STRUCTURAL STUDY OF A BIOTITE SCHIST

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INTRODUCTION

In the summer of 1989, I worked within the Quetico Provincial Park in an area, due north of Neil Island and into Lost Bay (see map), that includes the contact between a hornblende gneiss unit and a biotite schist unit near an anticline that deforms both units and is orientated N55E. Splays of the Burntside Lake Fault deform these units as well. The particular area has not been included in any small or large structural study in the recent past but the general area has been studied extensively by the Beloit College faculty and students (see Burntside Lake Fault Zone Project in *Second Keck Research Symposium in Geology* and the conclusion to this abstract). To futher the knowledge of the history of the area, I studied the structural deformation of the biotite schist macroscopically and microscopically.

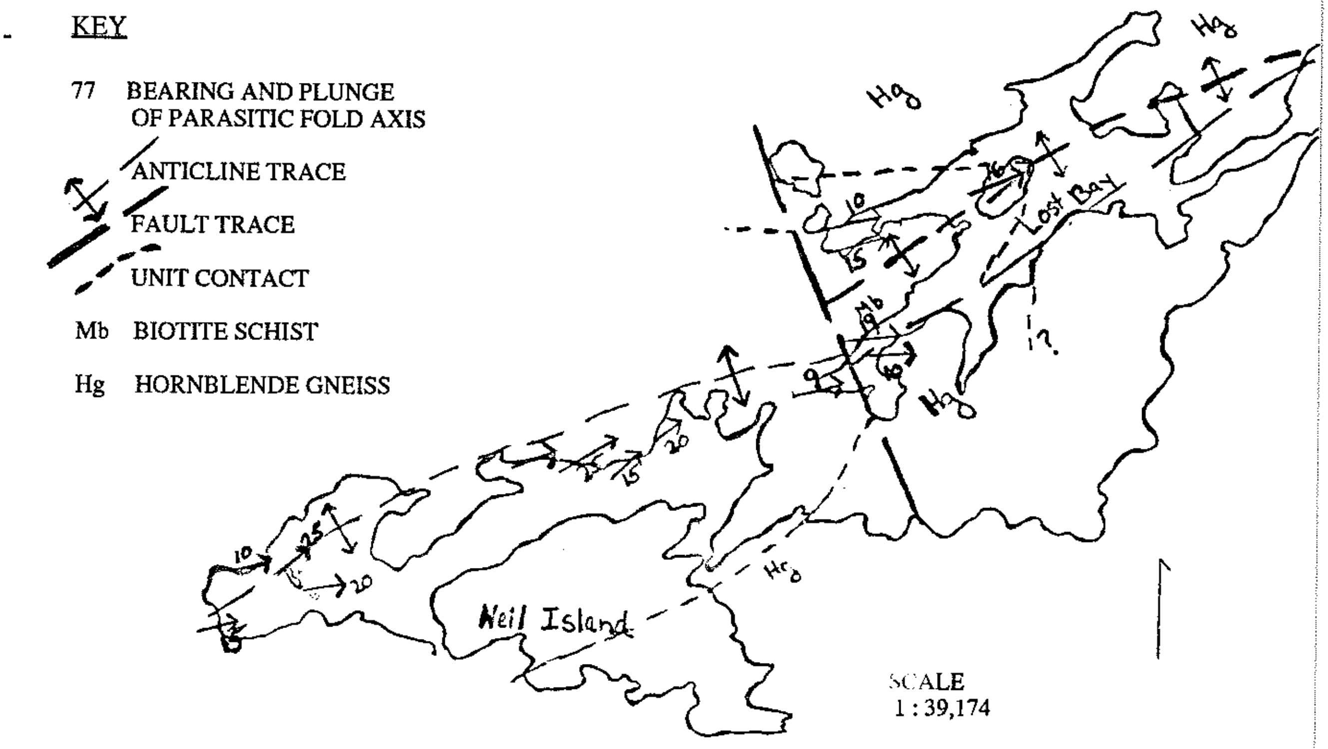
METHODS OF STUDY

I photographed and measured orientations the structural features and recorded their relationships to each other. Oriented specimens were collected of both the hornblende gniess and the biotite schist units and the dikes which cut them.

I compared the structural data collected in the field from the schist unit and contact between it and the gneiss unit on stereonets and maps attempting to correlate it with the the anticline, the Burntside Lake Fault and its splays, and the microscopic structural features observed in thin section.

I collected specimens of the schist around the anticline and atvariable distances away from the fault splays to compare the samples for their relative deformation, mineralogy and petrography. I also collected specimens of some intrusions from this area in order to compare their deformation and mineralogy to that of the rock into which they intruded.

MAP SHOWING WORK AREA AND BEARING OF PARASITIC FOLD AXES



conclusion that the brittle deformation post-dates the ductile deformation.

Additional analysis indicates that the brittle deformation followed the ductile deformation significantly later in time, after a period of non-deformation, and not as a transition or gradual change. Some ductile processes can lead to work hardening, which may build to the point of brittle failure. However, this occurs primarily with lower temperature ductile mechanisms, and it appears more likely that the ductile deformation in this area proceeded at relatively high temperatures, indeed high enough to produce flow of material (dislocation creep), which "can counterract the hardening processes" (Knipe 1989, p.133). Brittle deformation is restricted to low temperatures, especially when extensive shattering of crystals, to the point of creating a microbreccia, is the result. This difference in likely formation temperatures of the brittle and ductile features indicates that the brittle deformation occurred after cooling from the temperatures which allowed for ductile deformation. Probably this cooling was not at all immediate, and a significant amount of time passed between episodes of deformation.

Brittle deformation occurs within a very narrow fault zone, approximately 100 to 200 yards wide, while ductile deformation is universal among my specimens. The five microbreccias have experienced the most brittle deformation, and except for one, all are located directly on the main trace of the fault. The nine breccias received a moderate amount of brittle deformation, and generally are the same distance or slightly farther from the fault trace than the microbreccias. The five mylonites experienced little or no brittle deformation, and are generally farther from the fault trace than the breccias. Ductile deformation appears to be fairly uniform among the specimens, indicating that it was likely the result of regional metamorphism, while the brittle deformation was later in time and was far more localized.

CONCLUSIONS

The granitic migmatite unit along the Burntside Lake fault zone exhibits evidence for both brittle and ductile deformation. Ductile deformation was caused by high temperature regional metamorphism and faulting, which affected all specimens, and produced mylonites. Brittle deformation occurred significantly later than ductile deformation, and made breccias from the pre-existing mylonites. Brittle deformation was confined to narrow fault zones, and consequently affected only those specimens collected very close to the trace of a brittle fault.

The main fault trace within the Burntside Lake fault zone, east of Kettle Lake, may be mislocated as currently mapped, since fracturing of outcrop, evidence of nothing more than late-stage brittle deformation, was the main feature used to identify the fault in the field. If indeed the brittle deformation occurred much later than the ductile deformation, and in a far more restricted area, it may be inappropriate to assume that brittle effects produced the faults most significant in regional structural analysis. With further study, other linear features of the landscape may be found to contain a better "main trace," one which has a larger displacement and was created by the regional metamorphism.

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MACROSCOPIC FEATURES OF BIOTITE SCHIST

The biotite schist's composition is highly quartzofeldspathic with varying percentages of biotite and hornblende. It has foliations that are fairly constant on either side of the anticline. The poles to these foliations (both sides of the anticline) are shown on STEREONET 1. They form a rough saddle with a statistical pole of 9,N55E, which very nearly represents the axis of the anticline traced on the map of the area prepared by the Beloit faculty. This indicates that the foliations predate the anticline and are folded by it.

There are parasitic folds and lineations throughout the area, particlularly prevalent near the anticline, which should parallel the major fold to which they are related with vergences corresponding to the limb on which they are located and to their distance away from the major axis. These folds are represented by their axes on STEREONET 2 and the map. Their average statistical pole is 18,N56E. This pole again very closely agrees with the anticline traced on the map prepared by Beloit but plunges more steeply then the axis suggested by the foliation data. Unfortunately, a vergence could only be recorded for a few of these parasitic folds because many were influenced heavily by intrusions.

MICROSCOPIC RESEARCH OF BIOTITE SCHIST AND INTRUSIONS

The hornblende/biotite rich rocks are highly variable in mineralogic composition and structural deformation but they share in common these characteristics: the plagioclase feldspar grains generally are rounded, some exhibit dynamic recrystallization; the quartz grains form ribbons, demonstrate undulose extinction, polygonization, and dynamic recrystalization; and the specimens exhibit foliation defined by their biotite and hornblende grains. The deformation exhibited in these rocks is characteristic of both brittle and ductile deformation.

The specimens collected from outcrops that are obviously folded in a parasitic manner contain a higher percentage of biotite. This percentage seems to be the only control on the occurrence of the folding but a more consistent study of these folds would be helpful. The observed wavelengths of the parasitic folds appear to be related to the percentage of biotite and the thickness of the bitoite schist unit.

The specimens of igneous rocks that intrude the biotite schist are highly variable but they share these common features: they are highly quartzofeldspathic with a small percentage of biotite and accessory minerals; their quartz grains commonly exhibit undulose extinction and some polygonization and dynamic recrystallization; some exhibit foliation defined by stretched quartz grains or biotite and hornblende grains. In addition to these shared characteristics some specimens also exhibit rounded plagioclase grains; some others exhibit fractures that contain small strain-free biotite, chlorite and quartz crystals; and still others are non-foliated and exhibit quartz strain.

The highly deformed intrusional specimens that exhibit foliation most likely represent the pre-folding hornblende and potassium intrusions and demonstrate ductile deformation post intrusion. Since many of these intrusions crosscut the foliaton of the schist they intruded into and have foliations that differ as much as 20° in both dip and strike from the schist near them, they also demonstrate ductile deformation pre-intrusion.

The fractured intrusions, which also exhibit a high degree of quartz strain and foliation that is crosscut by the fractures, demonstrate a period of brittle deformation after some period of ductile deformation. If water was present at the time of the deformation, the strain-free crystals could have grown concurrently; if no water was present, there may have been a later heating event.

The non-foliated intrusions must post-date the major faulting and folding of the region. However, since they do exhibit quartz strain (demonstrating some type of deformation) there may have been a period of stress, probably ductile, after the major folding and faulting of this region and intrusion of these specimens. However, these specimens of intrusion could also represent heterogeneous deformation; they could post-date the folding and pre-date but not be affected by, the faulting.

CONCLUSION

This general study of the structure of the biotite schist unit in the Quetico Belt suggests possible solutions to the deformation history. With findings in this project and the history of the area compiled by others (see Introduction to Burntside Lake Fault Project in *Second Keck Research Symposium in Geology: Abstracts Volume*) a revised rough history is as follows:

Volcanic activity formed an extensive pile of intrusive, extrusive and volcaniclastic rock. The biotite schist unit is presumably a section of the volcaniclastic pile.

Thick sills of granite, containing hornblende and potassium feldspar, intruded into these units. The Hg is a

Thick sills of granite, containing hornblende and potassium feldspar, intruded into these units. The Hg is a section of this intrusion.

An extensive period of ductile deformation first created a foliation in the schist and secondly a series of folds, including the anticline that deforms my work area. Synchronous to this ductile deformation, partial melting and migmitization of the schist occurred, forming trondjhmemitic leucosomes.

The Vermillion Batholith intruded the existing rocks and injected sills and dikes of biotite leucogranite throughout the area. This Batholith and its sills postdate the folding and pre-date the faulting.

The complex was deformed in brittle manner, creating the Burntside Lake Fault and its numerous splays. This brittle behavior suggests a lessening of heat and pressure of the rock, perhaps caused by an uplift event.

There may have been another heating event, suggested by some petrology of the various intrusions and the the infill of biotite and chlorite into the micro-fractures created by the faulting.

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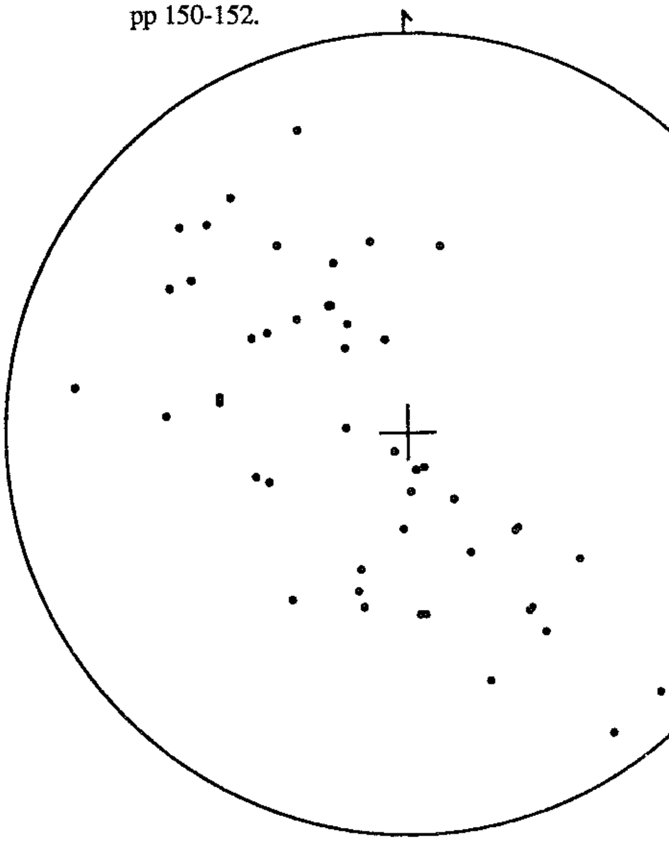
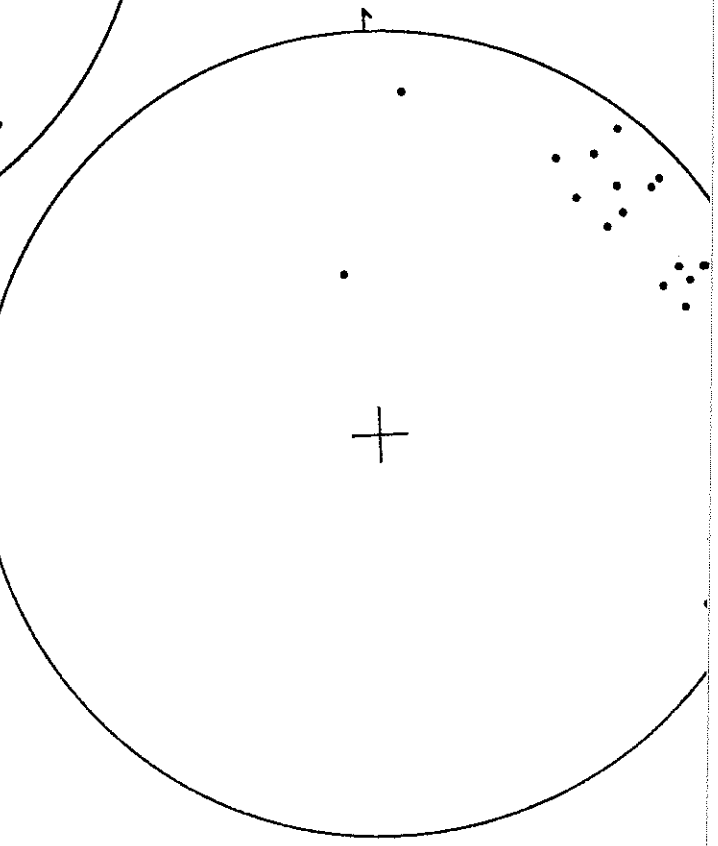


STEREONET 1
(figure left)
POLES OF FOLIATIONS
ON BOTH SIDES
OF ANTICLINE



STEREONET 2
(figure right)
ORIENTATION
OF PARASITIC
FOLD AXES