DOCKING MECHANISM OF THE QUETICO-WAWA JUNCTION AS INDICATED BY STRUCTURAL MAPPING AND ANALYSIS OF AUGEN ZONES IN QUETICO PROVINCIAL PARK, CANADA

Anupma Gupta
Carleton College
Northfield, MN 55057

Kevin Weng
Williams College
Williamstown, MA 01267

Introduction

The Quetico Provincial Park in southwestern Ontario is a picturesque region of small lakes and coniferous/deciduous forest. Slopes are often steep but the amplitude of relief is very small; soils tend to be very thin. There is outcrop along much of the lake shore and frequently inland, although often lichen- and moss-coated. The bedrock is composed of intensely deformed Archean rock with a number of significant structural boundaries. The lineament of Yum Yum and "No Name" Lakes is the junction between two structural belts, the Quetico belt lying to the northwest and the Wawa belt to the southeast (Woodard and Weaver, 1990). [See section preface].

We spent three weeks investigating the structural geology of an area about 3 km by 6 km northwest of the junction encompassing two lakes, "No Name" and McNiece. We attempted to determine the style of deformation at the Quetico-Wawa belt junction by taking structural data. The Quetico belt contains a large body of quartz monzonite with many feldspar phenocrysts, whereas the Wawa belt rocks are predominantly fine grained. The lithology of the Quetico belt was thus more conducive to the formation of macroscopic augen structures than the lithology of the Wawa belt. Since augen can indicate the nature of deformational events, our research was focused mainly in the Quetico belt. We took a lot of data in the vicinity of McNiece Lake; it is the only major lake in the area which does not follow the dominant northeast lineament, and so we investigated the possibility of structural control over this.

Methods

Travelling by canoe or on foot, and using pace and compass mapping, we measured the trend and plunge of fold axes, the strike and dip of S1 (the dominant foliation in the region) and examined macroscopic augen structures. Augen analysis was done by finding outcrops with recognizable augen development and counting the number of grains in a measured area (about $1m^2$), noting their shear-sense. In the lab, augen were studied in three planes at right angles since these views showed whether the grains were sigmoid or disc-shaped. Sigmoid cross-sections indicate a shearing force during formation, whereas a uniform disc indicates a coaxial sigma-1 force, i.e. flattening. (Fig. 1) The structural data, primarily strike and dip values for the dominant foliation (S1), axial planes of folds, and strike and dip of fault surfaces, were plotted on mylar overlays of aerial photographs. Stereoscopic lineament analysis of the photographs aided in data interpretation.

Results

Structural data are plotted in Figure 2. The orientation of the dominant foliation (S1) parallels the topographic lineament of the belt junction. However, McNiece Lake does not follow the N50°E lineament. The augen analysis showed that there is a predominance of flattened phenocrysts with a slight left-lateral shear sense. The augen are generally oriented parallel to S1 and contained within its planes. The shear-sense of the augen we counted were: left-lateral, 84, right-lateral, 10, flattened (no shear-sense), 1256. The total is 1350.

Stereoscopic lineament analysis revealed several arcuate lineaments north of McNiece Lake.

Discussion

Since the dominant foliation parallels the belt junction and the augen are contained within the dominant foliation, the three features were likely produced by the same event. Furthermore, no evidence was found of an older deformational event occurring in both belts. This leads us to hypothesize that the S1 foliation was formed during

"NoName Lake". The S2 foliation did not create folds that could be measured on an outcrop or megascopic scale. The orientations of these F2 folds could not be measured in the field because of their microscopic nature.

S1 foliations in the migmatite units range from an average of N75E/70NW near the south end of Yum Yum Lake to an average of N50E/55NW near the north end of "NoName Lake" (figure 3). S2 foliations remain relatively constant over the area. However, these foliations are much more difficult to measure than the S1 foliations and therefore there may be more measurement error.

There were very few biotite schist rafts within the tonalite. Developed within these few rafts, folds could be seen with structural orientations similar to those rafts caught within the biotite-rich migmatite and the pink granitoid of the Quetico subprovince.

The pink granitic migmatite Mg in the Quetico has more rafts allowing the S1 and S2 structures to be preserved. These too had the same structural orientations as those in the biotite-rich migmatite. The strong S1 foliation is usually the only visible foliation outside of the biotite schist rafts.

CONCLUSIONS

There are at least two periods of deformation in this area. The relative ages of these two deformations are established by observing the weaker foliation cross-cutting two limbs of a fold whose axial plane is parallel to the dominant S1 foliation (figure 2). Our study also indicates that the S1 foliation varies whereas the S2 remains relatively constant over the study area.

Both foliations are consistently at an angle to the junction of the subprovinces. This large scale relationship between the junction and the strikes of the foliations could resemble a large scale S-C fabric from the time that these two subprovinces were "docked". The angular relationship suggests dextral shear sense along the entire junction because foliations form perpendicular to the maximum stress in a rock.

REFERENCES CITED

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Woodard, H.H., and Weaver, S. G.. 1990. The nature of the boundary between the Wawa and Quetico belts, Basswood Lake area, Minnesota-Ontario. Third Keck Research Symposium in Geology, Northhampton, Massachusetts, p. 82-85.

the "docking event," when the two belts came together. From the augen data obtained we can also suggest a docking mechanism. The preponderance of flattened phenocrysts indicates simple compression (coaxial sigma-1 stress) rather than a wrenching, shearing or rotational event. This means the belt junction could have been formed by the docking of two continental plates (assuming plate tectonics existed in some rudimentary form during the Archean) in which there was a coaxial sigma-1 stress perpendicular to the junction. The presence of biotite rich migmatite between the belts indicates a zone of partial melting, possible only if high temperature and pressure conditions were prevalent. High temperature and pressure would be expected at a continental plate margin.

If the belt junction is a plate boundary, then a relative chronology of deformational events supports the idea that the docking event produced the S1 foliation and the augen. Chastain and Kolinski (1991) established that the dominant foliation, S1, was formed earlier than S2; all other ductile deformation evidence is found in the Quetico belt only, so it must have been formed before the docking event. The S1 foliation was produced by the oldest deformational event to affect both belts and the only events which could have formed the augen are those which produced S1 and S2. Since the augen are parallel to S1 and the belt junction itself, it is almost certain that the augen, the S1 foliation and the belt junction were formed at the same time. S2 was produced prior to this, since in occurs only on the Quetico side of the junction.

Conclusions

1. The augen structures, the dominant foliation and the Quetico-Wawa belt junction were formed by the same docking event.

2. The mechanism of docking may have been a plate convergence with roughly coaxial sigma-1 stress perpendicular to the belt junction.

3. This event (from conclusion 1) may have been a continental convergence.

Further Work

Our continental convergence hypothesis requires further study. Isotope analysis could be a valuable tool in determining whether or not our belts have the right chemistry to be a continental convergent margin. Looking at microscopic augen on both sides of the junction in thin-section would also be helpful; if Wawa belt rocks also contain microscopic flattened augen structures our continental convergence hypothesis would be further supported. In this analysis it would be important to distinguish between the behavior of microscopic and macroscopic augen grains, as they may behave differently during deformation.

A more extensive search for foliation older than S1 in both belts is needed. Study of other continental convergent margins during the Archean would also be recommended.

The orientation of foliation along a section of the north shore of McNiece Lake does not follow the dominant northeast trend. Analysis of the stereo-photographs revealed several arcuate patterns north of McNiece Lake which correlate roughly with structural data, suggesting a series of small folds. We speculate that these folds may comprise a larger anticline which has an axial plane oriented subparallel to the curvature of McNiece Lake. This means that McNiece Lake may have been formed by the erosion of a northeast plunging anticline trending subparallel to the belt junction. A glacier moving southward could have plucked on the north and abraded on the south, creating McNiece Lake. The local relief fits this hypothesis; rocks along the north shore of McNiece Lake are well exposed with many outcrops, mostly cliffs, whereas the south shore has little local relief and is covered by till and soil. These hypotheses are highly speculative and further work is needed before any conclusions can be reached about the structural nature of the McNiece Lake area.

References Cited

Chastain, L. M. and Kolinski, A. L., 1991, Character of Megascopic Ductile Structures at the Wawa Subprovince and Quetico Subprovince Junction in Quetico Provincial Park, Ontario, Canada : unpublished undergraduate research report, Department of Geology, Beloit College.

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Figure 2. Map showing structural data.

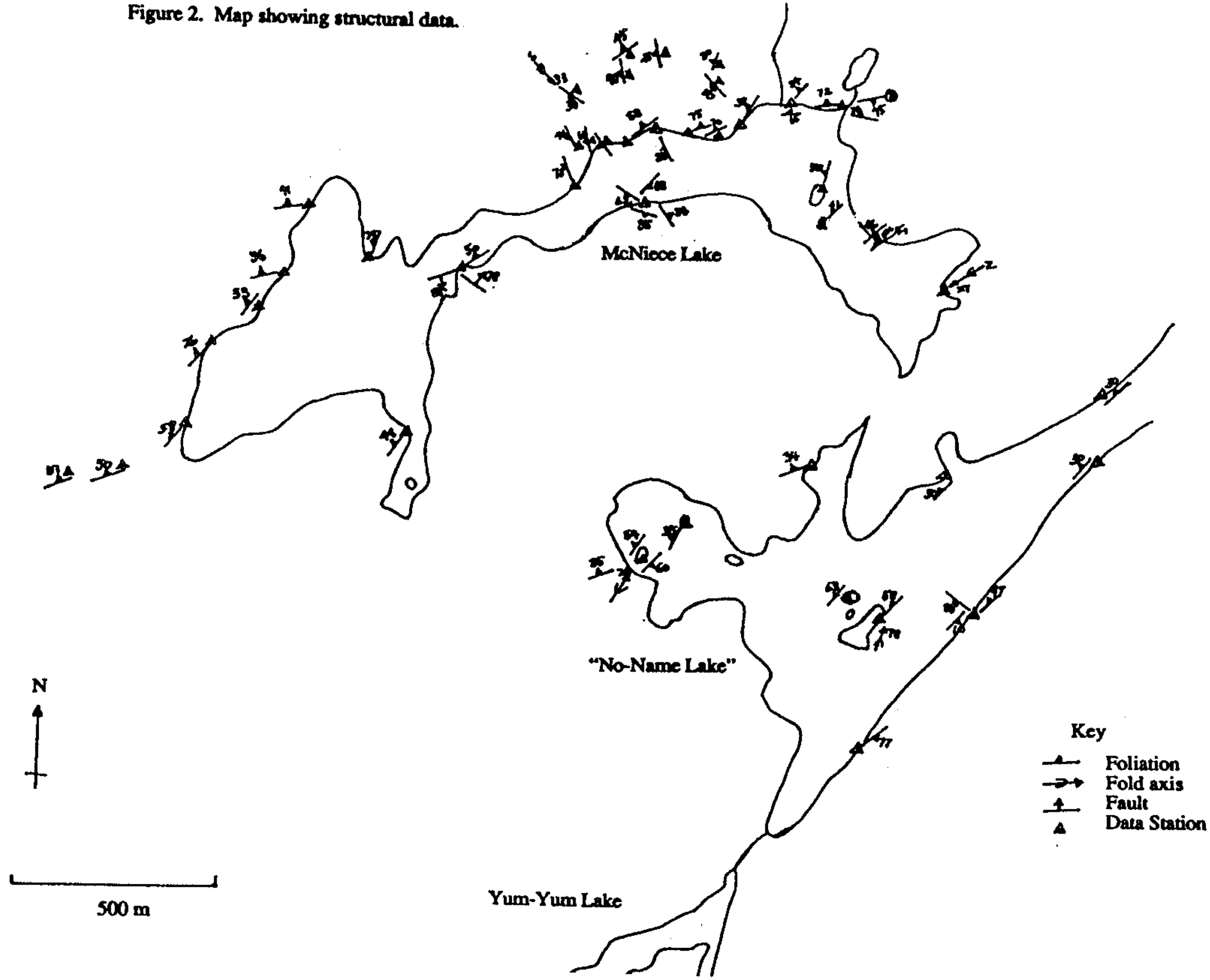
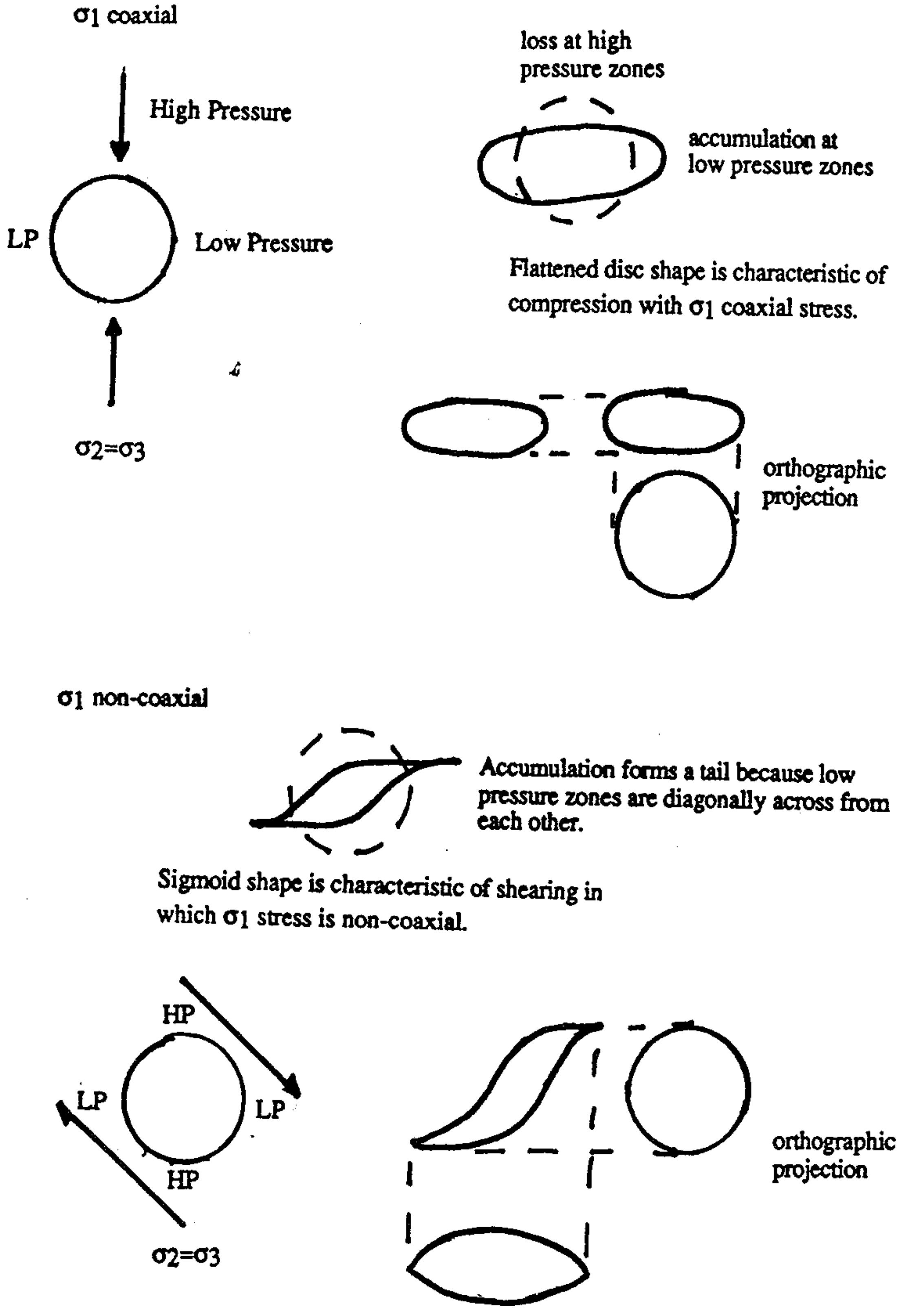


Figure 1. Formation of augen structures.



SEQUENCE OF INTRUSIVE EVENTS IN THE GRAY LAKE REGION OF THE WAWA SUBPROVINCE, QUETICO PROVINCIAL PARK, ONTARIO, CANADA

Anita Ho, Carleton College, Northfield, MN 55075
Eric Small, Williams College, Williamstown, MA 01267

Introduction

A sequence of intrusive events is represented in the Archean rocks of the Wawa Subprovince of the Superior Province. This study examines the sequence in the Grey Lake region of the Quetico Provincial Park, Ontario, Canada. The sequence includes (from oldest to youngest) ultramafic volcanics, tonalites, trondhjemites, potassium feldspar pegmatites and quartz veins. The dikes are emplaced along zones of weakness in the host rock such as faults, shear zones, and preexisting dikes. These veins, dikes, and bosses vary compositionally and texturally and were emplaced by different igneous processes. These processes include volcanism, the junction of suspect terranes, and the emplacement of the Vermillion Batholith in the adjacent Quetico belt. A late trondhjemitic stage could be related to the Vermillion Batholith and provides evidence that this batholith acted as a stitching pluton between the volcanic-plutonic Wawa subprovince and the adjacent Quetico subprovince, which abuts the Wawa to the northwest (Card and Ciesielski, 1986).

The Quetico belt consists of metasedimentary rocks, metavolcanics, and some igneous intrusions. Percival and Williams (1989) suggest that the Quetico belt represents an accretionary prism of sediments between the Wawa terrane and the Wabigon, another metavolcanic subprovince which bounds the Quetico belt farther to the northwest. Anatexis of these sedimentary rocks resulted in granite/pegmatite intrusions in the Quetico belt (Card and Ciesielski, 1986).

The Wawa belt consists of an amphibolite-rich, greenschist to lower amphibolite facies metavolcanics and a hornblende tonalite unit with biotite schist rafts. Field observations indicate the hornblende tonalite unit consists of quartz, plagioclase feldspar and hornblende, with about 10% mafics. This strongly deformed unit has a foliation which parallels the Wawa-Quetico junction and several regional lineaments, trending N50E to N70E and dipping steeply to the north.

The junction between the Wawa and the Quetico belts trends N40E and has been traced for over 40km. The Burntside Lake Fault trends subparallel (about N30E) to the Wawa-Quetico junction and crosses it near Nest Lake to the south of the study area (Woodard and Weaver, 1990).

The Vermilion Batholith was emplaced in the Quetico belt after the host rocks were foliated and prior to the appearance of the Burntside Lake Fault (Gerber, 1990). Emplacement of the batholith resulted in the introduction of potassium in both the Quetico and Wawa rocks (Mariano and Woodard, 1984). Intrusion of batholithic material into both belts suggests that the Vermilion Batholith may have acted as a stitching pluton (Gardner et al., 1988) along the Wawa-Quetico junction.

Methods and Observations

The intrusive sequence in the Wawa belt was determined by observing the orientations, cross-cutting relationships, and compositions of dikes. The presence, distribution, and relative age of crystallization of potassium feldspars was determined by staining specimens in a saturated solution of sodium colbaltinitrate at Beloit College and examining the resulting textures. The observed sequence of intrusions into the metavolcanic and tonalite units of the Wawa belt is summarized as follows:

Ultramafic feeder dikes cut through volcanic breccia within the tonalite. The crosscutting relationships between these units are not clear. These dikes have chill zones and are deformed.

Tonalite dikes are found in the metavolcanic unit and in the tonalite unit itself. These dikes are <5cm wide and continuous laterally for <2m.

Leucocratic stringers cut across the tonalite and metavolcanic units as well as the ultramafic feeder dikes. They are <1cm wide, not continuous, with no clear orientation. They crosscut each other and show compressional deformation.

Trondhjemite dikes cut across all the above, and consist of quartz, plagioclase, <5% mafics, and 15-25% potassium feldspar shown by staining to be mostly secondary. Some contain unoriented mafic clasts. They are foliated with the regional foliation at about N50E, and show a general increase in size over time. The three "generations" were determined by their groupings when plotted on a stereonet. (See Figure 1.) The first-generation dikes are <5cm wide, continuous for <2m. They are folded, sheared and offset 1-100cm. They trend variably with