend west, parallel to the elongate shape of the lake (Map 1). Along the north shore of the lake there is a narrow belt of arkosic greywacke interbedded with chert and iron formation and basic volcanic flows, and intruded by numerous dykes and sills. A unit of intermediate to acid volcanic breccias and tuffs strikes through the lake and is best exposed on the east shore and on a number of islands. Interbedded greywacke, shale, chert and iron formation outcrop on a string of islands and peninsulas along the south shore of the lake. The area south of the lake consists of

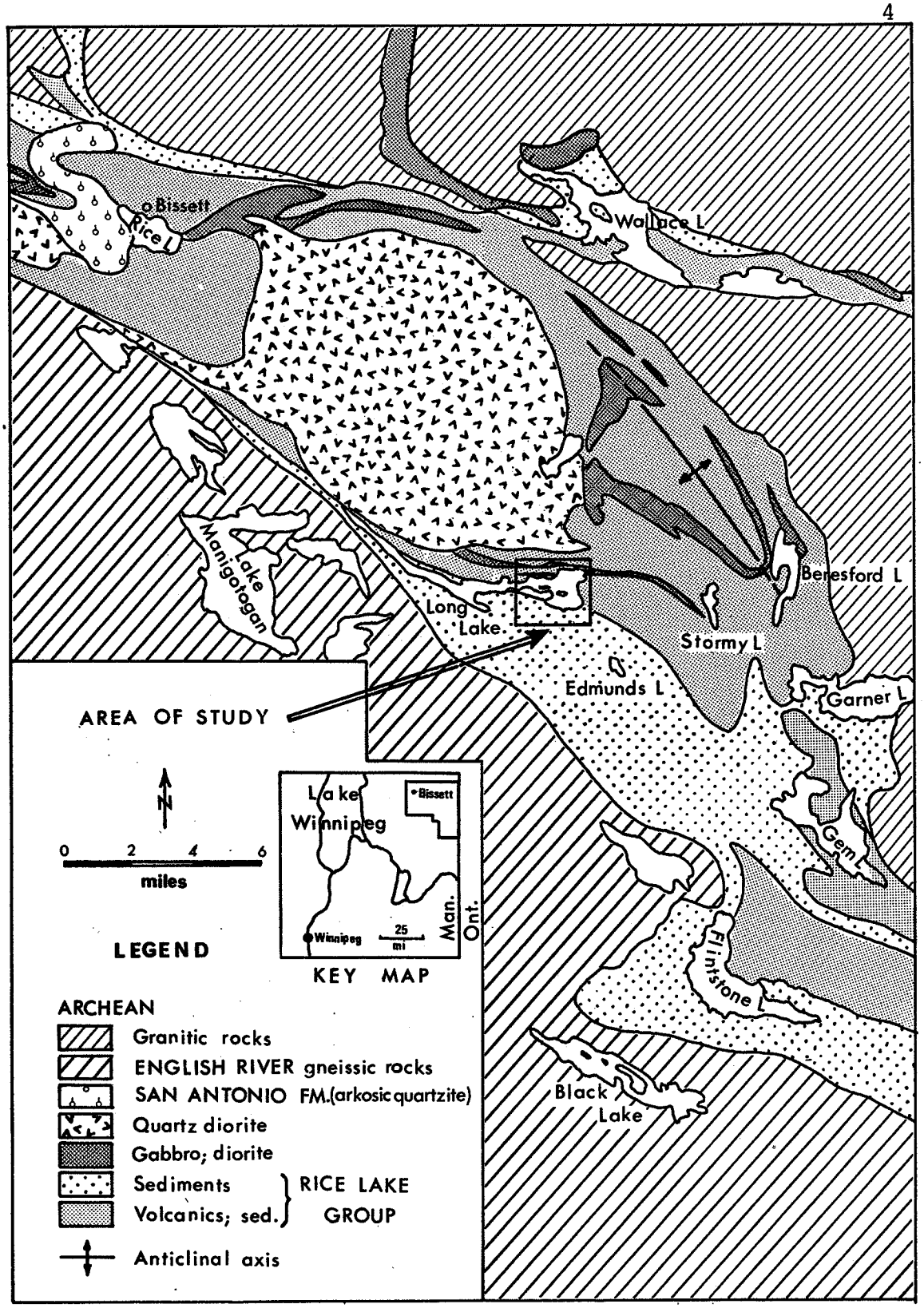

Figure 1. Location map and general geology, (after Turek, 1968).

quartzose greywacke. Only a few narrow dykes occur in the central and southern parts of the map-area.

The Beresford Lake area which includes the Long Lake area was mapped in 1938 by C. H. Stockwell (G. S. C. Map 809 A). In the marginal notes Stockwell indicated that sedimentary rocks rest conformably on acid to intermediate volcanic rocks and that tops are generally to the south. However he did not separate arkosic greywackes from pyroclastic rocks north of Long Lake. South of the lake he recognized that

> grain variations indicate that (sedimentary) rocks have been folded into a succession of closely compressed isoclinal folds

and that the present area of study lies on the southwest flank of a large anticlinal structure.

All rock types have been subject to regional metamorphism of the greenschist facies, and many have suffered considerable dynamic metamorphism. Quartzo-feldspathic rocks have preserved most of their primary structure but basic and pelitic rocks have been converted to chlorite and sericite schist. In shear zones a few bands of mylonitic schist have been developed.

The map-area is characterized by strong westerly linear trends expressed by the elongate shape of the lake, narrow bays and islands and westerly trending ridges and depressions adjacent to the lake. These features can be readily related to a west-striking, steeply dipping

foliation. This foliation is ubiquitous throughout the Long Lake area. It is defined by a strong rock cleavage caused by the tabular alignment of platy minerals. Several types of linear structures are developed on the foliation surfaces and the foliation is occasionally kink folded.

Contacts between formations, beds and igneous bodies strike west to northwest and generally have steep dips. In the southern part of the map-area bedding contains numerous major and minor folds. A large number of veins occur throughout the area. These veins generally trend parallel to the regional foliation but a few veins are folded throughout the entire area.

CHAPTER II

STRATIGRAPHY

The formational names used in this thesis have not been published previously. They are presented here to facilitate the description of the structures of the rocks in the Long Lake area. All units belong to the Rice Lake Group (Stockwell, 1945) and all appear to be conformable.

In the map-area rocks can be divided into three formations. A west-trending unit of arkosic greywacke which underlies the area north of Long Lake has been named the Stormy Lake Formation after a small lake east of the map-area. This unit faces south and overlies a unit of basic volcanic rocks. The succession of pyroclastic and epiclastic volcanic rocks also trends west and overlies the Stormy Lake Formation. It outcrops on the east shore of Long Lake and on some of the islands. This unit has been called the Long Lake Formation. The overlying greywacke unit south of the lake has been named the Edmunds Lake Formation after a small lake southeast of the map-area. The geographic location of the lakes is given in Figure 1, and the distribution of the formations is depicted on Map 1.

Stormy Lake Formation (Map Unit 1)

The oldest rocks in the map-area are the arkosic

TABLE I

FORMATIONS

Group	Formation	Map Unit	Lithology
Rice Lake	Edmunds Lake	3c	arkosic sandstone, pebble conglomerate
		3b	quartzose greywacke
		3a	arkosic greywacke, shale, chert, iron formation
	Long Lake	2d	volcanic breccia and tuff breccia of intermediate to acidic composition, minor sandstone
		2c	crystal tuff of intermediate composition
		2b	volcanic breccia and tuff breccia of intermediate composition, minor shale and sandstone
		2a	volcanic breccia of intermediate to basic composition, minor sandstone
	Edmunds Lake	1d	andesite or basalt
		1c	volcanic pisolite
		1b	iron formation
		1a	arkosic greywacke, chert, arkose
Intrusive Rocks		5	quartz-feldspar porphyry, quartz diorite
		4	gabbro, diabase, diorite

greywackes interbedded with chert, iron formation, volcanic pisolite and basic volcanic flows which are exposed on the low-lying outcrops north of Long Lake. Most of the high outcrops in this vicinity consist of meta-gabbro or quartz-feldspar porphyry sheets which have been intruded into the Stormy Lake Formation.

The Stormy Lake Formation is characterized by the following lithologies:

Arkosic greywacke interbedded with chert and arkose (map unit 1a);

Banded magnetite rich iron formation (1b);

Volcanic pisolite (1c);

Massive and pillowed andesite or basalt (1d).

The greywacke (1a) is grey-green to dark green on weathered surfaces and the interbedded chert is light grey. In a number of the coarser beds the grain size grades from coarse at the bottom to fine at the top. The arkose is massive and is difficult to distinguish from the quartz-diorite sills. The iron formation (1b) is black and serves as marker beds. There are at least three units of iron formation, each of which consists of one or two 12 inch beds. There is a single unit of volcanic pisolite (1c) which is up to 20 feet thick. It is a tuffaceous sedimentary rock which is composed of small ovoid bodies ranging from 2 to 10 mm in diameter. Two or three basic volcanic flows (1d) are intercalated with the sedimentary

rocks. The maximum thickness of a single flow is 75 feet. The dark green colour of these rocks suggests that they are andesites or basalts. They are usually highly schistose.

Long Lake Formation (Map Unit 2)

The Long Lake Formation consists of layered and massive clastic volcanic rocks. The formation is exceptionally well exposed in the map area; the east end of Long Lake was chosen as type section. These rocks form large high outcrops on the east shore of the lake, north and south of the Narrows, and on many of the islands. The formation is light green on weathered surfaces. It consists of predominantly pyroclastic rocks which can be divided into volcanic breccia, tuff breccia and sand-size crystal tuff. There are subordinate amounts of epiclastic rocks which consist of tuffaceous sandstone and shale. Mappable units of the Long Lake Formation comprise the following lithologies:

Volcanic breccia with intermediate to basic fragments (map unit 2a);

Volcanic breccia (Fig. 2) and tuff breccia (Fig. 3) with intermediate fragments (map unit 2b);

Crystal tuff (map unit 2c);

Volcanic breccia and tuff breccia with intermediate and acidic fragments (Figs. 4 and 5, map unit 2d).

Basic fragments are confined to the basal zone of

Figure 2. Deformed volcanic breccia of intermediate composition, map unit 2c, Long Lake Formation.

Figure 3. Deformed tuff breccia of intermediate composition, map unit 2c, Long Lake Formation. Fragments are outlined with marker pen.