COMPOSITION GRADIENTS IN TONALITES OF THE WAWA SUBPROVINCE, SUPERIOR GEOLOGIC PROVINCE, CANADA

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INTRODUCTION

The research was conducted on tonalite samples collected from within the Wawa Subprovince of the Superior Province, Quetico Provincial Park (see Woodward, et al., this volume). A series of tonalites of similar age displays a variety of contact relationships with several other lithologies of various ages (e.g. granitic intrusions, basaltic dikes and amphibolites). The focus of the research was to document composition gradients between tonalites and adjacent lithologies and to determine if mobilization of material has taken place between these rocks during intrusion and subsequent metamorphism.

METHODS

Through petrographic study of thirty samples, modal analyses were approximated. Chemical staining of the samples with Na-cobaltinitrite was used to determine distribution and quantity of alkali feldspar present. Based upon mineral assemblages and distinct intrusive contacts, three samples were selected for electron microscopic analysis and backscatter electron imaging on a JEOL microprobe at the University of Georgia. Using the microprobe chemical compositions of selected feldspar and amphibole grains were determined. Secondary backscatter imaging proved useful in visualizing and interpreting textures of the sample fabrics.

RESULTS

The rocks of this study are chiefly medium- to fine-grained tonalites. The tonalitic samples demonstrate one of three distinctly different petrographic characteristics: tonalites with hypidimorphic-granular textures (Group A), tonalites intruded by granitic dikes (Group B), and tonalitic-appearing samples which have granitic mineralogies (Group C).

Group A samples display hypidiomorphic-granular textures, which is generated by early unrestrained growth of certain crystals (Best, 1982). The mineralogies of these samples are: 30-40% quartz, 25-35% biotite, 25-35% plagioclase, 10-20% amphibole, <5% sphene and <1% alkali feldspar. These modal abundances classify the samples as tonalite (Hyndman, 1972). Confirmed by staining with Na-cobaltinitrite, Group A samples are deplete in alkali feldspars.

Samples in Group B are tonalites cross-cut by centimeter-wide granitic intrusions. The modal mineralogies of the tonalites in these samples are similar to those of Group A: 25-35% plagioclase (compositions from albite to bytownite; fig. 2, QT10 & QT6), 30-40% quartz, 15-20% amphibole (edenitic hornblende; fig. 3), 25-35% biotite, and <5 sphene. The granitic intrusions are more rich in alkali feldspar (<90% Or). The granitic rocks contain medium- to coarse- grained minerals which coarsen away from contacts. The tonalite-granitic dike contacts show some gradation into one another; this overlap area, where alkali feldspar is present, ranges from millimeters to centimeters. The minerals in these granitic rocks are mostly alkali feldspar, quartz and minor biotite. This contact was one of the foci of the study. The tonalites are also in contact with amphibolites and basalt. The tonalite-basalt and the tonalite-amphibolite contacts are sharp and do not demonstrate any gradation.

Figure 2

A. Stereonet of the Burntside Lake Fault slickenline data. The box indicates the mean vector for this plot. The mean vector is N32E, 18.4 degrees.

B. Stereonet of the Quetico-Wawa junction slickenline data. The mean vector for this plot is N21E, 16.4 degrees.

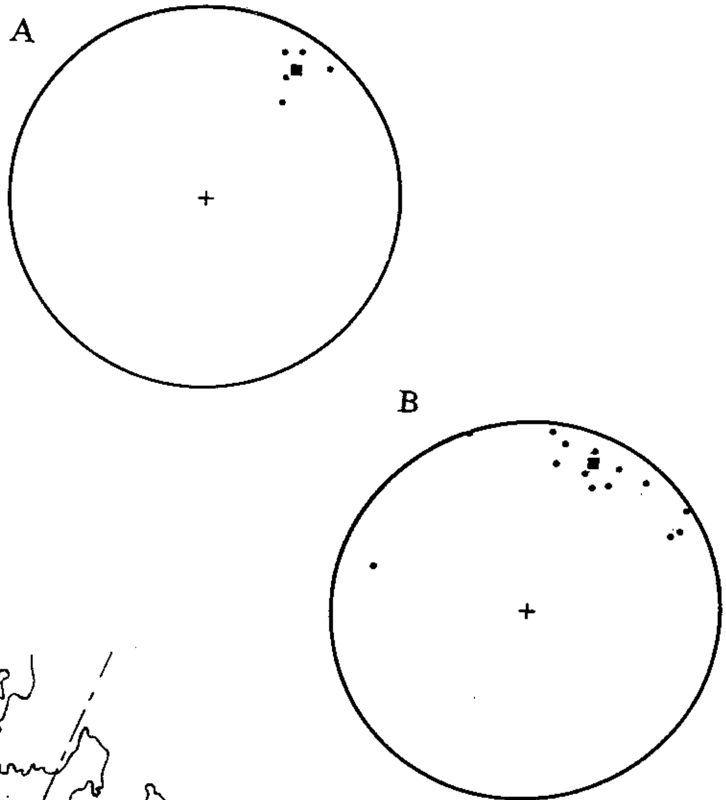
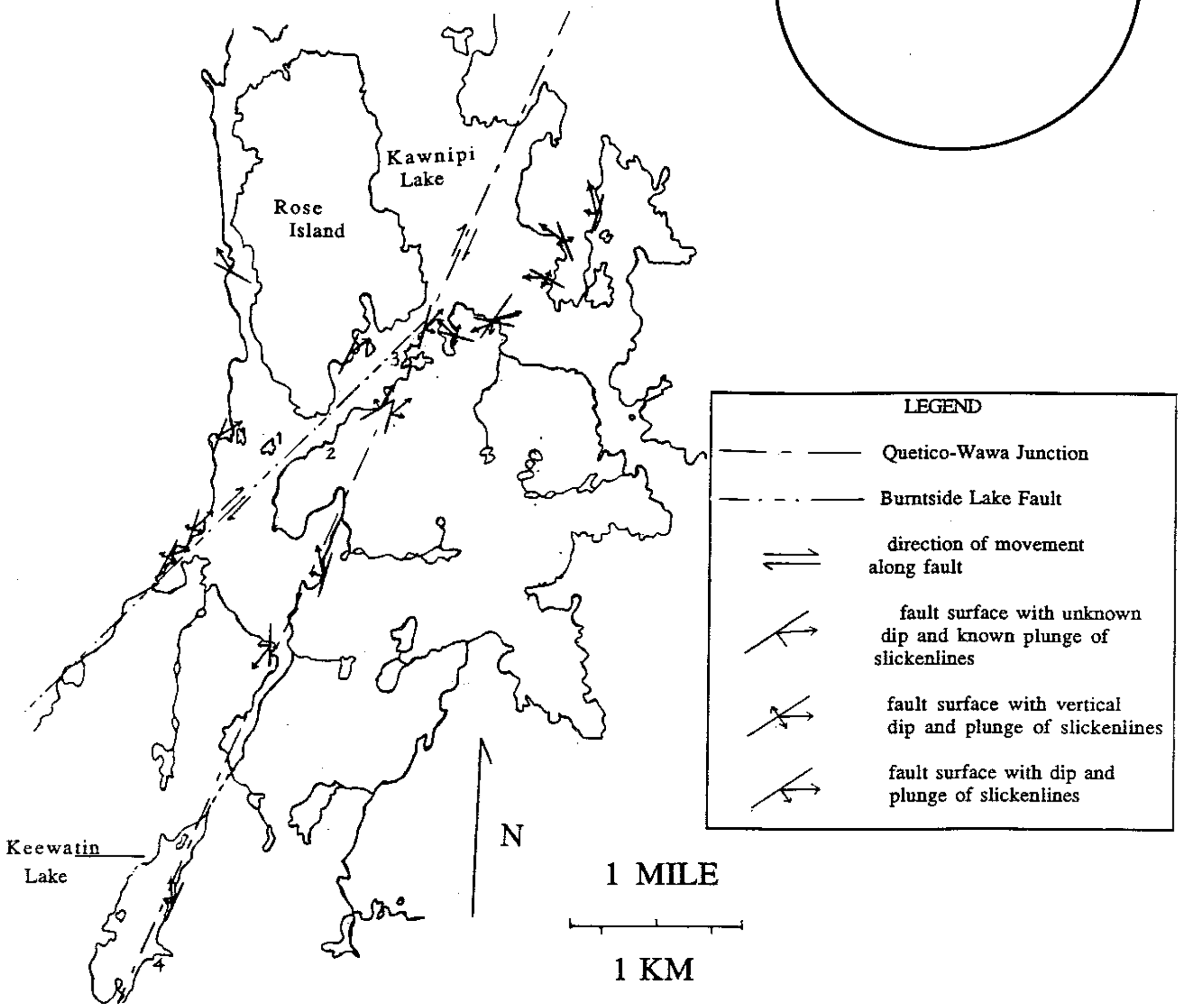


Figure 1



Group C samples have alkali feldspar distributed uniformly throughout. The mineralogies of these samples consist of: 30-35% quartz, 25-35% biotite, 10-20% plagioclase (compositions oligoclase), 10-20% alkali feldspar (see fig. 2), 15-20% amphibole (edenitic hornblende and magnesio-hastingsitic hornblende; fig. 3), and <5% sphene. Mineralogically these samples are granite.

The rocks in Group C are fairly homogenous. In appearance, these samples bear some resemblance to the tonalites in Group A, however their compositions are analogous to those of granites (Hyndman, 1972). The grains are subhedral, inequant and medium to coarse in size. Biotite grains are included inside of the alkali feldspar grains (fig. 1). There is evidence of shearing in these rocks: quartz grains are elongated and planar in orientation and biotite grains are strongly lineated. This shearing was not observed in Groups A and B.

DISCUSSION

The rocks of the study are slightly metamorphosed igneous rocks. Evidence that they are igneous lies in: presence of igneous textures, absence of metamorphic textures, igneous and low grade plagioclase compositions, igneous amphibole compositions, and disequilibrium of alkali feldspars. The samples exhibit relict igneous textures like hypidiomorphic granular grains. They also show no metamorphic crystalloblastic textures. The plagioclase compositions range from bytownite (relict igneous) to albite (low grade metamorphic). Amphibole compositions plot on the "igneous" side of Leake's (1971) limit of igneous compositions. Finally, actinolite, a low grade amphibole is not present in the samples.

The samples are divided into three groups: Group A samples are tonalites, Group B tonalites with granitic intrusions and Group C intruded tonalites which have undergone intense shearing. Group A samples are tonalites which crystallized from a liquid producing hypidomorphic granular textures. Secondary metamorphism of Group A samples affects the chemistries of some minerals present in this group. Group B is composed of tonalite that was cross cut by granitic intrusions after initial crystallization. Evidence for the later intrusion is the sharp nature of contacts between tonalite and granitic intrusion and coarsening of granitic intrusion away from the contacts. Group C is a homogenous rock that was formed by intense shearing of "Group B" type rocks. Fluids, temperatures and pressure associated with shearing cause the alkali feldspar components in granitic intrusions of Group B-type rocks to mobilize and redistribute throughout previously alkali feldspar deplete tonalite.

There are several lines of evidence that shearing occurs in Group C rocks. The presence of low temperature of alkali feldspar in conjunction with higher temperature calcic plagioclase. Intergranular, disseminated distribution of alkali feldspar throughout the samples which have been intensely sheared. The concurrent alteration of hornblende, (K-free mineral) to biotite (K-rich mineral) documents that alkali feldspar was disseminated as a secondary mineral in the tonalites and caused the hornblende to alter to biotite.

Pressure estimates were calculated using Schmidt's pressure equation (1992), because a large number of phases were present in some samples (e.g. hornblende, biotite, plagioclase, alkali feldspar, iron-titanium oxides and sphene). The large number of phases limits the aluminum content in hornblende to being dependent on pressure (Johnson and Rutherford, 1989). Pressure was estimated to be 5-6 kB, based on the aluminum content in hornblende; which last equilibrates at 5-6 kB, a depth of approximately 15-20 km. Crustal thickness in the Archean was thinner than today because it still new, how much thinner is not known. Pressure estimates indicate that the crust was not too thin when tonalites last equilibrated. The estimated 15-20 km depth is close to present day thickness of crust.

CONCLUSION

Despite mineralogy, it is known that the rocks in this group are not granite. The plagioclase grains crystallized at a higher temperatures than the alkali feldspars. The tonalite formed and was later intruded by the granitic dike. The intruded tonalite was secondarily sheared at depth, resulting in plastic deformation of the rock materials and the redistribution of the alkali feldspars.

The samples, based on their mineralogies, are igneous in origin (fig. 3). All of the samples were originally tonalites, despite the granitic mineralogy of Group C. Group C samples are simply altered tonalite. It has been determined that only a minor amount of material mobilization has taken place. This mobilization is attributed to the shearing of intruded tonalites. The intruded tonalites which have undergone no shearing show no mobilization of material across contacts.

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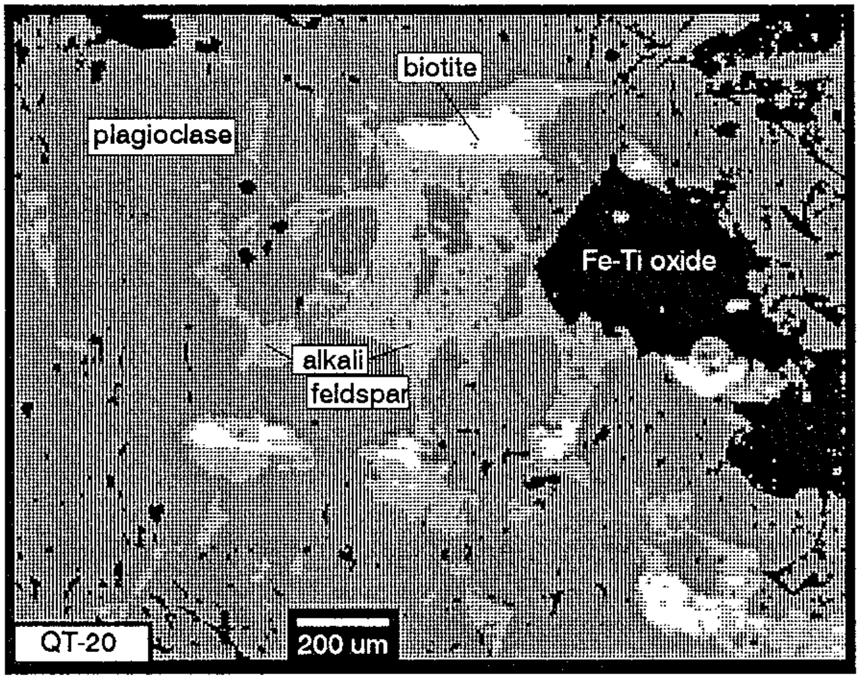

Figure 1. Backscatter electron micrograph showing distribution of biotite (white), alkali feldspar (light gray), plagioclase (dark gray) and Fe-Ti oxide (black). Note disseminated distribution of alkali feldspar and inclusion relation of biotite.

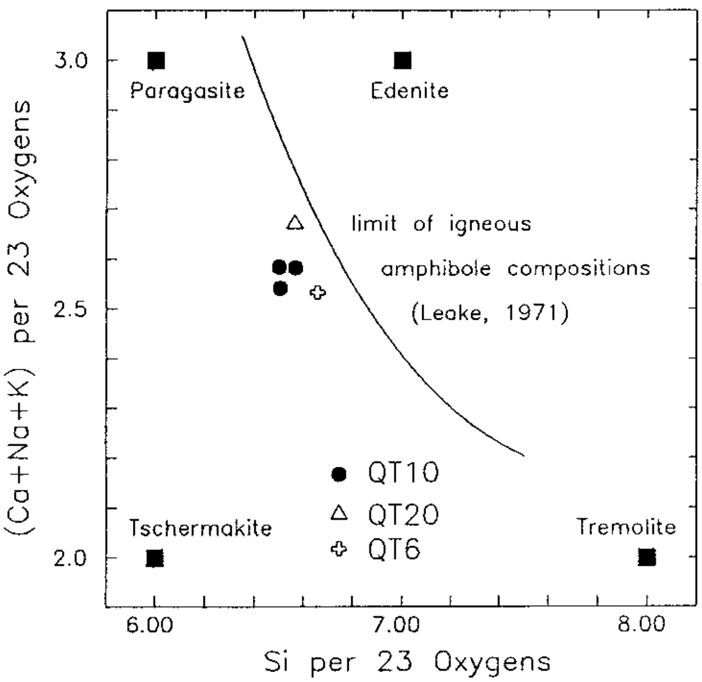

Figure 3. Compositions of amphiboles in Quetico tonalites compared to Leake's (1971) *limit of igneous amphibole compositions*. Samples plot on *igneous* side of this line.

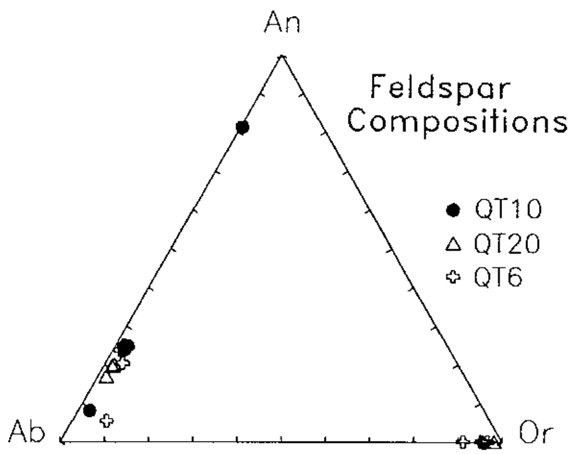

Figure 2. Ternary feldspar compositions. Clustering of compositons around $An_{20\text{-}30}$ may suggest metamorphic reequilibration.

LITHOLOGIC AND STRUCTURAL ANALYSIS OF THE QUETICO AND WAWA SUBPROVINCE JUNCTION, KAWNIPI LAKE, QUETICO PROVINCIAL PARK, ONTARIO CANADA

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Introduction

The purpose of this study was to analyze the lithologies and structural characteristics of the Quetico and Wawa belts near their junction, on northwest portion of Kawnipi Lake in Quetico Provincial Park, Ontario Canada. These two belts belong to the Superior Province (Card and Ciesielski, 1983). The Quetico belt contains volcanically-derived metasediments that pass southward into a zone of relatively high grade metasedimentary migmatites. However, the Wawa belt is composed primarily of metamorphosed mafic volcanic rocks with mappable units of intermediate and felsic volcanics (Williams and Stott, 1991).

Discussion

Lithology and structure of the Quetico subprovince

The primary mappable units of this subprovince are amphibolite migmatite breccia and granite-rich and biotite schist-rich migmatite. Biotite schist-rich migmatite contains more than 50% biotite schist rafts within a granitic matrix. Alongside these rafts, granitic leucosomes and quartz veins are commonly found. Granite-rich migmatite is composed of 5%-50% biotite schist rafts within a granitic matrix. The less abundant amphibolite migmatite breccia is composed of coarse-grained gabbro blocks that are shaped into lense-like structures within a granitic matrix. The biotite schist-rich migmatite and granitic migmatite foliations within this subprovince have strike orientations that fall within the range of N20°E to N40°E. The strike of the axial planes of most antiformal and synformal structures are oriented within the range of N20°E to N45°E. Ptygmatic folds of the leucosomal material found within the granite-rich migmatite strike at N44°E. The amphibolite lenses in the amphibolite migmatite breccia unit, are oriented at N40°E.

The Lithology and Structure of the Wawa Subprovince

The Wawa subprovince is a highly mafic region consisting of amphibolite-biotite schist-rich migmitite (Abs), granitic migmatite (Agx) amphibolite migmatite breccia (Anmb), and biotite schist-rich migmatite (Ap) . Abs is the most abundant unit, while Agx is less abundant. Anmb and Ap are the least abundant units. Abs contains amphibolite schist rafts and biotite schist rafts which are all set within a granitic matrix. The amphibolite and biotite schist rafts contain quartz and granitic veins, as well as trondhjemitic and granitic leucosomes. Agx is a migmatite containing 5%-50% biotite schist rafts within a granitic matrix. Anmb is a migmatite containing coarse-grained amphibolite and gabbro clasts in a granitic matrix. The gabbro clasts are often cross-cut by granitic veins of this matrix. Data collected from fellow students in this program indicate that large bodies of tonalite are located to the east of our study area within the Wawa subprovince.

Foliations in the amphibolite-biotite schist-rich migmatite and granite-rich migmatite strike consistently in the range of N20°E to N40°E. The units are metamorphosed and highly deformed into sequences of antiforms and synforms. Leucosomes and mafic rafts have been deformed into two types of folds: thin, small-scale isoclinal folds and more massive isoclinal fold structures. The strikes of their axial planes range between N20°E and N50°E. The dips of the axial planes are oriented either vertically or dipping steeply to the northwest or southeast, while the fold axes plunge primarily to the northeast.