PETROGRAPHIC AND CHEMICAL COMPARISON OF GRANITIC-RICH MIGMATITE WITH THE LEUCOGRANITE OF VERMILION BATHOLITH, QUETICO PROVINCIAL PARK, ONTARIO.

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INTRODUCTION

The southeast margin of the Vermilion Batholith is located northwest of the Burntside Lake fault in southern Ontario. Positioned between the fault and the batholith, Granitic-rich Migmatite generally forms an outer zone surrounding the batholith(Figure 1). Granitic migmatite can contain up to 50% biotite schist rafts. These rafts make up the melanosome while the leucosome of the migmatite is granitic in character, and is often foliated. If no biotite schist rafts are evident in an outcrop, distinguishing between the batholithic rocks and migmatite is difficult. In general, the biotite schist rafts are aligned within the migmatite, and southwest, in the vicinity of Kett and Wilson Lakes, Thackray and Klug(1984) demonstrated that the aligned rafts could be used to delineate major folds within the migmatite(Figure 1).

Theoretically, migmatites may form from either partial melting, igneous injection, or both processes. The purpose of this study is to compare these two rock types to determine if they are petrogenetically related. Both petrographic and chemical data obtained with an inductively coupled argon plasma atomic emission spectrometer (I.C.A.P.) will be used.

OBSERVATIONS

Foliation

Cataclastic foliation is present in the migmatite leucosome. This structural element can be identified both in hand specimens and in thin section. The foliation approximately parallels the strike of the Burntside Lake fault suggesting that it is in large part related(Figure 1). Although most of the foliation measurements are in the general direction of the fault, not all of the foliations measured in the field are exactly parallel, giving evidence of two periods of shearing. The original shear foliation was further developed by the later movement along the Burntside Lake fault, as the original planes of weakness again became active. The leucogranite shows very little foliation and is therefore described as massive. This lack of foliation can be accounted for by noting the position of the leucogranite in relation to the Burntside Lake fault zone and because the emplacement of the batholith is later than the formation of the original foliation in the migmatite. Thus, the batholith does not exhibit foliation while the migmatite. Because the batholith is pre-movement on the Burntside Lake fault, foliations do develop locally associated with splays which enter the leucogranite.

Mineralogy

Mineralogically, there is little difference between the migmatite leucosomes and the leucogranite. Both have quartz, plagioclase(An_{37-42}) and two varieties of potassium feldspar; perthite and microcline. Small amounts of biotite and myrmekite are present along with the accessory minerals magnetite, zircon and allanite. Sericite is present as an alteration product of plagioclase but muscovite is rarely present. Secondary hematite can be seen in plane polarized light following the foliation within the rock. This hematite staining gives both rock types a pink color that is most prevalent in rocks closer to the fault trace. Remnant plaid twinning, indicative of microcline, is often found within the larger perthite grains. Even though the perthite grains are secondary, they do exhibit strain features and thus formed pre-shearing. Two ages of potassium feldspar also occur in the unfoliated leucogranite, but to a lesser degree. The microcline found in the leucogranite is generally less engulfed by perthite than the microcline in migmatitic rocks.

Petrography and Chemistry

Point count analyses were done on fifteen thin sections, five from the leucogranite and ten from migmatite rocks. When plotted on an IUGS classification triangle for igneous rocks, all specimens plot as granites (Figure 2). The results of this analysis show no distinct difference in mineralogy between the two rock types mapped as separate units(Figure 1). Chemical data compiled on the leucogranite were completed by my field partner, Mark Newcomb, while I gathered data on the migmatite rocks. Both data sets were pegmatites were affected the most by this event, since they had probably formed in previous zones of weakness. The sharp contact between the sheared pegmatites and the wall rock suggest that the wall rock is on a whole resistant to this shearing.

The rare places where the wall rock has been sheared there are two certain characteristics, an enrichment in feldspar and quartz and a very fine crystalline texture. The shearing could easily grind down the size of crystals within the shear zone, and the nearby pegmatite supply the feldspar and quartz that enriches the zone. Intermixing of crystals within the zone during shearing could account for the movement and enrichment of feldspars and quartz.

The faulting itself was either accompanies or followed by one or more periods of hydrothermal activity. This activity accounts for the hematite staining found through out the region. It also accounts for the small Quartz veins that cut through the entire region as well. This phase of hydrothermal activity is most likely responsible for the alteration and break drown of the intrusions as well as the healing of cataclastic zones.

Conclusion

The history of intrusion in this region is far more complicated than the chronology given above. The shearing that has occurred along the dikes has obscured most of the cross cutting relationships found in the region. This shearing and hematite staining also obscured field data and caused an initial misidentification of dikes.

The pegmatites themselves deserve more study. The of pegmatite intrusion is most likely composed of at least two or three complicated phases. Exactly how these relate to the increase in potassium feldspar and any metamorphic events is at this time poorly understood. A comparison between the pegmatites and the granitic intrusion should also be looked into. More study should also be given to the amphibolite in the region and it's origin.

This study truly only scratches the surface of the intrusive history in the this region. It shows that any further study must acknowledge and recognize the shearing that has occurred within dikes at the field. Only by accounting for this shearing will any such study be successful.

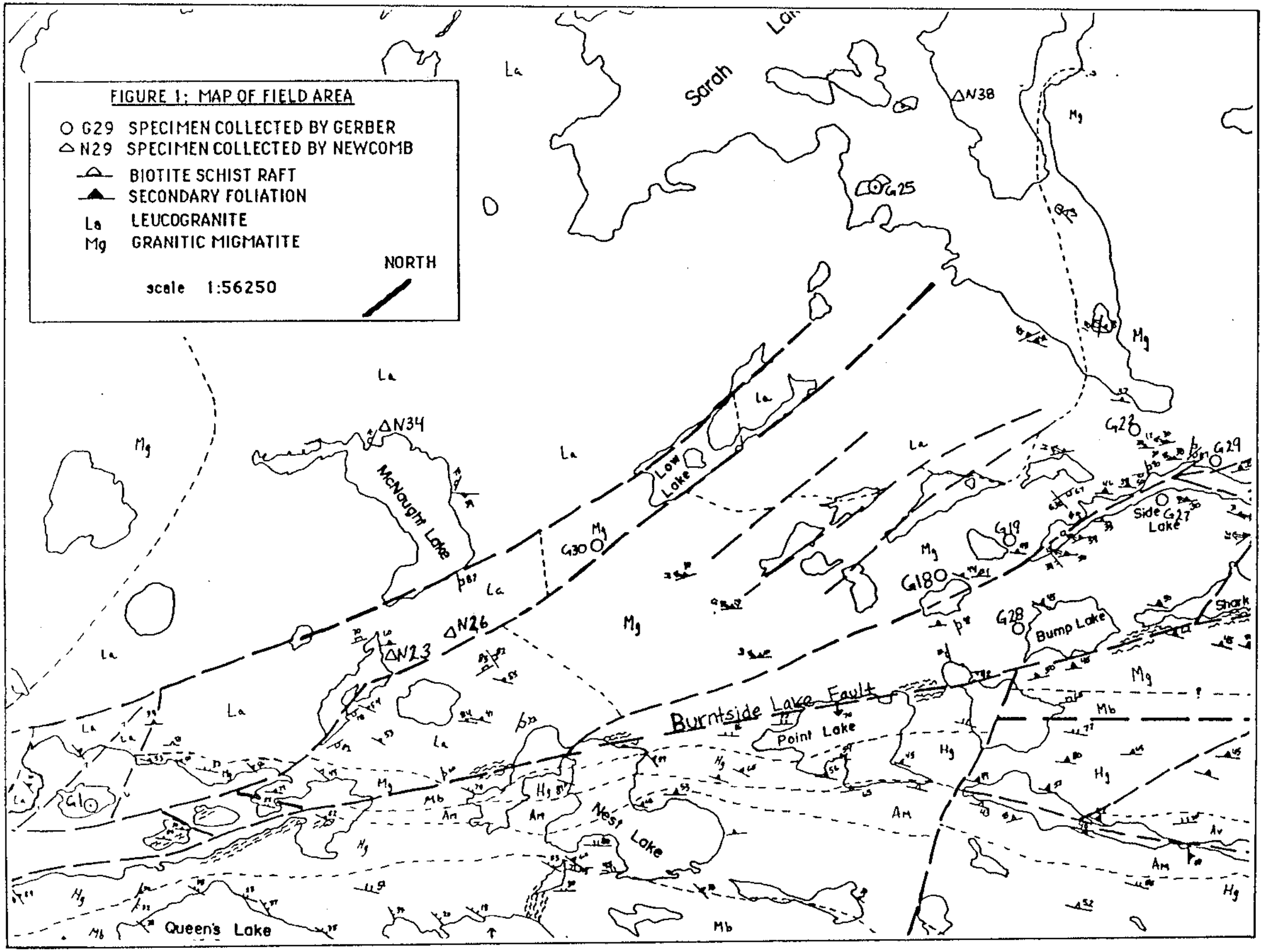
FIGURE 1: MAP OF FIELD AREA
G29 SPECIMEN COLLECTED BY GERBER
N29 SPECIMEN COLLECTED BY NEWCOMB
BIOTITE SCHIST RAFT
SECONDARY FOLIATION
La LEUCOGRANITE
Mg GRANITIC MIGMATITE
NORTH
scale 1:56250
Sarah
N38
G25
N34
McNaught Lake
Low Lake
G30
N26
N23
G19
G18
G28
G29
G27
Side Lake
Bump Lake
Shark
Burntside Lake Fault
Point Lake
Nest Lake
Queen's Lake
G1
La
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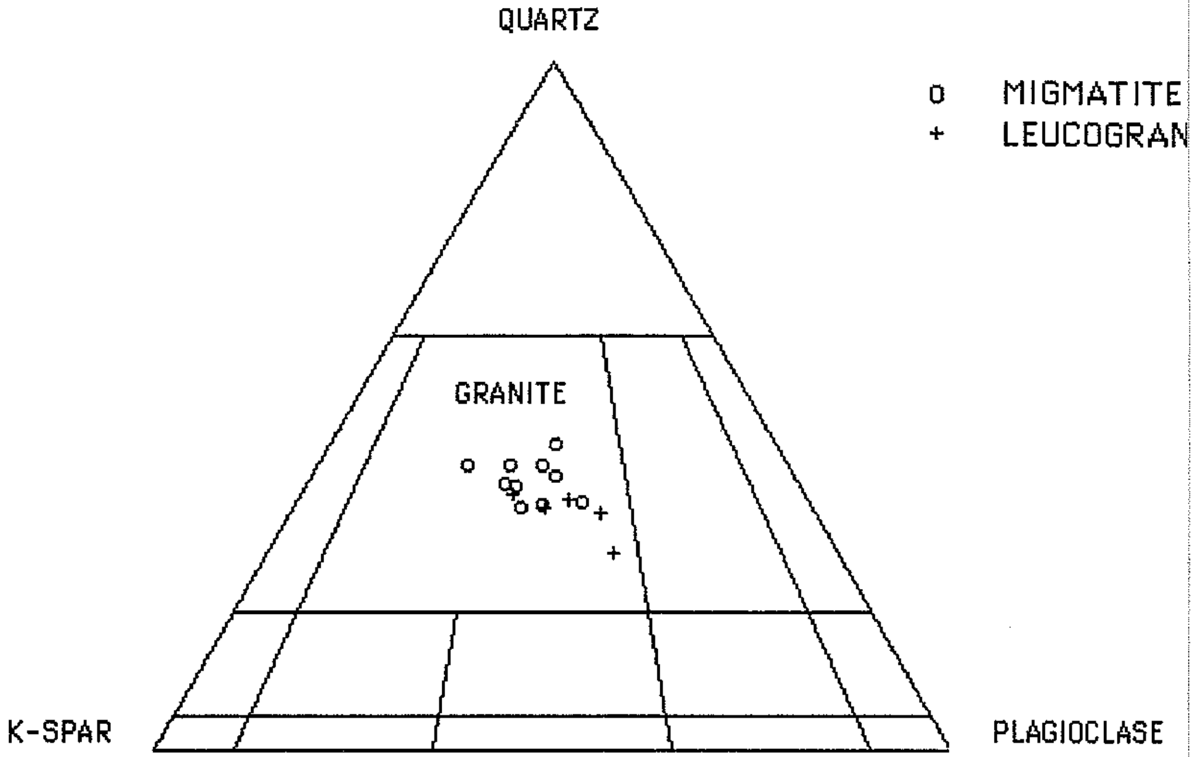

FIGURE 2: MODAL ANALYSIS

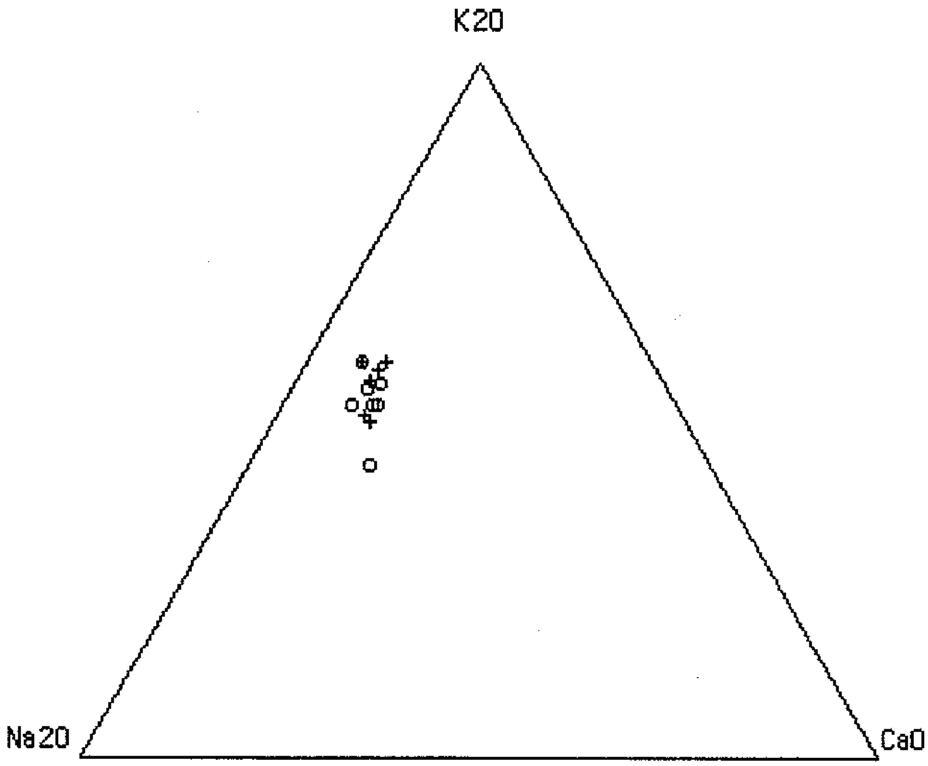

FIGURE 3: K2O-Na2O-CaO PERCENTAGES IN LEUCOGRANITE AND MIGMATITE

analyzed on an I.C.A.P. Six leucogranite specimens and six migmatite specimens are plotted on a ternary diagram according to the potassium, sodium, and calcium percentages in each rock (Figure 3). These data also exhibit overlapping chemistry for the two rock types.

An interesting relationship exists between the pre-existing microcline and plagioclase with the later perthite. The perthite appears fresh and glassy and surrounds older or replaced microcline indicating the perthite is secondary relative to the microcline. This relationship can be explained by an introduction of potassium-rich fluids into the pre-existing rocks. Plagioclase(An37-42) plus potassium ions forms perthite according to the reaction given by Collins (1988):

$$\begin{array}{l} CaAl_2Si_2O_8 + K = KAl\,Si_3O_8 + NaAlSi_3O_8 + SiO_2 + Ca + Al \\ NaAlSi_3O_8 \qquad\qquad\qquad\quad CaAl_2Si_2O_8 \\ \qquad\qquad\qquad\qquad\qquad\qquad\qquad \text{MYRMEKITE} \end{array}$$

A volume for volume replacement of the pre-existing plagioclase with potassium ions forms perthite and myrmekite. The myrmekite grains contain plagioclase with the composition of about half of the An content of the parent plagioclase. This relationship is present in both batholithic and migmatitic rocks: parent plagioclase $An_{37\text{-}42}$, myrmekite plagioclase $An_{18\text{-}22}$.

CONCLUSIONS

Petrographic and chemical analysis shows the migmatite leucosomes are mineralogically and chemically similar to the leucogranite. Perthite, engulfing older microcline, along with the presence of myrmekite, indicates an introduction of potassium into these rocks. Also supporting this conclusion is the fact that the An composition of the myrmekite is half the An composition of the parent plagioclase (Collins, 1988).

REFERENCES CITED

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Thackray,G., and Klug,D., 1984, Geology of portions of Basswood Lake West and Jackfish Lake Quadrangles, Minnesota: unpublished undergraduate research report, Department of Geology, Beloit College.

BRITTLE AND DUCTILE DEFORMATION IN THE BURNTSIDE LAKE FAULT ZONE OF QUETICO, ONTARIO

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INTRODUCTION

Granitic specimens collected within the Burntside Lake fault zone in Ontario's Quetico Provincial Park have undergone both brittle and ductile deformation. Examination of twenty-three thin sections formed the bulk of this study in which the styles and results of physical deformation within the Burntside Lake fault zone are described.

All specimens were taken from the same unit, referred to in the field as granitic migmatite. This unit is a quartz, plagioclase, and alkali feldspar rock, with occasional rafts of biotite schist. The schist rafts were rare and no specimens of this portion of the unit were taken for this study. The specimens exhibit a considerable variety of brittle and ductile deformational features. Continuous fractures and microfaults with offset are evidence for brittle deformation, while crystals with undulose extinction, subgrain development, and kinked twins show the effects of ductile processes. Specimens were classified as breccia, microbreccia, or mylonite, following the scheme of Wise, et al. (1984).

OBSERVATIONS AND DISCUSSION

The best indications of brittle deformation are "continuous fractures cutting across grains of different compositions and orientations" (Mitra 1984, p.52). This is evident in Figure 1, which shows a set of parallel microfaults cutting across the entire thin section. Often it is difficult to tell how continuous a fracture is, but visible offsets, present in several specimens, along such a fracture can help indicate a microfault. Brittle deformation fractures crystals, and can produce a breccia of angular crystalline fragments. In most of the specimens classified as breccias, it was fairly obvious that the rock had been a mylonite prior to brittle deformation, since features caused by ductile deformation were only slightly obscured by brittle fracture. Where brittle deformation has been most intense, grain size is reduced further by multiple fractures, creating microbreccias. Usually, grains of all compositions have been completely shattered. However, the pieces sometimes remain in place and the approximate dimensions of the original grain can be seen. In Figure 2, a grain of ribbon quartz remained somewhat intact, but is surrounded by tiny angular fragments typical of the microbreccias.

Ribbon quartz is the result of ductile deformation, and is detectible in all specimens to a certain degree. Ribbon quartz means elongated quartz subgrains. Recovery responses to strain, like dislocation glide and cross-slip, which are thermally activated, can generate subgrains with high-angle boundaries (Knipe 1989), as seen in the ribbon quartz. Lobate grain boundaries, observed in several specimens, are likely the result of syntectonic migration recrystallization, and such "textures are generally relict in the low-temperature environment" (Groshong 1988, p.1331). These ductile deformation features observed in the quartz are, therefore, created in a relatively high temperature environment.

Undulose extinction caused by ductile deformation is universal in the feldspars in the specimens, but is not nearly as extreme as that seen in the quartz. Kinking of albite twins produces extinction bands in plagioclase and is also indicative of ductile deformation. Quartz experiences ductile deformation at lower temperatures than feldspar (Tullis and Yund 1977). Consequently, at temperatures producing extensive ductile deformation in quartz, feldspar will show some evidence of ductile processes, but will be far less deformed. As shown in Figure 3, feldspar has somewhat undulose extinction, but the quartz has been far more deformed into the elongate subgrains of ribbon quartz. In the photomicrograph, the quartz appears to have flowed around the feldspar, confirming the fact that feldspar is more rigid at high temperatures. The relatively fresh appearance of the feldspar, compared to the quartz, does not disprove the theory that the ductile deformation occurred at relatively high temperatures, since feldspar remains fairly rigid, even at temperatures that allow significant deformation of quartz.

It is extremely important to note that the fractures and microfaults formed by brittle deformation cross the ribbon quartz. This is shown in Figures 1 and 4. It thus appears impossible for the brittle and ductile deformation to have occurred simultaneously. Since the brittle features override, and partially or wholly destroy the ductile features, it is my