PETROLOGY AND GEOCHEMISTRY OF A HORNBLENDE QUARTZ DIORITE GNEISS, BURNTSIDE LAKE FAULT ZONE, QUETICO PROVINCIAL PARK, ONTARIO,CANADA

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INTRODUCTION

The geology along the Burntside Lake fault zone, and indeed much of the Wawa and Quetico blocks, has been described by Canadian and other geologists as pink granite, a part of the 2.7 billion year old Vermillion Batholith. Upon closer examination, however, it becomes clear that the rocks in the Wawa block south of the fault do not belong to the Vermillion Batholith. Instead, the rocks consist of folded metasedimentary/volcaniclastic units and an orthogneiss intruding this sedimentary pile. The metasediments, which mainly consist of biotite schist (Mb in Fig. 1), are often migmatized to such an extent that the leucosome (pink granitic material) exceeds the metasedimentary melanosome. The intruding orthogneiss unit (upon which this paper is focused) appears granitic in the field due to the pink staining of abundant feldspars. The unit, in fact, has been classified from hand specimen by Beloit College workers as a hornblende granite gneiss (Hg, as it is now referred to on the geologic map, Fig. 1). This study addresses the problem of classifying the unit and examines the petrologic and chemical variation in a suite of Hg.

The study area spans from Nest Lake, near the southern border of the Quetico Provincial Park, to the northeast along Point, Isabella, Dell, and Grey Lakes. Hg is found along this entire 10km transect which also follows the trend of the fold axis of a major structural anticline. The outcrop pattern of the Hg suggests that it may have intruded as a sill, and was subsequently folded with the Mb wall rock. Mapped geology of the study area and specimen locations are shown in Fig. 1.

FIELD AND PETROGRAPHIC DESCRIPTIONS

In the field, the Hg unit appears to be a granitic gneiss with amphibole as the mafic constituent. The amphiboles are oriented in a planar rather than linear fashion with a variable degree of foliation. The amount of ferromagnesian minerals also varies from outcrop to outcrop, ranging from hornblende gneiss to amphibolite or hornblendite. In many outcrops, there is a distinctive pink coloration to the feldspars, which, coupled with a lack of macroscopic albite twinning, makes them appear to be potassium feldspars. Quartz is also evident in field observations, but not in high percentages.

Several rock types are closely associated with the Hg in field relationships. A leucocratic trondjhemite regularly cross cuts the Hg, forming various sized dikes. A more extensive unit which is mapped within the Hg is labeled as Am in Fig. 1. The Am unit consists of highly mafic coarse grained amphibolite blocks surrounded by a pink leucocratic matrix. The angular blocks may represent a volcanic breccia with late stage intrusion of granitic material or they may be the result of incomplete hydrothermal differentiation as described by Collins (1988).

Modal analyses of thin sections made from specimens located in Fig.1, revealed that the hornblende granite gneiss is not a granite. A Streckeisen diagram was constructed using point count analysis data and a ternary plot program (Fig.2). According to this diagram, the specimens plot as hornblende quartz monzonite, hornblende quartz monzodiorite, hornblende granodiorite, hornblende quartz diorite, and hornblende tonalite.

The mineralogy of the specimens is dominated by plagioclase and hornblende. Using the Michel-Levy method, the euhedral plagioclase is found to be predominantly oligoclase (An_{10}-An_{30}). Most grains show no zoning, although there are exceptions. Sericitization of plagioclase is ubiquitous but variable in degree. Albite twinning is apparent in some grains and is often bent due to shearing in the fault zone. Many plagioclase grains, however, show no twinning. Plagioclase was, therefore, frequently discerned from potassium feldspar by using optical relief and comparative chemical alteration. The hornblende grains display alteration to biotite and chlorite and also contain quartz " sieve structures, " as discussed in Collins (1988). At the core of some amphiboles are relict clinopyroxenes. This is good evidence for an igneous protolith; the change from clinopyroxene to hornblende may indicate a change in magma chemistry during crystallization. Potassium feldspars include microcline and perthite which fill interstitial spaces. In some sections, the microcline is seen engulfing remnant plagioclase as if it is

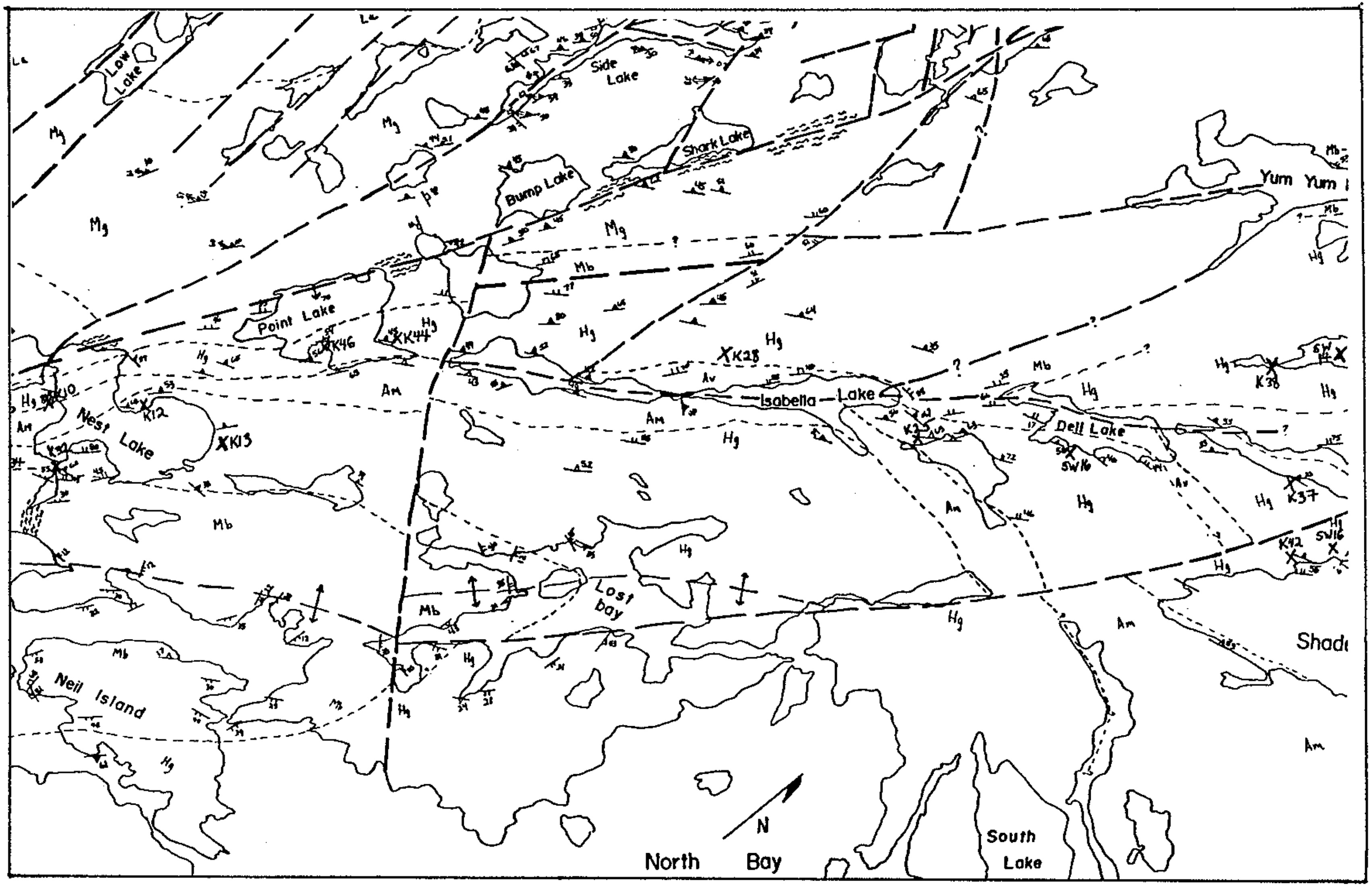


Figure 1 Geologic map of study area (H.H.W. 1989).
Scale is 1:24,000 " X "designates specimen sites

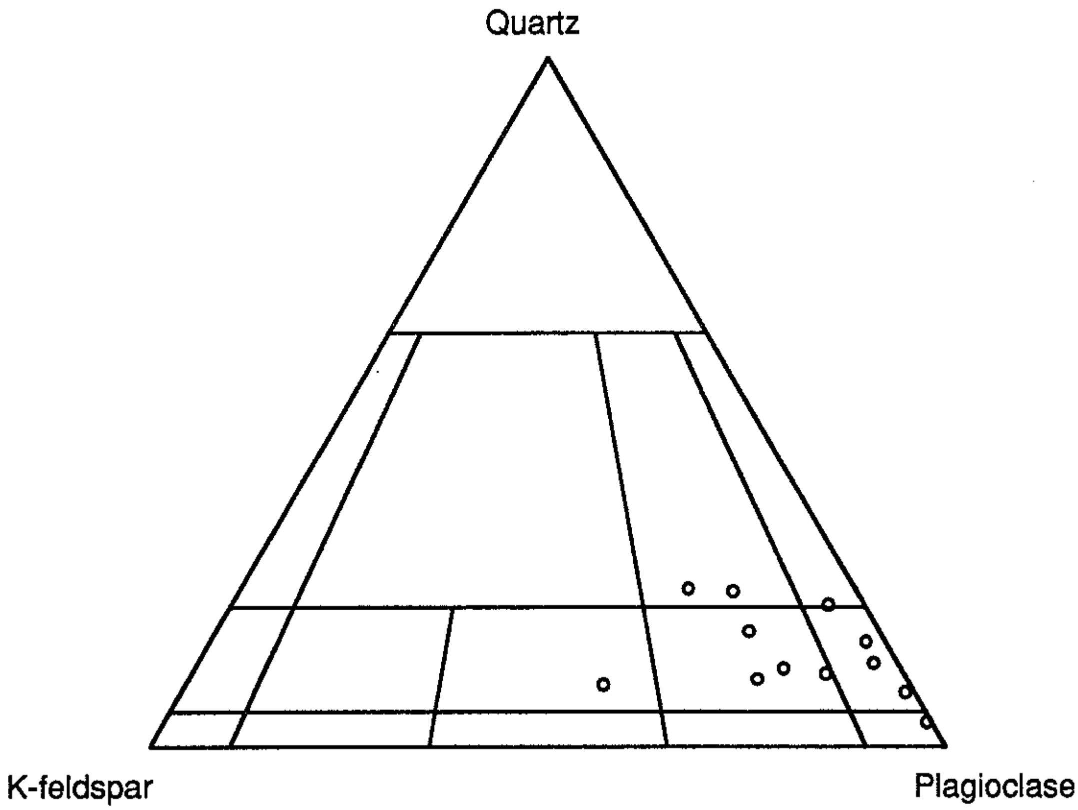


Fig. 2 Streckeisen Diagram

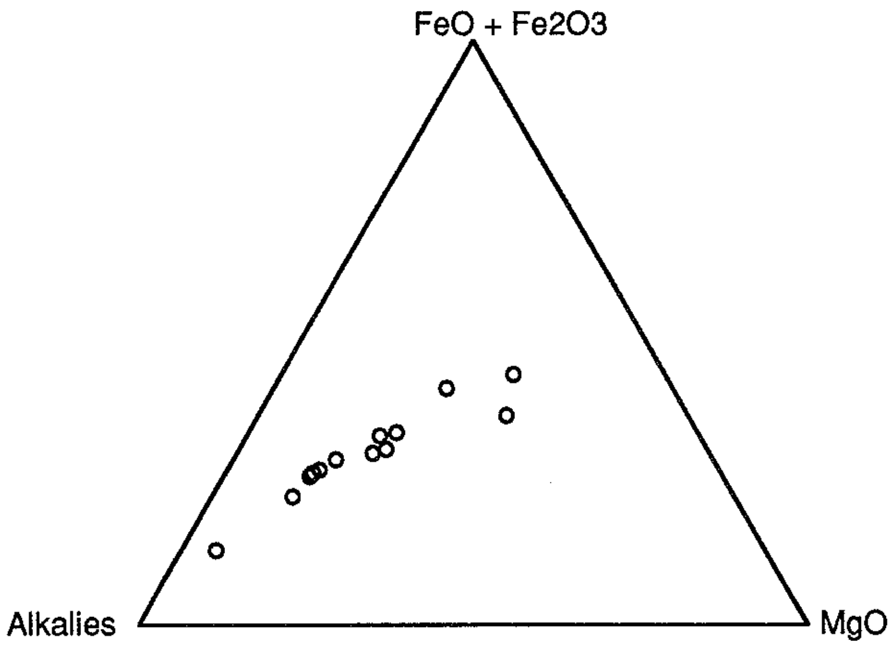


Fig. 3 AFM Diagram

replacing it. The distribution of potassium feldspar is not homogenous, but rather concentrated in patches. Quartz, which is either interstitial or found within plagioclase and hornblende grains, is frequently polycrystalline and exhibits undulatory extinction. Accessory minerals include sphene, zircon, allanite, and epidote The sphene is often found in close association with the hornblende. Myrmekite is also present in nearly all specimens which, along with other data, may be an important indicator of metasomatic modification of these rocks (Collins, 1988).

GEOCHEMISTRY

Geochemical analyses for major and selected trace elements were done at Beloit College with a newly acquired inductively coupled argon plasma atomic emission spectrometer (ICAP). When plotted on an AFM diagram the rock suite follows a typical calc-alkaline trend (Fig. 3). The Harker diagram of Alkalies vs. SiO_2 (Fig. 4) shows an abnormally high alkali content for calc-alkaline rocks. Furthermore, there is a wide range of alkali content at equivalent SiO_2 percentages. This suggests that, if the rocks are genetically related, magma differentiation is probably not responsible for the alkali variation. When K_2O is plotted against Na_2O (Fig. 5), a replacement relationship is suggested; as sodium decreases, potassium increases in a crude linear fashion. Both Figs. 4 and 5 may be evidence for metasomatic replacement by potassium or hydrothermal differentiation as suggested by Collins (1988).

Rare Earth element analyses produced rather enigmatic results. In plotting chondrite normalized Ce and La vs. SiO_2 (Fig.6), two distinct groups of rocks emerge: those with high light REE content and those with lower light REE content. The SiO_2 content is approximately the same (about 60% SiO_2) for both groups; thus, the conclusion of two separate intrusions is a possibility. Furthermore, the two groups can be separated geographically. However, when La is plotted against Ce (Fig.7), a linear relationship emanating from the origin is exhibited. From this relationship, we may infer that the specimens analyzed are genetically related, i.e., the La/Ce ratio remains fairly constant among all of the specimens. More work remains with respect to the implications of these relationships.

DISCUSSION

L. G. Collins in Hydrothermal Differentiation(1988), describes the presence of myrmekite in rocks as indicating the involvement of metasomatic hydrothermal reactions. He explains a number of phenomena which seem homologous to what I have encountered both mapping and analyzing the Hg. Collins asserts that in or near shear zones, potassium rich hydrothermal fluids are able to permeate rocks and exchange ions. This ion exchange makes it possible, in extreme replacement, to change the mineralogical and textural characteristics of diorite/gabbro to those of granite: hence the name hydrothermal differentiation.

Where the rock is strained and hydrothermal fluids are able to penetrate, the mafic minerals, such as pyroxene and hornblende, break down and leave behind quartz. If this process is limited or incomplete, quartz sieve textures form within these ferromagnesian minerals . Similarly, the K- rich fluids deplete the plagioclase of Ca and Al, and are able systematically to replace the plagioclase with myrmekite. If the process continues, the plagioclase may be completely replaced with microcline or perthite, depending on equilibrium conditions (Collins, 1988).

CONCLUSIONS

If the Hg suite has been, to whatever extent, hydrothermally differentiated, several curious aspects of my field observations, thin sections, and chemical data may be explained.

1.) In the field, the presence of angular mafic enclaves surrounded by granitic material (Am) may indicate that the matrix is hydrothermally differentiated material which was once the same composition as the enclaves. The implication is that the impermeable enclaves broke under stress instead of forming microfractures necessary for hydrothermal differentiation. In other words, hydrothermal fluids were not able to alter the enclave mineralogy.

2.) In thin section the presence of myrmekite can be explained as a product of hydrothermal differentiation.

3.) Lack of plagioclase zoning and albite twinning may be due to early or partial hydrothermal differentiation which depletes the plagioclase in Ca and Al.

4.) The abundance of sphene, zircon, and epidote may have formed by the hydrothermal breakdown of ferromagnesian minerals which released the cations necessary to form these accessory minerals.

Fig. 4 Alkalies vs SiO2

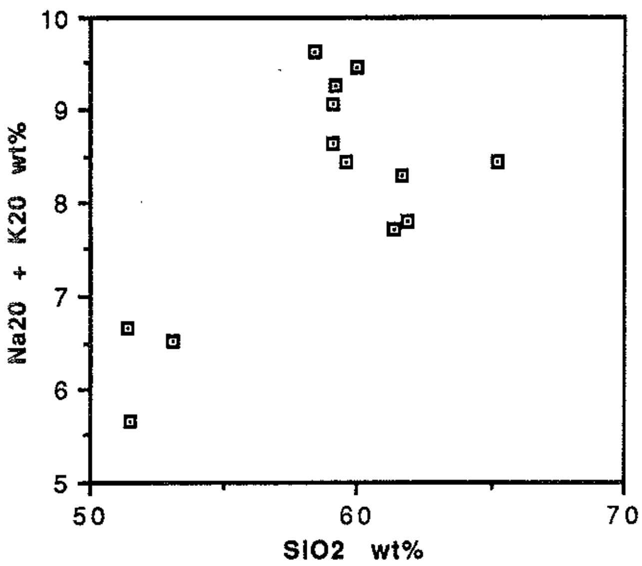


Fig. 5 K2O vs Na2O

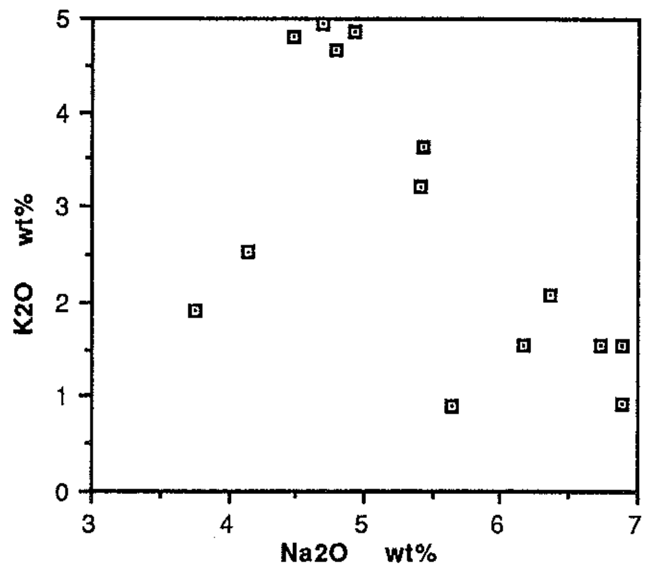


Fig. 6 Ce vs SiO2

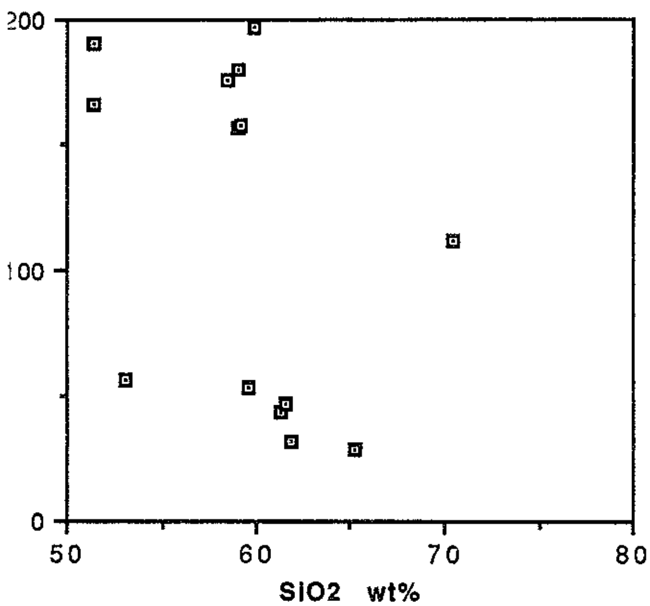
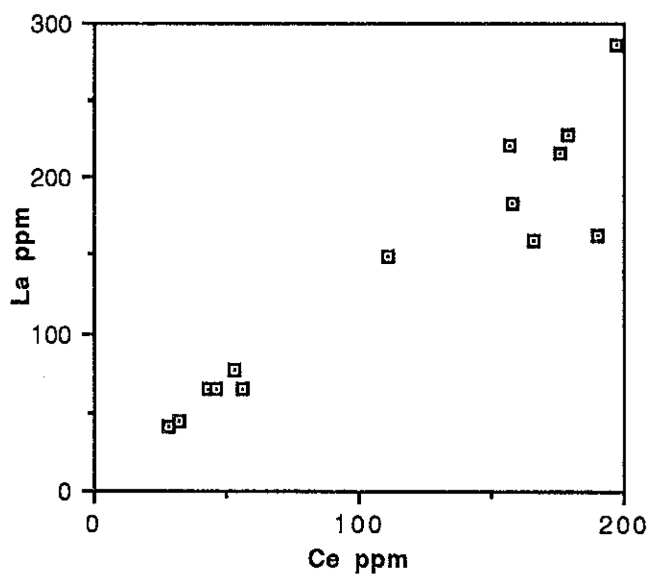


Fig. 7 La vs Ce



5.) The presence of quartz sieve structure within hornblende, biotite, and plagioclase grains is an indicator of early or limited hydrothermal differentiation.

6.) The presence of both microcline and perthite can be related to hydrothermal differentiation.

7.) The inhomogenous distribution of potassium feldspar is indicative of hydrothermal differentiation; hydrothermal fluids may act preferentially along certain fractures or weaknesses.

8.) The wide variation of alkali content in rocks of equivalent SiO_2 percentage suggests that secondary hydrothermal differentiation rather than magma differentiation is responsible for varying alkali content.

9.) Both magma differentiation and hydrothermal differentiation may have occurred within the suite of Hg, creating the variation shown on the Streckeisen and chemical diagrams. The best classification for the Hg unit is hornblende quartz diorite gneiss. If both magmatic and hydrothermal differentiation have taken place, a diorite or quartz diorite was probably close to the original Hg composition.

REFERENCES

Best, Myron G., 1982, Igneous and Metamorphic Petrology: W.H. Freeman, 630 p.

Collins, Lorence G., 1988, Hydrothermal Differentiation: Theoprastus Publications, 381 p.

Hanson, Gilbert N., 1978, The application of trace elements to the petrogenesis of igneous rocks of granitic composition: Earth and Planetary Science Letters, v. 38, p. 26-34.