UNIVERSITY OF MANITOBA

PEBBLE DEFORMATION

IN THE

SAN ANTONIO FORMATION, RICE LAKE AREA, MANITOBA

A DISSERTATION

SUBMITTED TO THE GRADUATE SCHOOL

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ABSTRACT

The San Antonio formation is a sheared feldspathic quartzite which contains pebbles concentrated in conglomeratic beds and scattered throughout the quartzite. Field data supports the contention that the pebbles were all deformed under the same environmental conditions. Most of the pebbles were derived from granitic rocks, vein quartz, and volcanic rocks. Studies of the average shapes of pebbles of these compositions have indicated the following orthogonal dimension ratios (a:b:c):

Granitic	1.95 : 1.45 : 1.0
Quartz	2.30 : 1.55 : 1.0
Volcanic	6.30 : 4.50 : 1.0

The long axes of the pebbles pitch an average of 64° to the east in the plane of the regional foliation of the quartzite, and are oriented approximately parallel to the interpreted direction of shearing movement on these planes. The mechanism of deformation of the pebbles is interpreted as brittle fracture followed by recrystallization, resulting in flattening and elongation in the shear planes during low temperature shear folding of the San Antonio formation.

A comparison of compositional data versus the relative deformation indicates that the degree of deformation generally increases with increasing mica content in the pebbles, and decreases with increasing quartz and feldspar content.

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CHAPTER 1

INTRODUCTION

Statement of the Problem

The San Antonio formation in the Rice Lake area consists mainly of sheared feldspathic quartzite which contains pebbles of various compositions scattered throughout the quartzite and concentrated in conglomeratic beds ranging up to forty feet in thickness. Previous field observations had suggested that these pebbles of different rock types were deformed to varying degrees in the same structural environment. These observations led to the present study, the objective of which is to compare the nature of the strain behavior of pebbles of various rock types which have been subject to the same stresses during the deformation of the San Antonio formation. More specifically the objectives may be stated as follows:

1. To determine the average shape, orientation, texture, and composition of the most abundant pebble types.

2. To determine the relationship between the degree of deformation and pebble composition and texture.

3. To delineate the type of strain responsible for the pebble deformation.

4. To outline the conditions under which deformation took place.

5. To propose a possible mechanism to account for the observed types of strain.

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Location and Access

The San Antonio formation is located in the Rice Lake area, approximately one hundred air miles northeast of Winnipeg, and thirty miles east of Lake Winnipeg. (Figure 1). The major community in the area is the gold mining town of Bissett, which is connected by an all weather road to Pine Falls on the Winnipeg River. The area chosen for detailed study is shown on Figure 3 and lies to the north of the road, approximately six miles west of Bissett.

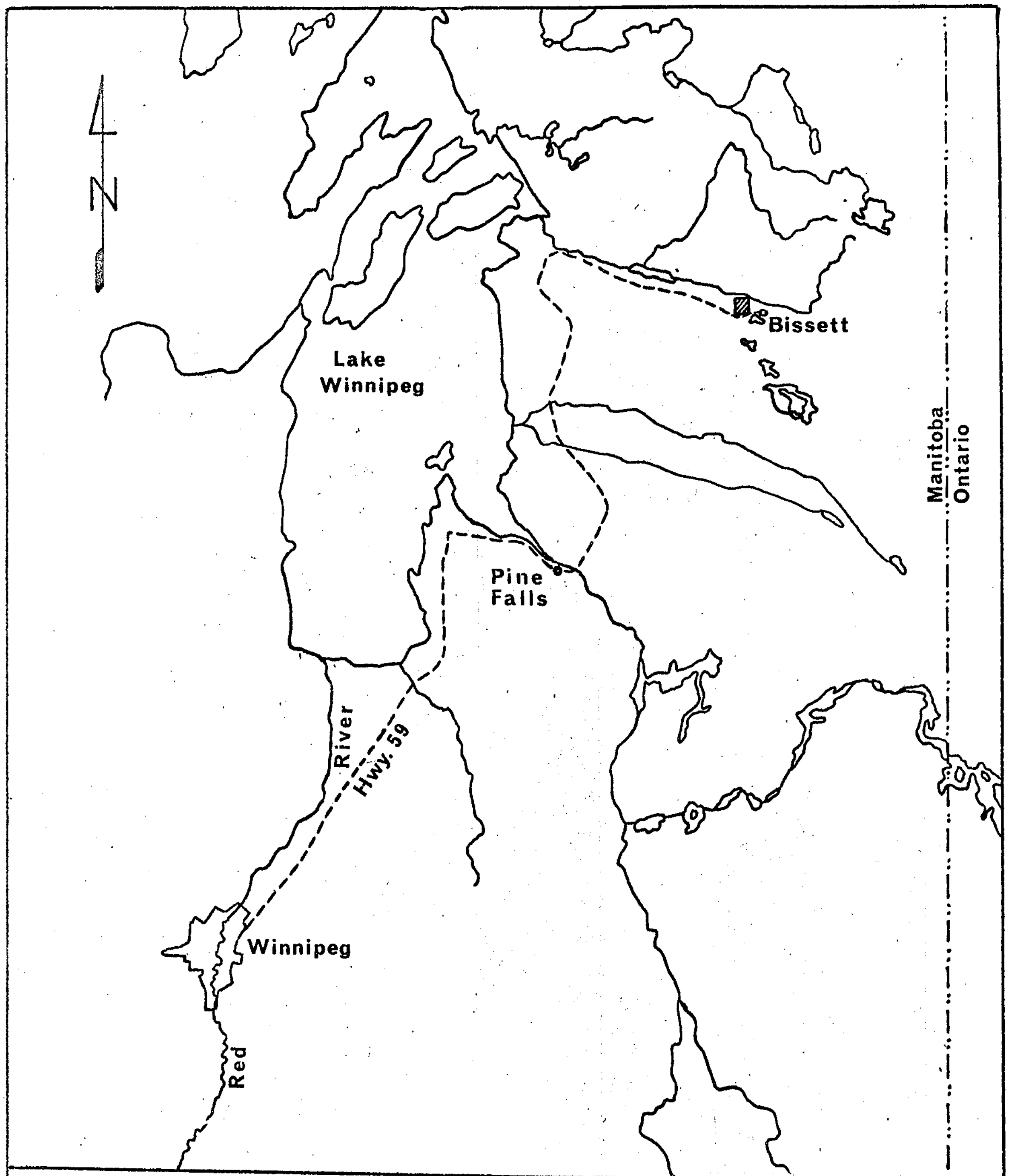

FIGURE I

INDEX MAP

▨ AREA OF STUDY

Collection of Data

Approximately two weeks were spent in the field in the fall of 1965, gathering structural data and measuring the shape and orientation of the pebbles. Oriented samples of individual pebbles and of the conglomerate were also collected for later laboratory study.

Topography

Most of the area of study consists of large rounded rock hills and ridges which have a characteristic glaciated appearance (Figure 2). Swamps separating the outcrops often have a linear outline parallel to the regional foliation and may represent the surface traces of zones of strong shearing. Fires in the past have destroyed most of the vegetation, leaving large clean rock exposures which are excellent for geological study.

Previous Work

Early work in the Rice Lake Area was done by Moore (1912), Cooke (1921), and Wright (1922). However, Stockwell (1938) was the first to recognize a separate sedimentary unit unconformably overlying the Rice Lake group of sedimentary and volcanic rocks. This younger unit he termed the "San Antonio formation".

Stanton (1941) conducted a heavy mineral study of the San Antonio formation and the surrounding intrusive rocks, the results of which supported Stockwell's work. By comparing the zircon content of the San Antonio formation to that of the intrusive rocks, Stanton

Figure 2. Typical outcrop of the San Antonio formation in the area of study. A thin conglomerate bed is present slightly to the right of centre on the large rock outcrop in the photo. Attitude of the bed is N25°E/55°W

concluded that the formation was younger than all of the surrounding intrusive rocks.

Davies (1949, 1950, 1953, and 1963) has made other studies of the Rice Lake area, the most recent of which (1963) concentrates on the relationship of the San Antonio formation to the Rice Lake group.

Rector (1966) studied the macroscopic, mesoscopic, and microscopic fabric elements of the San Antonio formation, concentrating on the quartz microfabric.

CHAPTER 2

GENERAL GEOLOGY OF THE SAN ANTONIO FORMATION

Surface Distribution

The surface distribution of the San Antonio formation forms an irregular "S" (Figure 34, in the pocket). The best exposures are generally on the large clean outcrops to the west of Horseshoe Lake.

Age Relationships

All of the consolidated rocks of the Rice Lake area are Precambrian in age (Figure 34, in the pocket). Beds of the San Antonio formation rest unconformably on the metamorphosed volcanic and sedimentary rocks of the Rice Lake group and on the calcic intrusive rocks which cut this group (Stockwell, 1938). The granitic rocks to the north may be younger (Davies, 1963), however there is no evidence that the San Antonio formation has been intruded by younger rocks.

To the west of Horseshoe Lake the beds of the San Antonio formation appear to dip beneath the adjacent lavas of the Rice Lake group (Figure 34, in the pocket). This, however, has been interpreted as a faulted contact by Stockwell (1938), due to the wide zone of intense shearing along this edge of the formation. Davies (1963), interpreted this contact as a *décollement* surface, postulating that the San Antonio formation had been thrust southward over the Rice Lake group.

Lithologic Description

Feldspathic quartzite is the most abundant rock type within the San Antonio formation. It is greenish-grey to red in color and is composed of medium grained subangular quartz, and lesser plagioclase and microcline, in a fine groundmass of granular quartz and sericite. Minor carbonate and chlorite are present in the groundmass. In the area of study, to the west of Horseshoe Lake, the quartzite has a pronounced reddish colour due to the films of hematite which cover the quartz grains (Stockwell, 1938). Well rounded pebbles are scattered through the quartzite in this area, and occasionally concentrated into thin beds from one to four inches thick. According to Stockwell (1938), the most common types of pebbles are granite, white quartz, greenschist, and rhyolite.

Approximately three thousand feet west of Horseshoe Lake, near the western edge of the area of study, there is a conglomerate zone occuring on the nose of a fold (Figure 34, in the pocket). The southern portion of this fold is the study area.

Within the area of study, which is divided in Figure 3 into numbered sub-areas, the conglomerate zone reaches its maximum thickness in sub-area 27, where two, forty foot thick beds are separated by approximately twenty feet of quartzite. Thinner beds occur to the east, in sub-area 28, and to the south in sub-areas 12, 24, and 25. Although these beds have been referred to previously as a basal conglomerate (Davies 1963), they appear to be interbedded with, and usually underlain by, quartzite. Pebbles in this conglomerate show considerable variation in the degree of deformation, and impart a strongly sheared appearance to the rock (Figure 4).

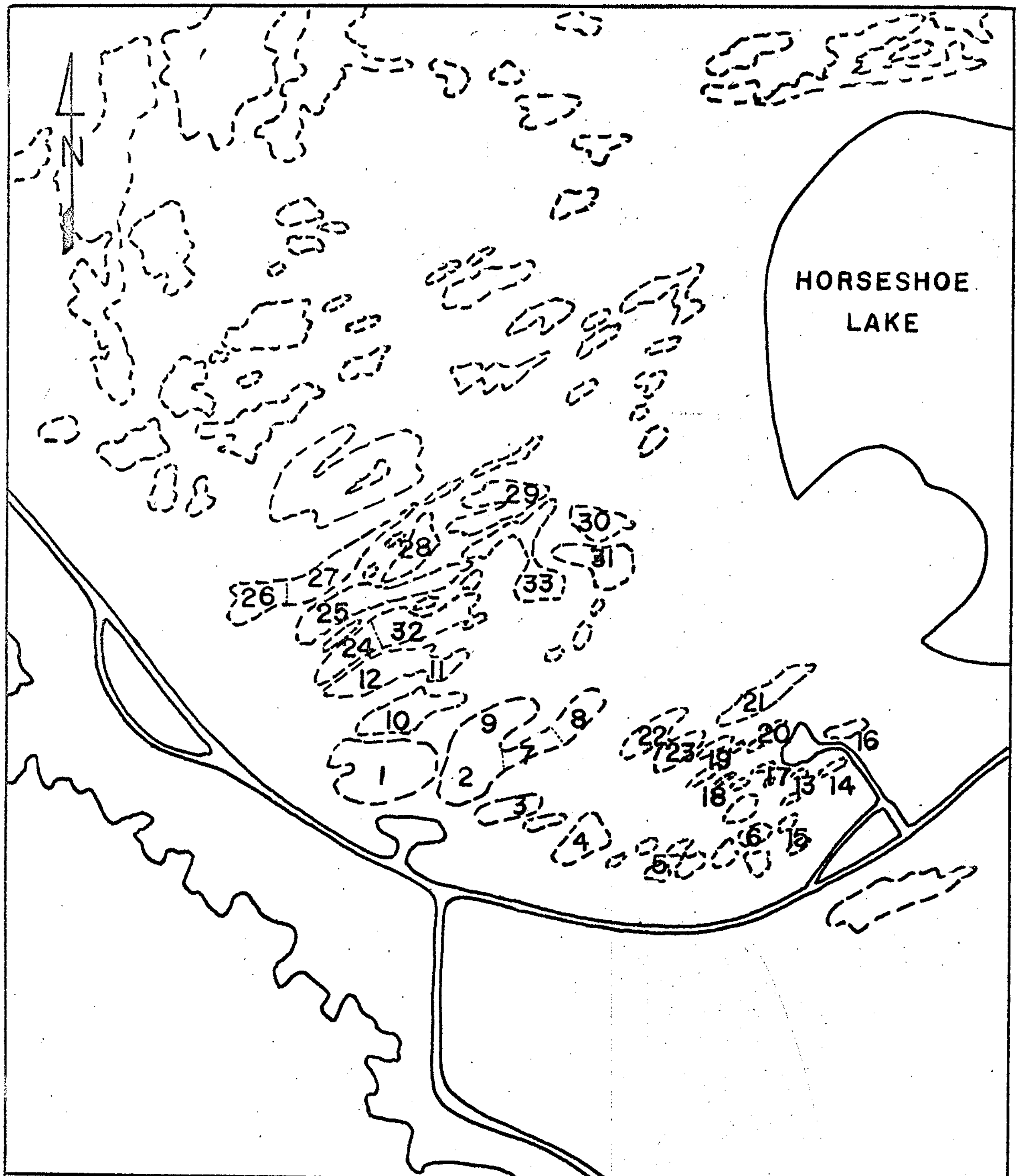

FIGURE 3
SUB AREA DISTRIBUTION

LEGEND
OUTCROP
ROAD

0 500 1000
FEET

Structural Geology

Bedding

Conglomeratic beds permit the determination of bedding attitudes in parts of the area of study. Otherwise the formation varies from massive to thickly bedded, and few attitudes can be obtained.

At several localities large scale cross-bedding is present from which top determinations can be made.

The strikes of bedding in the area of study vary from 0° to 180°. Dips are steep in all directions.

Folding

According to Stockwell (1938), the San Antonio formation has been folded into an anticlinal-synclinal pair overturned to the south (Figure 34, in the pocket). On the basis of stereographic plots of bedding attitudes, Rector (1966) concluded that the plunge of the anticline was 70°/N 15° W; the plunge of the syncline was determined to be 16°/N 85° E. Both axes are in the plane of the axial plane foliation, which has an attitude of N 74° E/70° N (Rector, 1966) An explanation of the difference in plunge is given by Rector (1966).

Davies (1963) stated that the structures of the Rice Lake group are not generally imposed on the San Antonio formation. He postulated that the San Antonio formation had been thrust southward over the Rice Lake group, the unconformity acting as a <u>décollement</u> surface. According to Davies, the intrusion of the potassic granite to the north provided the force for the thrusting, while the quartz diorite appears to have acted as a buttress against which the formation was thrust (Figure 34, in the pocket). The folding into an anticlinal-synclinal pair as well as the faulting found along the contacts of the

Figure 4. Conglomerate zone, sub-area 12, San Antonio formation. The numbered quartz pebble in the centre of the photo is $3\frac{1}{2}$ inches long and $2\frac{1}{2}$ inches wide.

formation were thus explained (Davies, 1963).

Rector (1966) agreed with Davies, stating that all of the fabric elements he studied indicated that the deformation was caused by a north-south oriented compressive stress acting in a horizontal plane. He interpreted the anticlinal structure to be a product of flexural slip folding modified by later passive slip folding on the planes of the regional foliation.

The orientation of the deformed pebbles shows a definite relationship to the orientation of the planes of the regional foliation, on which slip can be observed.

Foliation and Shearing

The most prominent structural feature of the area of study is the cataclastic foliation which strikes approximately north 70° east and dips steeply to the north, regardless of the attitude of the beds of the formation. Davies (1963), Rector (1966), and Stockwell (1938) have all considered this foliation to be an axial plane foliation. Shearing movements on the planes of this regional foliation are indicated by deformation of cross-beds and offsets of conglomerate lenses, as well as slickensides on foliation surfaces in the conglomerate zone.

A narrow zone of intense shearing is found at the contact of the San Antonio formation with the underlying Rice Lake group to the west of Horseshoe Lake. This shearing strikes approximately 140° Az. and dips beneath the San Antonio formation at 60° to 70°, truncating the bedding, which dips to the west at this location.

Topographically low areas which separate outcrops have a strong linear character which is approximately parallel to the strike of the foliation. These low, swampy areas may represent the surface traces of zones of strong shearing movement.

CHAPTER 3

PEBBLE DESCRIPTIONS AND COMPOSITIONS

General Statement

Three main pebble types are present in the quartzite and conglomerate zones of the San Antonio formation in the area of study. On the basis of hand specimen examination these pebble types have been referred to as granite, quartz, rhyolite, and greenschist (Rector, 1966, and Stockwell, 1938). These four names were used during the field work for this thesis in the fall of 1965, but subsequent thin section examination has indicated that both the rhyolite and greenschist pebble types should be grouped under the term volcanic pebbles. Compositional data obtained for the granite pebbles indicated that they should be termed granitic. The term quartz pebbles was retained.

On outcrop surfaces in the area of study granitic pebbles are well rounded with an ellipsoidal shape. Quartz pebbles generally have a similar rounded ellipsoidal or "egg" shape (Figure 5). Volcanic pebbles are much more extensively deformed; they show approximately ellipsoidal sections with "feathered" ends (Figure 6). All pebble types were assumed to approximate triaxial ellipsoids. The orthogonal dimension axes of the ellipsoids were designated "a", "b", and "c", representing the longest, intermediate, and shortest axes respectively.

Thin sections were cut perpendicular to each of the three orthogonal dimensional axes of the pebbles, using both oriented fragments of individual pebbles and pebbles exposed in sawed sections