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LITHOGEOCHEMISTRY

OF

KEWEENAWAN IGNEOUS ROCKS

A Final Report to the Minnesota Department of Natural Resources

by

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INTRODUCTION

General Background and Rationale

Rock chemistry is well recognized as being useful in the search for economic mineral deposits. This is so whether the deposits are of primary magmatic origin, are exhalative, or are epigenetic resulting from the introduction of material into a solid rock. In the Keweenawan igneous rocks of northeastern Minnesota, several types of mineral deposits are either known to exist (but are presently subeconomic) or potentially exist, and a program of rock geochemistry should greatly increase our understanding of the mineral potential of this large and important geologic province.

Many billions of dollars' worth of Cu and Ni sulfide mineralization have been identified in the basal zone of the Duluth Complex in the Hoyt Lakes-Kawishiwi area. This basal zone has undergone intensive mineral exploration over the past 20 years or so, and the large resources discovered await improvement in market factors to initiate development and exploitation. The present study is thus focussed on other possible types of mineral deposits.

Concentrations of Fe and Ti oxides (potentially also valuable for their V content) have been described in the Duluth Complex, especially from the Water Hen intrusion south of Hoyt Lakes (Mainwaring and Naldrett, 1977), the Longnose peridotite east of Hoyt Lakes (E. Linscheid, in prep.), and the Gunflint Prong (Grout et al., 1959; Nathan, 1969; J. Feenstra, in prep.). In other well-known layered mafic tholeiitic intrusions such as the Skaergaard, Bushveld, Kiglapait, etc., magnetite and ilmenite are relatively late in the crystallization history. This is because of the relatively low oxidation state of these mantle-derived magmas (which suppresses magnetite crystallization) and the incompatible character of Ti which prevents early crystallization of ilmenite. Compositions of the silicate minerals associated with these oxide concentrations would give an index of the differentiation stage at which they formed, and would thus provide evidence for their origin and an exploration tool for other such concentrations that might be economic.

Chromium (as chromite) and the platinum group metals (PGM) are other elements found as primary stratified ore deposits in other large layered mafic intrusions such as the Bushveld and Stillwater. Although no concentrations of these metals have yet been found in the Duluth Complex (except for some of the PGM in the Cu/Ni sulfide ores and one drill core south of Ely), their potential should be evaluated. These elements are generally found associated with early-crystallizing minerals in the major ore-bearing intrusions, where Mg/Fe and Ca/Na ratios are relatively high. In contrast, the various parts of the Duluth Complex which have been geochemically studied so far (e.g., Weiblen and Morey, 1980) tend to have less primitive, more evolved compositions, i.e. with lower Mg/Fe and Ca/Na. Some of the associated lavas (North Shore Volcanic Group, NSVG), however, which are thought to be consanguineous with the Duluth Complex, are fairly primitive (Green, 1982; BVSP, 1981). It is, therefore, possible that some plutons of the Duluth Complex may be primitive enough to have precipitated chromite, Pt minerals, or both.

Many deposits of economic minerals are associated with felsic intrusive rocks, including Cu, Mo, Zn, and Ag in "porphyry coppers" as disseminated and vein networks, and Sn and W minerals in veins, disseminations, and replacements in country rocks. Many intermediate to granitic intrusions are associated with the Duluth Complex and higher-level bodies intruding the NSVG. These are poorly known geochemically as is their origin -- direct differentiates of gabbroic magma (with or without liquid immiscibility), partial melts of Archean/Lower Proterozoic crust, remelts of Keweenawan rhyolites, "zone refining" by upward-moving magma within the crust, or some combination of these. Although porphyry Cu and Mo deposits and Sn-W ores are primarily associated with convergent plate-boundary magmatism (e.g., Sawkins, 1984), the Keweenawan rift association should be fully investigated. Tin deposits are found in the analogous felsic roof rocks of the Bushveld intrusion (e.g. Lenthall and Hunter, 1977).

Many ore deposits are associated with felsic volcanic rocks, of which there is a large proportion in the NSVG. These include especially Au, Ag, Cu, and Zn as well as Sn deposits. Although most of the sulfide ores associated with volcanic rocks apparently were emplaced in an environment of submarine volcanism, not continental rifts, it would be valuable to explore the potential of these Keweenawan flows, both lavas and ash flows. Native Cu and Ag and some sulfides and arsenides of these elements are of course important in the great Keweenawan copper district of Michigan in lavas of the Portage Lake Volcanics.

Finally, the Duluth Complex is composed nearly entirely of cumulate rocks, which do not represent liquid (magma) compositions. Therefore, in order to understand the Minnesota Keweenawan magmatic systems better, it is necessary to increase our knowledge of the chemistry of such liquids. Dikes and lavas, particularly those without appreciable phenocrysts, represent such liquids chilled rapidly enough to prevent crystal segregation. These can tell us much about the genesis and evolution of the magmas from which the cumulate rocks of the Duluth Complex and other major Keweenawan intrusions crystallized, and can help to evaluate the potential for some of the types of mineral deposits mentioned above.

Purpose and Content of this Study

This investigation is intended to better characterize the chemical composition of Minnesota's Keweenawan igneous rocks as a whole, and also the compositions of significant minerals in some representative intrusive rocks, for the ultimate purpose of a clearer evaluation of their mineral potential. The principal data obtained are chemical analyses, including both major elements and an appropriate array of trace elements depending on the particular rock type and information sought, of carefully selected and prepared samples of the several rock groups discussed above. These analytical results are then discussed in terms of their implications for economic mineral concentrations.

Sampling

Selection of samples was accomplished by two means: a retrospective survey of rock samples already collected by the principal investigator (JCG) over many years of field work in the district; and new field work/reconnaissance aimed especially at selecting representative samples of otherwise unstudied rock units. A few samples were also taken for microprobe analysis from drill core recently obtained by the DNR, and a few were provided by other workers (i.e. Val Chandler, E. Mullenmeister).

About 200 rock samples were collected during the field work; of these 77 were sent for analysis and 77 of JCG's collection from earlier work were analyzed. Of the total analyzed, 35 represent mafic phases of the Duluth Complex and other mafic intrusions; 19 represent intermediate and felsic intrusions, 53 are mafic dikes, 29 are mafic and intermediate lava flows, and 18 are from felsic volcanic units. The rationale for each is indicated in Table I along with the unit it is from and location. Locations are also shown on the individual 7 1/2 minute quadrangle maps. Table II is a key to the rock unit symbols referred to in the other tables.

Staff

Overall direction, planning, and supervision was done by the writer, as well as some of the field sampling, much of the petrography, and all of the sample selection, evaluation, discussion, and writing. Thomas Fitz, graduate student at UMD, performed much of the field sampling and most of the sample preparation, assisted by Paul Bulger, UMD senior undergraduate. Fitz also performed the microprobe analyses. Carolyn Boben and Karol Oja built a computer data bank of information on JCG's previously-collected samples to aid in selection of samples for analysis.

Field Work

Whereas evaluation of JCG's existing samples began with the start of the project, field sampling began on 1 June 84 and continued through most of the summer of 1984. Several further sampling trips were carried out during the fall and some in spring 1985. U.S.G.S. 7 1/2 minute topographic maps were used as a base, and U.S. Forest Service aerial photos were used in part of the area in Cook County. In view of the purpose of this study (mineral evaluation) and the legal constraints on development in the Boundary Waters Canoe Area Wilderness, the BWCA was generally excluded from sampling.

WHOLE-ROCK GEOCHEMISTRY

Introduction

The Keweenawan igneous province is becoming one of the best characterized chemically in the world. A compilation of analyses of Keweenawan intrusive rocks of Minnesota (other than the Duluth Complex) done between 1900 and 1971 was published in Green (1972). Geochemistry of the volcanic rocks of northeastern Minnesota (the NSVG) has been treated in Green (1972; 1982), BVSP (1981), and Brannon (1984). These studies have shown a continuous range in compositions from primitive olivine tholeiites through high-Fe tholeiites to basaltic andesites, icelandites, and rhyolites (Fig. 1). Intrusive rock compositions occupy a somewhat wider field because many of them are cumulates and are not restricted to liquid compositions (Fig. 2). These investigations however have left large areas of the magmatic complex unsampled or poorly represented.

Sample Selection

Rock samples were chosen for analysis according to several criteria. First, it was desired to increase the geochemical data base for some previously poorly-characterized rock types or units, including felsic lavas and intrusions, mafic and intermediate intrusions, and dikes. Second, geographic distribution was sought so that a more comprehensive view of the chemistry of the various units would be possible. Third, samples representing the great variety of mafic intrusive rock types were sought. Finally, the samples were screened for freshness through macroscopic and petrographic examination, in order to obtain results as close as possible to the original igneous composition of the rock. For most samples, some alteration was unavoidable. Values for L.O.I. (loss on ignition), representing H_2O^+ and CO_2, in the analyses give a general index of degree of alteration. From previous experience, L.O.I. values over about 3.5% are indications of considerable alteration and possible metasomatism involving other elements (some of which are more mobile than others). L.O.I. values below 2.0% are preferred.

In a few cases - especially for some felsic lavas - rocks that had clearly undergone some hydrothermal introduction of secondary minerals were selected for screening for certain elements of interest (Sn, W) that might have been introduced.

Sample Preparation

Once a specimen had been selected for analysis, a slab about 5-8 mm thick was cut on a diamond saw, a thin section was made with part of it, and the remainder was prepared for analysis. Any weathered or obviously altered portions (veinlets, amygdules, etc.) were removed, all traces of saw marks or metal from the saw blade were ground off, and about 15 to 25 g of the slab was washed in acetone and distilled water and then crushed. Initial breaking into small chips was accomplished on an "anvil" of tough, fresh Tertiary basalt for the mafic rocks and on a block of coarse, polished granite for the felsic rocks, to avoid contamination by unlike material. The chips thus produced were then ground to a powder in a SPEX Industries Shatterbox employing an alumina ceramic grinder again to avoid contamination. The powders thus made were placed in acid cleaned new glass vials, labelled, and sent to the analyst.

Analytical Laboratories, Procedures, Standards

The rock analyses were carried out in two laboratories: the Geochemistry Lab at the Department of Geology and Geophysics, University of Minnesota, Minneapolis; and X-Ray Assay Laboratories, Ltd. of Don Mills, Ontario (XRAL).

The analyst at the Geochemistry Lab at the U. of M.-TC is Mr. R.L. Knoche. This newly established lab uses the technique of direct-current plasma spectroscopy (DCP) but is not yet set up for analyzing H_2O or CO_2, and several of the desired trace elements could not be analyzed. Analyses of standard geochemical samples run at the same time as the LGC samples are presented in Appendix B, along with the recommended values from Abbey (1980). Blind standards were also submitted by the writer among the samples to be analyzed, and the results are also shown in Appendix C. These demonstrate the rather good accuracy of these analyses for most components. The analyst did not, however, supply numerical estimates of analytical error.

Analyses done at XRAL used a variety of techniques, as shown on the Certificates of Analysis along with their detection limits for each element. XRAL's advertised results on a suite of geochemical standards are presented in Appendix A. Blind standards were also submitted with some batches of LGC samples: these analyses are given in Appendix C. The agreement with the recommended values is again good for nearly all components.

The Analyses

A total of 154 whole-rock chemical analyses were obtained from the two analytical labs. The analyses are presented in Appendices D-G sorted according to the groups of rocks they represent, and the analysts' raw reports are also attached as Appendix I. Samples analyzed seperately for tin and tungsten are given in Table IV.

Discussion

Lavas. The 42 whole-rock analyses of lavas were intended to increase our knowledge of the plateau volcanism in heretofore less well known areas, particularly interior Cook County but also some in Duluth and Lake County, and to search for more primitive compositions that might indicate a higher probability of finding economic deposits of Cr, Ni, and PGM in associated intrusive rocks.

Compositions of the analyzed lavas are plotted on Figures 3 and 4. The AFM diagram (Fig. 3) shows that the sampled lavas have a similar distribution to NSVG lavas previously analyzed, although a greater number of rhyolites are now available. The distribution is consistent with Irvine and Baragar's (I & B's) (1971) and Jensen's (1976) discriminators between tholeiitic and calc-alkaline rocks, nearly all lying in the tholeiitic field as expected. The one major exception, ML-37, contains 3.31% volatiles and high alkali contents for 50% SiO_2, and has probably been metasomatically altered. On I & B's classification diagram for subalkaline rocks (Fig. 4) the compositions plot in the appropriate fields, although their "dacite" would include some "icelandite" and "rhyolite" of the Lake Superior district. Sample MI-28, a spherulitic rhyolite, contains 80% SiO_2 and 55% normative quartz and is assumed to have been partly silicified.

The most primitive (high color index, An content, Mg/Fe ratio) samples are as predicted from past experience the ophitic basalts, from a variety of localities ranging from Duluth to Sugarloaf (eastern Lake Co.) to interior Cook County. These new samples however did not include any quite as primitive as some previously known - especially the group between Knife River and Two Harbors, in SW Lake County. Two samples of basal flows from the Grand Portage area (GP-11, 16) confirmed some previous analyses showing these to be uniquely mafic but rich in both compatible elements (Cr, Ni) and incompatible elements and thus probably having a somewhat different magmatic origin from the subsequent flows.

Trace-element concentrations are of most interest in the basaltic and felsic volcanics (Table III). The Cr contents of a few of the more primitive basalts are high enough (>250 ppm) to indicate that somewhere in the Keweenawan magma system there could be chromite concentrations, but that these particular magmas did not get depleted by a large amount of chromite extraction. (Chromium also is depleted by subtraction of clinopyroxene, which has also evidently not happened in large degree to these magmas.) These same basalts have relatively high Ni contents, which indicate that they have not been strongly depleted either by sulfidization to produce a sulfide (pentlandite-crystallizing) melt, nor by much olivine subtraction. The fact that two of these relatively high-Ni basalts also have As and Sb values above detection limits also suggests that they have not had their base metals scavenged by a sulfide phase. On the other hand, Cu and Zn values in these same two samples are relatively low compared to the other basalts, implying some loss. Gold was detected and - only at the minimum detection limit - in only two of the basalts, and uranium is also uniformly low. None of these basalts showed silver above detection limits.

There are several different trace elements of economic interest in the felsic volcanic samples. Arsenic and antimony give an indication of possible hydrothermal sulfide activity, and in general those samples relatively high in one of these elements was also relatively high in the other. But these samples were selected for analysis on the basis (among others) of their relative lack of alteration. The only sample with an unusual concentration is MI-26 with 110 ppm As reported. The same sample has a tungsten anomaly as well (42 ppm) although its Mo, a possibly associated metal, is below detection limits. The Cu and Zn values in this sample are also among the lowest of the felsic rocks.

The only other W concentration of interest is found in H-15, a porphyritic rhyolite from the Hovland area. It also has low Cu and Zn but Mo at the detection limit, which is very unusual for this entire suite of analyses.

The uranium values of the felsites are all above those of the basalts, as expected, but not particularly noteworthy.

Three of the felsites gave barely detectable values for gold, whereas none showed detectable silver.

Dikes. The 53 whole-rock analyses of dikes provide further evidence of the compositions of magmatic liquids that were available in the Keweenawan rift system in Minnesota. In general, they show a similar distribution to that of the lavas (Figures 5 and 6), except that felsic dikes are much less abundant. (It should be stated here however that only dark-colored, basaltic-looking dikes were sampled for this study. Nevertheless, the writer's considerable field experience in the district supports the conclusion of a relative paucity of felsic dikes.) As with the volcanic rocks sampled, the dikes show the typical range of continental tholeiites from moderately primitive olivine tholeiites through Fe-Ti tholeiites and basaltic andesites to icelandites. The dike compositions however appear to be more preponderantly concentrated in the high Fe-Ti tholeiite-basaltic andesite range than the lavas. This is not felt to be due to a sampling bias in the dykes, as it is not as easy to predict their composition from hand sample/outcrop as it is the lavas. This implies that the upper parts of the Keweenawan magmatic system (lavas and their feeders) are mostly relatively evolved and therefore that their plutonic equivalents would be more likely to produce Fe and Ti oxide concentrations than Cr, Ni, or PGM deposits. The dikes of the Pigeon River group near Grand Portage, and some in the Duluth area, are in general more primitive than the others sampled.

In accordance with the relatively evolved major-element content of the dikes, Cr and Ni concentrations are relatively low in most of the dikes, indicating depletion by clinopyroxene, olivine, and perhaps sulfide at depth. Silver and gold are below detection limits except for rare low-level samples such as four in the Carlton County swarm that contain between 10 and 70 ppb Au. These also contain low but measureable As. The highest As value was 45 ppm in dike D-170 in Duluth, but this was associated with Ag and Au values only at or below detection limits although it was highest in Mo (7 ppm). Copper in the dikes tended to be somewhat higher than in the lavas.

Other Mafic Intrusions. Of the 36 samples of mafic intrusive rocks (other than dikes) analyzed, 27 are from the Duluth Complex, 5 are from the Beaver Bay Complex, and 4 from other miscellaneous intrusions. Their compositions are illustrated on the AFM diagram of Figure 7. Among those from the Duluth Complex, 13 are from the Troctolitic Series, 5 are from the Anorthositic Series, and 9 are miscellaneous, not assignable to one of these two divisions.

Because of their cumulate texture and inferred origin, neither the troctolitic series nor the anorthositic series samples can be assumed to represent liquid compositions. For this reason several samples plot in the subalkaline field of the AFM triangle. Compared to the compositions of Minnesota dikes, these rocks tend to be lower in high-field-strength incompatible elements including Ti and Zr but are surprisingly similar to the dikes and basaltic lavas in other incompatibles such as P, La, and Rb, which would be concentrated in any intercumulus liquid present. Ni and Cr contents probably directly relate to the proportions of olivine and pyroxene present, except for D-106, a gabbroic olivine anorthosite from Duluth which contains a high Cr value (480 ppm) but rather little pyroxene. The other exceptionally Cr-rich rocks are the two peridotites, DG-37 and DG-51, and a mafic-rich cumulate gabbro of the Layered Series in Duluth, D-105. The highest Ni contents are found in the olivine-rich peridotite DG-37 and a fayalite ferrodiorite of the Beaver Bay complex, F-237. Exceptional TiO_2 values (>10%) are also associated with ilmenite-rich cumulate rocks: the mafic layered gabbro D-105 and the peridotite DG-51.

Five "chilled margin" samples were selected for analysis in an attempt to find a liquid composition for the bulk of the troctolitic series of the Duluth Complex. These are relatively fine-grained (or fine to medium-grained), with a non-foliated, aphyric texture and were outcrops as close to the basal contact as possible in Duluth (Nopeming) (ES-23), the Dunka pit (BAB-9), east of Hoyt Lakes (DG-32), and southeast of Ely (M-7358, M-7671). They all show moderately evolved compositions, not as primitive (in terms of Mg# - .40 to .56, or normative An-49 to 63, for instance) as some basalt flows or dikes (Fig. 3,5,7). This evidence for a lack of primitive magmas involved in the bulk of the Duluth Complex is corroborated by the mineral compositions reported and discussed in another section.

The samples with the highest normative An compositions are cumulates of the Greenwood Lake intrusion (DG-53, An 70.4), a troctolite ("Highland troctolite") north of Two Harbors (TH-62, An 70.2) a troctolite near Wilson Lake (C-3, An 70.1), and the peridotite from Bardon Peak, DG-51 (An 80.8). Those with the highest Mg# are the same three cumulates mentioned above (DG-53, Mg# = 0.71; Th-62, 0.68; C-3, 0.68) and a troctolitic anorthosite southwest of Babbitt (DG-34, 0.64). Because these are adcumulate or mesocumulate rocks, these values reflect the crystal compositions; the magmas from which they crystallized must have been higher in Na/Ca and Fe/Mg than these rocks.

A comparison between the troctolitic series and anorthositic series samples is limited by the fact that only five of the latter were analyzed, and three of these are from the Duluth area. However, they all show normative An content in the same range (An 59-67) as the majority of the troctolitic series rocks. However, the anorthositic series rocks have somewhat lower Mg# values (.39 - .53) than most of those of the troctolitic series cumulates.

Among the analyzed samples of mafic intrusive rocks not included in the Duluth Complex, none are as primitive as some of the basalts or the troctolitic DC rocks and most are fairly evolved. The least evolved of these samples are three from the Beaver Bay Complex related to Gehman's (1957) Beaver River

Gabbro (3001-21.4, F-256, F-275). The most remarkable is an extremely Fe-enriched ferrodiorite (F-237) from near Silver Bay, which has an Mg# of 0.05 (see also microprobe analyses below). Two sills that intrude the Biwabik I.F. in the Hoyt Lakes - Babbitt area (ALN-1, BAB-1) are considerably evolved and moderately similar in composition, though ALN-1, from the Wentworth Mine, is strongly altered.

Intermediate and Felsic Intrusions. Eighteen samples of intermediate and felsic intrusive rocks were analyzed, 14 from the Duluth Complex, 3 from the Beaver Bay Complex, and one from northeast of Two Harbors. They represent a wide geographic sampling. Those containing > 62% SiO_2 are called felsic, and those with < 58% SiO_2 are here called intermediate. Some of the latter might be classed as mafic, but their relatively high alkali contents and low Mg#'s and normative An contents allowed this distinction to be made. Many of these rocks are granophyric and are thought to represent liquid compositions fairly closely, and they are similar in composition to rhyolites, icelandites, ferroandesites, and andesites of the NSVG (Fig. 3). Some of them (e.g. F-35, LM-7, EM-1, WHY-2, BRL-1) are quite fine grained and probably are from shallow subvolcanic intrusions. As expected, they are all strongly Fe-enriched (Mg#'s from 0.4 to 0.03, mostly <0.25). In several places in northeast Minnesota large mafic sills are capped by granophyre where they underlie rhyolite lavas, and these felsic and intermediate intrusive rocks may have been derived in part by melting in place of their rhyolite roof. The relatively large volume of intermediate and felsic rocks (both intrusive and extrusive) in the Keweenawan of Minnesota has prompted the suggestion (e.g. Green, 1972) that the great addition of heat from the mantle-derived mafic magmas partially melted and assimilated considerable lower crustal rock (Archean granites?); this would have increased the relative amount of felsic differentiates of these mafic magmas. Some geochemical characteristics of these differentiates (low fO_2, low fH_2O) are in contrast to the typical products of partial melting related to convergent plate boundaries (I, S granites). However, these same characteristics are shared by many within-plate, non-rift-related continental granitic rocks which are thought to have been produced by deep crustal melting by basaltic plumes from mantle hot-spots, followed by fractional crystallization (e.g. Barker, 1981).

Two fine-grained red granophyres were analyzed for tin and tungsten, along with 14 rhyolites (Table IV): one just northeast of Duluth in the roof zone of the DC (D-138) and the Mt. Weber granophyre (WHY-2). Both showed 3 ppm W which was the highest concentration of all the intrusive samples analyzed, but is not indicative of economic mineralization. The Mt. Weber granophyre showed less than the detection limit of tin, and the Duluth granophyre contained only 5 ppm Sn. This is in the typical range of Sn-barren as opposed to Sn-bearing granites of Australia, the USSR, and South Africa (Juniper and Kleeman, 1979; Lenthall and Hunter, 1977).

The latter authors determined in a thorough geochemical study that a few trace elements showed markedly different concentrations in the South African tin-bearing Bobbejaankop granite (related to the Bushveld intrusion) compared to other related felsic rock units of the Bushveld area. Because of the geological similarities between the Bushveld and Duluth Complexes (including their within-plate Precambrian craton environment) the felsic Keweenawan samples were compared using these same elements (Table V). It can be readily seen that, compared to the LGC Keweenawan rocks, the Bobbejaankop Sn-bearing granite contains much more Rb, Y, and Sn; much less Sr, Ba, Zr, and Zn; La that averages somewhat higher though overlapping the Keweenawan range; and Ce that averages slightly lower but overlapping the Keweenawan range. Except for the latter, these are the same kinds of diffences as Lenthall and Hunter found for the South African rocks, and suggest that the Keweenawan felsic rocks probably do not constitute a potential Sn province.

Post-tectonic, late Precambrian alkali granites in the northwestern Arabian Shield are host to a suite of deposits of high-valence incompatible elements including rare earths, Nb, Ta, Y, Th, U, and Zr (Drysdall et al., 1984). A comparison of the LGC Keweenawan rocks to these shows that the Arabian rocks are a) in some bodies considerably poorer and in others much richer in La and Ce, and have different chondrite-normalized distribution patterns; b) much poorer in Ba and Sr; c) about the same or richer in Rb; and d) much richer in Nb, Sn, Ta, Th, U, Y, Zn, and Zr. Again the implication is that the Keweenawan does not show promise as a heavy-element district.

MINERAL CHEMISTRY

Polished thin sections were made of 32 Keweenawan intrusive rock samples, many of which were samples for which whole-rock geochemistry was known. Other rocks, principally cumulate rocks, were also studied since in these the mineral chemistry is more significant than the bulk rock composition. The sections were surveyed, photographed, and specific grains and areas chosen for analysis. The electron microprobe analyses were done by Tom Fitz, using the microprobe laboratory in the Department of Geology and Geophysics, University of Wisconsin, Madison, with the advice and assistance of Mr. Everett Glover, technician.

Primary effort was devoted to the major minerals plagioclase, olivine, pyroxene, magnetite, and ilmenite. Secondary targets, which only received brief investigation because of time and money constraints, were other oxides, sulfides, and hydrous silicates (biotite, hornblende). Priority was also given to mafic rocks over intermediate and felsic samples.

The compositions of the major silicates are important in drawing analogies to economically valuable zones in other layered intrusions, since the various minerals of value tend to occur at certain stages in the crystallization history of an intrusion. The oxides and sulfides are of interest in their own right, for their potential values of Cr, V, Ti, Pt group, Co, etc. Unfortunately it was not possible to analyze for vanadium.

Mineral compositions obtained are presented in Appendix H. Each analysis represents the average for generally 2-5 spots actually analyzed on one or more grains. Analyses with totals within 1% of 100% are probably best; those with totals greater than ±2% are probably not dependable except for very general considerations. Magnetite totals are expected to be low because all of the Fe is expressed as FeO from the microprobe; pure stoichiometric magnetite would show as "FeO = 93.0%." Increasing amounts of components other than Fe_2O_3 would bring the total closer to 100% such as is found in ilmenite. The biotite analyses are also low as analyzed, but most of this is due to the non-analysis for K_2O (normally 6.5-9%) and H_2O (normally 1.5-3.5%) because the X-ray spectrometers were set up for mafic minerals lacking potassium.

Plagioclase

Compositions of plagioclase are shown on Figure 9. Confirming earlier studies of Duluth Complex plagioclases (e.g. Weiblen and Morey, 1980), the great majority fall within the range An 50-65. Among the most calcic are phenocrysts and groundmass laths of an olivine tholeiite flow (T-65; An 65), which is still considerably less calcic than plagioclases in many other olivine tholeiite lavas of the NSVG (BVSP, 1981). It still remains problematic why cumulate rocks of the Duluth Complex have not been found which contain plagioclases appropriate to the early crystallization history of similar magmas. However, two relatively minor intrusions, the Pigeon Point sill and the Sonju Lake intrusion (Mudrey, 1973; Stevenson, 1974) do contain more calcic plagioclases (An 71, 83 respectively).

Representatives of both troctolitic and anorthositic suites give plagioclases in the An 60-66 range, although in general the troctolitic-series rocks showed somewhat higher An values than the anorthositic samples.

The most calcic plagioclase (An 76) was found in the Bardon's Peak intrusion, a peridotite (DG-51). This was unexpected since a sample of cumulate picrite from the nearby Layered Series (DG-1) gave An 55, and also because the peridotite itself is rather evolved with respect to its mafic minerals, with abundant ilmenite and relatively high-Fe silicates.

The intermediate and felsic rocks had, as expected, more sodic (and potassic) plagioclases.

Olivine

The olivine compositions are illustrated in Fig. 10, along with those of the analyzed pyroxenes. They show a rather consistent relationship in their Fe/Mg distribution compared to the coexisting pyroxenes, with olivines showing a higher Fe/Mg ratio. The only exception is the olivine-tholeiite basalt, T-65. This discordance may be more apparent than real, however, as the pyroxene is zoned and the average shown may be weighted toward its more Fe-rich rim (cf. BVSP, 1981).

As in the case of the plagioclases, no primitive, Mg-rich olivines were found as would be expected from plutons crystallizing from some of the more primitive, magnesian basalt magmas known to be available in the Keweenawan rift system in Minnesota. According to Roeder and Emslie's (1970) formulas, the most primitive basalt would be in equilibrium with Fo 87-88; slowly cooled crystallization experiments by Green (1979) on this rock produced Fo 85 as the first olivine. The most magnesian olivines found in the present study are Fo76 and Fo74; both of these were from drill cores. Most lie in the range Fo65-50. As in the plagioclases, the troctolitic-series samples tend to show, on the average, somewhat more magnesian olivines than those from the anorthositic series. A layered gabbro body near Silver Bay in the Beaver Bay Complex (F-237) was found to contain nearly pure fayalite. The rock is actually a ferrodiorite.

Pyroxene

The pyroxene analyses are also plotted on Figure 10. They are consistent in their Fe/Mg ratios with the coexisting olivines, having higher values in each case as discussed above. The great majority of pyroxenes analyzed are common augites, though intermediate and felsic rocks contain ferroaugite and the Silver Bay ferrodiorite mentioned above has nearly pure hedenbergite.

Three orthopyroxene rims on olivines were analyzed. They all showed significantly more magnesian compositions than the adjacent olivines, as indicated on the figure.

Hornblende

This mineral was analyzed in only one sample, the peridotite DG-51. It also shows a significantly lower Fe/Mg ratio than coexisting olivine, perhaps because it crystallized relatively late when abundant Fe-oxide precipitation was competing for iron in the residual magma. Its low total is at least partly due to non-analysis for H_2O.

Ilmenite

Seven ilmenite analyses are reported from a variety of Duluth Complex samples. They are rather ordinary, with MgO values ranging from 1.6 to 4.6.

Magnetite

Magnetite was analyzed in 6 samples. They vary considerably in their TiO_2 content (5.94-15.40). The highest value represents about 43% ulvospinel solid solution in magnetite and lower values probably reflect variable amounts of granule exsolution or re-equilibration at subsolidus temperatures (Buddington and Lindsley, 1964; Vincent and Phillips, 1954). The Al_2O_3 contents are higher than in most reported analyses (e.g. Deer, Howie, and Zussman, 1962), as are some of the MgO values. One sample (DUV-15-2435) contains magnetite unusually rich in both Al_2O_3 and Cr_2O_3 (7.41%).

Spinel

Another spinel-group mineral distinct from the above-mentioned magnetite was also found in DUV-15-2435. It is a Cr-rich hercynitic spinel, dominated by Al and Fe. No actual chromite was found, however. This grain is generally similar to, though not as Cr- and Ti-rich, as a Cr-spinel analyzed by Stevenson (1974) in the Sonju Lake intrusion.

Biotite

Three biotites were analyzed, all associated with oxide minerals in gabbroic rocks. They are fairly typical for gabbros (Deer, Howie, and Zussman, 1962) with molecular Fe/(Fe+Mg) (annite) values of 25-33% and TiO_2 ranging from 2.69 to 4.80%.

Sulfides

Only two sulfide minerals were analyzed, a pyrrhotite of ordinary composition in the peridotite DG37 from near Babbitt and a chalcopyrite from one of the Duval drillcore samples.

Discussion

Figure 11 shows coexisting olivine and plagioclase compositions from the Duluth Complex samples determined in this study, compared to similar data from Taylor (1964), Stevenson (1974), and from economically significant horizons of the Stillwater and Bushveld intrusions.

In the Stillwater intrusion, chromite-bearing zones of economic significance occur in the Ultramafic Series. Raedeke and McCallum (1984) report that the olivine in these zones has a composition ranging from about Fo83-86, much more magnesian than any olivine yet found in Keweenawan intrusive or extrusive rocks - but potentially possible given a large mass of the most primitive Keewanawan magma. The closest approach in the newly analyzed Duluth Complex samples is found in the drillcores DUV-15-2435 and NE-2-302 (Fo76 and 74 respectively). These should provide incentive for further investigation in those areas.

Platinum values have also brought widespread attention in the Stillwater intrusion (Raedeke, 1983). The Pt-group metals (PGM) occur at certain horizons in the noritic-anorthositic Banded Zone, where McCallum et al. (1980) report plagioclase compositions of An 73 to 80. This too is considerably more calcic (primitive) than plagioclases known from the Duluth Complex, except for the anomalous Bardons Peak peridotite DG-51 and the Sonju Lake intrusion (Stevenson, 1974). In the PGM-bearing subzone of the Stillwater (OBZ-1), olivine (Fo71) occurs along with bytownite (An 81-84) (Fig. 11). The coexisting olivine/plagioclase pairs of the analyzed Duluth Complex rocks are seen to be significantly more Fe- and Na-rich than those of the Stillwater Banded Zone. This cannot be considered encouraging, but should focus further attention on sampling other portions of the Complex and on further study of only the most Ca- and Mg-rich portions so far identified.

In the Bushveld intrusion of South Africa, the highly valuable chromite seams occur in the Critical Zone associated with feldspathic bronzitites, norites, and anorthosites. The exposed Duluth Complex does not have analogous environments, orthopyroxene being a rare cumulate mineral here. In the Bushveld Complex, cumulus plagioclase associated with the chromite layers has compositions ranging from An 67 to An 80 (Cameron, 1970). These too are more calcic than any Duluth Complex feldspars analyzed in this study, but the ranges nearly meet.

The Merensky Reef is the principal site of PGM occurrence in the Bushveld Complex. The plagioclase just above this horizon is An 76-77 (von Gruenewaldt, 1973), decreasing gradually upward through the 3200 m of Subzones A and B of the Main Zone. Just beneath the Merensky Reef (top of Basal Series), plagioclase of composition An 80 is associated with Mg-rich olivine (Fo 86) (Wager and Brown, 1967). As in the Stillwater, these compositions are more primitive than any yet found in the Duluth Complex.

In the Upper Zone (2000 m) of the Bushveld Complex (von Gruenewaldt, 1973) several layers contain high and economic concentrations of magnetite. These are in the portion of the Complex that has undergone sufficient fractional crystallization to crystallize more Na-rich feldspars and more Fe-rich mafic silicates. In the Skaergaard intrusion (Wager and Brown, 1967) magnetite first appears as a cumulate phase at the top of the Lower zone, where the plagioclase is An 54 and olivine is Fo 55. In the Kiglapait intrusion (Morse, 1979) magnetite starts precipitating at 88.6% ("main ore band" at 93.5%) solidified. The Makaopuhi lava lake basalt started crystallizing magnetite at about 70% solidified (T.L. Wright, U.S.G.S., undated), and in dynamic crystallization experiments on a primitive NSVG basalt, the oxides formed at roughly 90% crystallized (Green, 1979). These are all far along on the crystallization path of what might be assumed "typical" continental or rift-related tholeiitic intrusions, under typical conditions of relatively low oxygen fugacity (near the Fayalite-magnetite-quartz buffer: Haggerty, 1976). If the magma crystallizes under more oxidizing conditions magnetite will appear earlier (as in calc-alkaline systems, Osborn, 1962), but considering the generally strong Fe-enrichment trend of Keweenawan rocks this appears unlikely in these rocks.

In the Bushveld Upper Zone, the magnetite bands are associated with plagioclases of An 59-50 composition, and olivines in this zone have compositions of Fo 52 to 28 (von Gruenewaldt, 1973). In the Kiglapait, the magnetite layers occur associated with An 50-40 plagioclase and Fo 60-50 olivine, but the layers are not of economic size (Fig. 11). These are somewhat more Fe-rich (Bushveld) or more sodic (Kiglapait) than the bulk of Duluth Complex mineral pairs.

On the other hand, there are a few concentrations of oxides (magnetite and ilmenite) known in the Duluth Complex (e.g. "Snake Anomaly" near Greenwood Lake; Longnose and Longear peridotites near Hoyt Lakes; Water Hen intrusion; Poplar

Lake , Gunflint Trail) associated with rocks which are only moderately evolved. These may indicate that the local magmas were slightly enriched in oxygen, perhaps from the engulfing of large volumes of supracrustal roof rocks.

SUMMARY AND RECOMMENDATIONS

This study has significantly enlarged the geochemical data base for the Keweenawan igneous rocks of Minnesota, with the aim of increasing our ability to evaluate the economic potential of these rocks. A wide variety of rocks, from a wide geographic area, has been sampled and analyzed, and mineral compositions have been determined for many of these samples from both outcrop and drill core.

The new analyses of mafic lavas and dikes, which most closely approximate magma compositions, show that the magmas which were able to reach the surface and upper parts of the crust during rifting were moderately evolved; that is, they contain a higher Fe/Mg ratio and more incompatible elements than one would expect from a primary magma derived by significant partial melting of mantle lherzolite. In this way these rocks resemble other large but younger plateau-basalt provinces such as the Columbia Plateau, Deccan, and Parana traps (BVSP, 1981). Only a relatively few lavas and fewer dikes are more primitive. This generalization is corroborated by the analyses of intrusive rocks, many of which are cumulates. Both these cumulates and the minerals analyzed from them also show that the Duluth Complex and related layered Keweenawan intrusions crystallized from considerably more evolved magmas than those of the Stillwater and Bushveld complexes. Because the valuable Cr and PGM deposits of these bodies are associated with their more primitive early phases characterized by higher An contents in plagioclase and higher Mg contents in olivine and pyroxene than have been found in the Keweenawan intrusions (with the possible exception of the Sonju Lake intrusion), the implication is that the great bulk of the Keweenawan intrusive complex provides little optimism for such economic mineral deposits.

However, a very large portion of the Keweenawan plutonic rocks is either not exposed or still not adequately geochemically characterized. It is thus unwise to suggest that such deposits are not possible. In fact, a few minor occurrences of PGM, for instance, have been described both in drill core and in glacial drift (T. Brown, personal commun.)

Therefore it is recommended that this geochemical survey be continued and expanded into other areas and plutons not yet sampled, by both outcrop sampling and drilling. Because some fairly primitive magmas are known to have been available to the rift system, there should be layered intrusions somewhere that crystalized from such magmas and which could have a greater chance of forming Cr or PGM deposits. Peridotites in particular should be investigated. The Greenwood lake area in particular deserves further study. The well-foliated cumulate rocks found in the rare exposures (Erie RR cut; Highway 2 north of Greenwood Lake - Sample DG-53) are some of the most primitive yet found in the Complex, and this "Greenwood Lake pluton" may have a direct connection to the nearby "snake anomaly" of oxide-rich rocks. The Sonju Lake intrusion near Finland has at its base some of the most primitive rocks in the entire Keweenawan complex. Its basal, picritic zone and contact relations should be thouroghly investigated. As aeromagnetic interpretations become more refined they will be of increasing aid in locating new plutonic bodies to sample.

The well known Cu and Ni deposits (especially near the base of the Duluth Complex) are related to a large extent to the extrinsic factor of supply of sulfur from the footwall country rocks.

The relatively evolved Fe-rich composition of the bulk of the Keweenawan magmas, as determined by this project, make it more likely that oxide concentrations containing Fe, Ti, and V may be present: again several are already known. Further investigations of magnetic anomalies, continued surveying of rock and mineral compositions, and perhaps basal till prospecting should be pursued in the search for oxide deposits.

The felsic rocks, both intrusive and extrusive, are of interest particularly with respect to their potential for hosting Sn, W, Cu, Ag, and Au deposits. This initial geochemical survey has found that only very low concentrations of these metals (especially Sn, Ag, and Au) are present in the sampled rocks. A few rhyolite samples showed above-background levels of W, but they are not in a geological/structural situation to suggest that larger associated deposits are likely. These rocks have few of the trace-element geochemical characteristics of known tin-mineralized rocks in other parts of the world. Many more Keweenawan felsic rock bodies, particularly their more permeable (and potentially mineralized) phases, remain to be sampled, and this is recommended, but the potential for these types of deposits seems to be less than those discussed above for mafic plutonic rocks.

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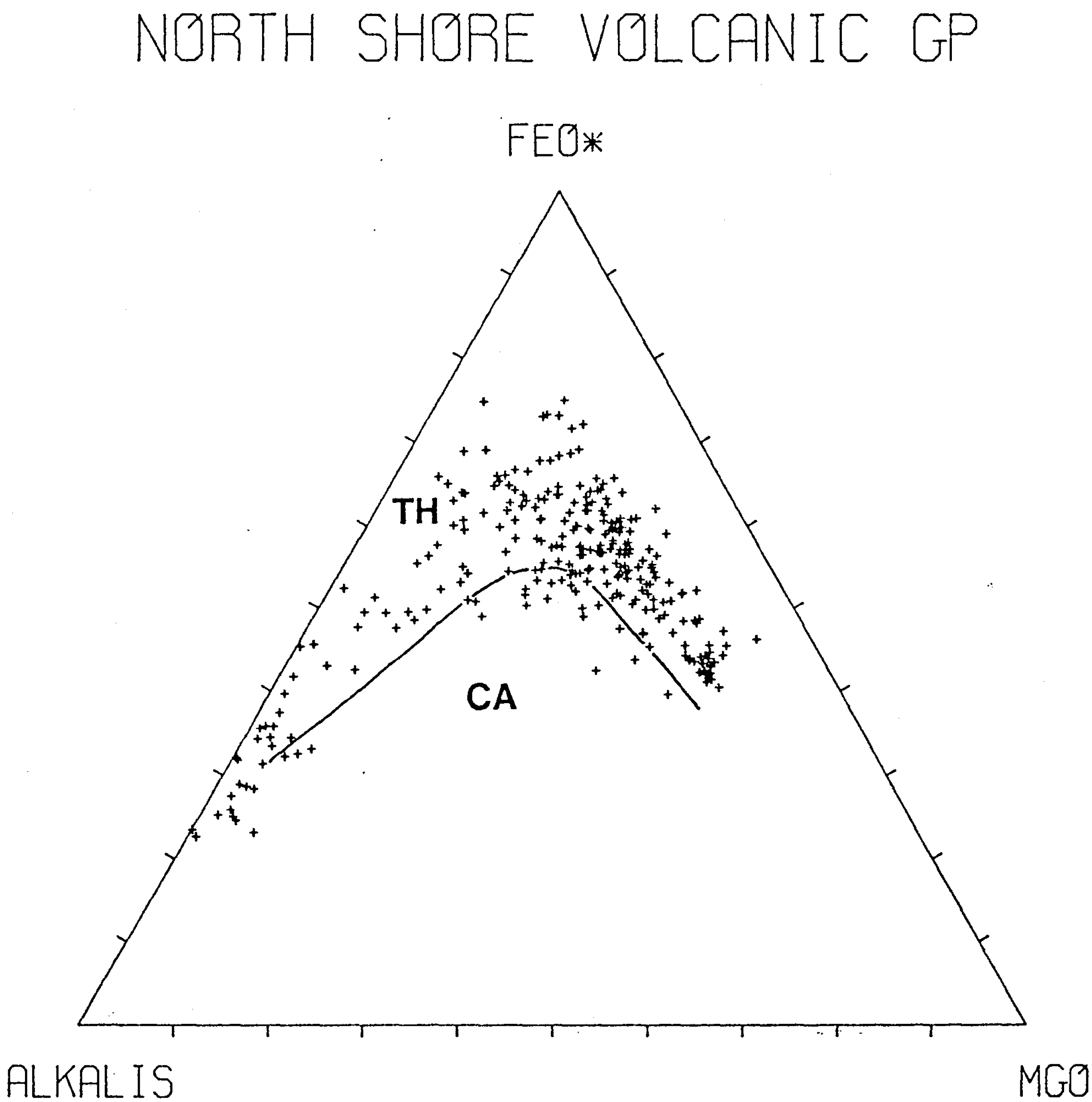

Figure 1. AFM diagram for 277 Minnesota Keweenawan lavas, from published and unpublished analyses including this study. A = $Na_2O + K_2O$; F = FeO + 0.9 Fe_2O_3; M = MgO, all in weight percent. Line shows Irvine and Baragar's (1971) discrimination between tholeiitic (above) and calc-alkaline (below).

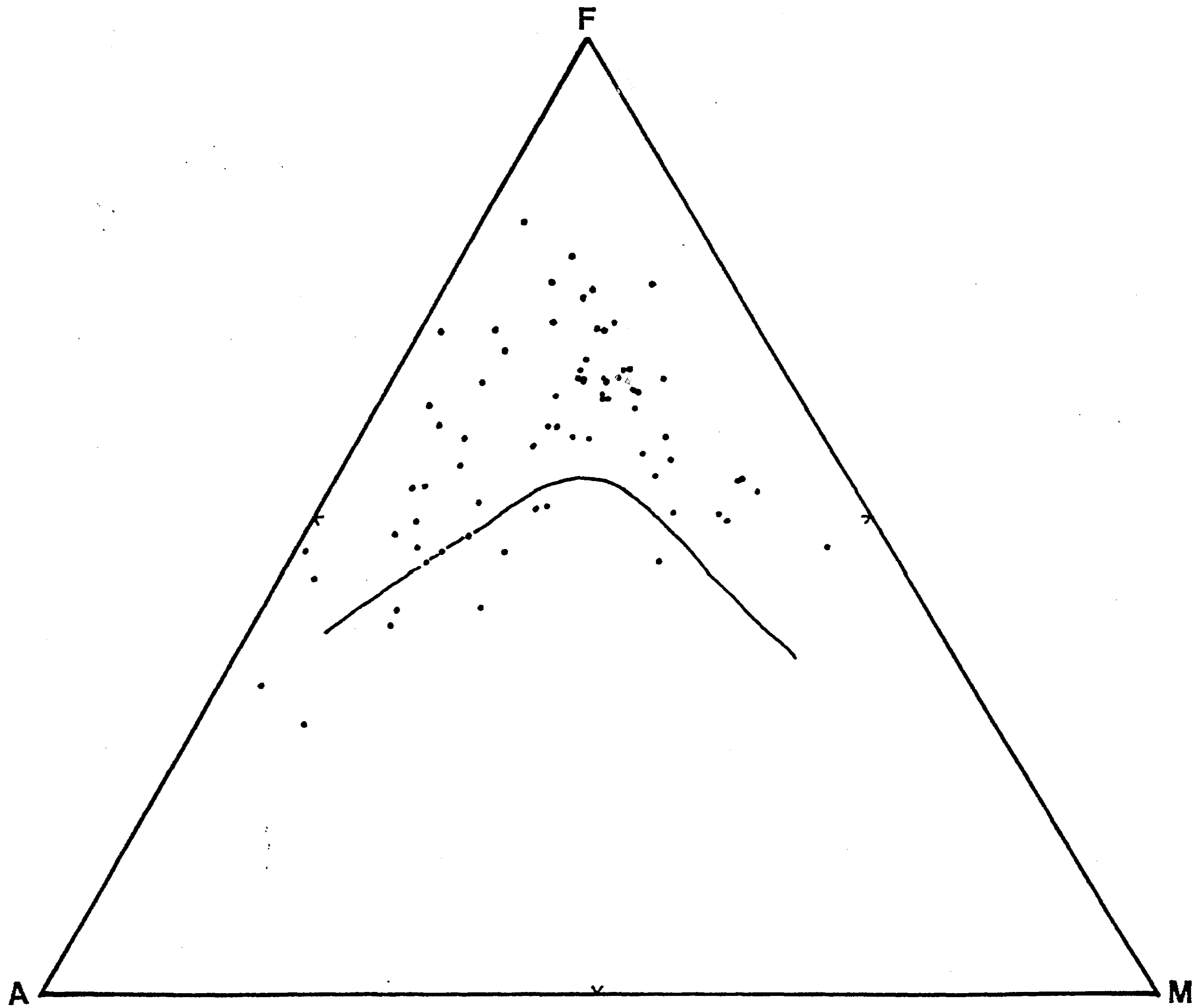

Figure 2. AFM diagram for 78 Keweenawan intrusive rocks form Minnesota and Ontario, exclusive of the Duluth Complex, from Green (1972), Geul (1970), and Mudrey (1974).

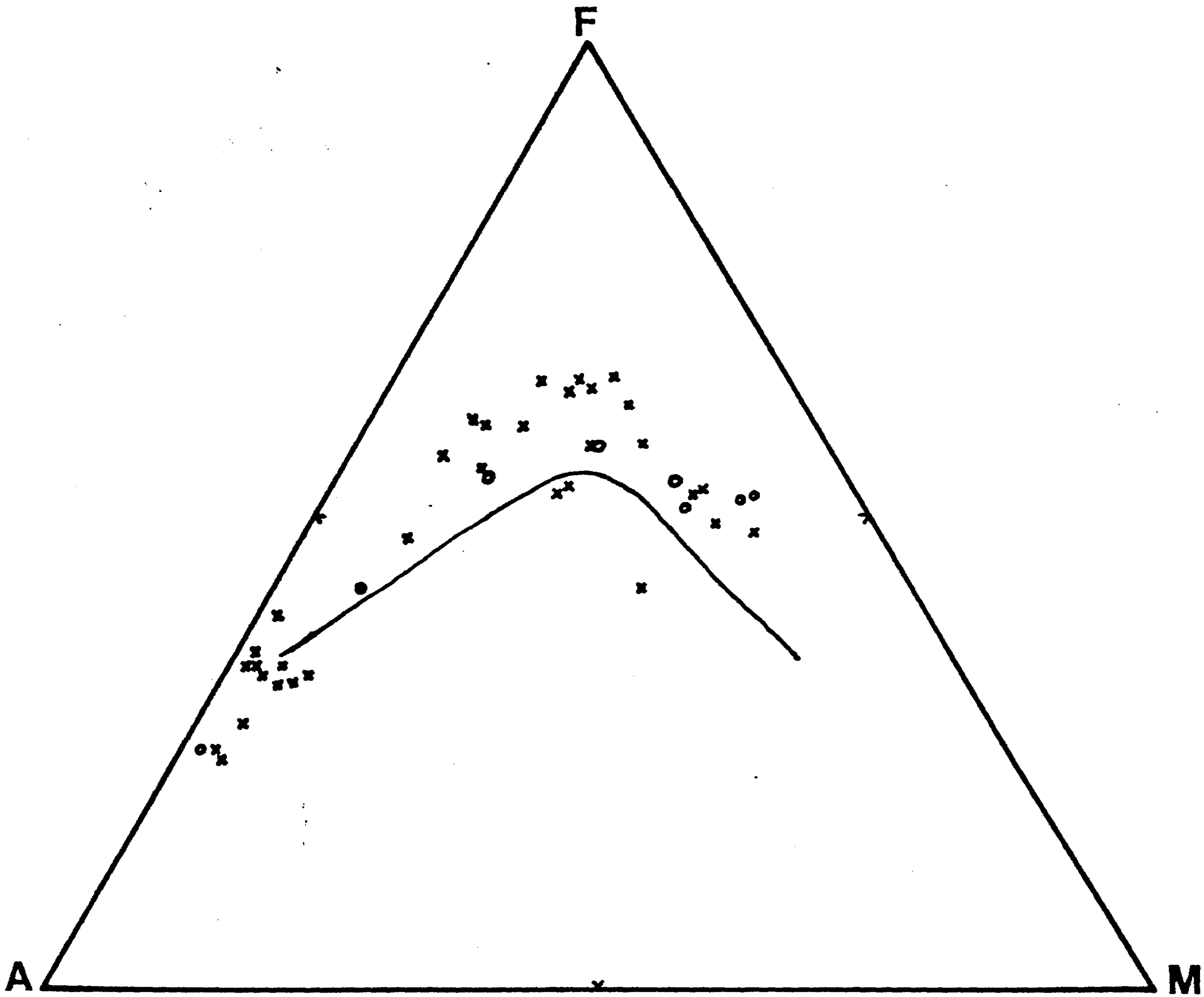

Figure 3. AFM diagram for Lithogeochemistry Keweenawan lavas. X = normal polarity, O = reversed polarity.

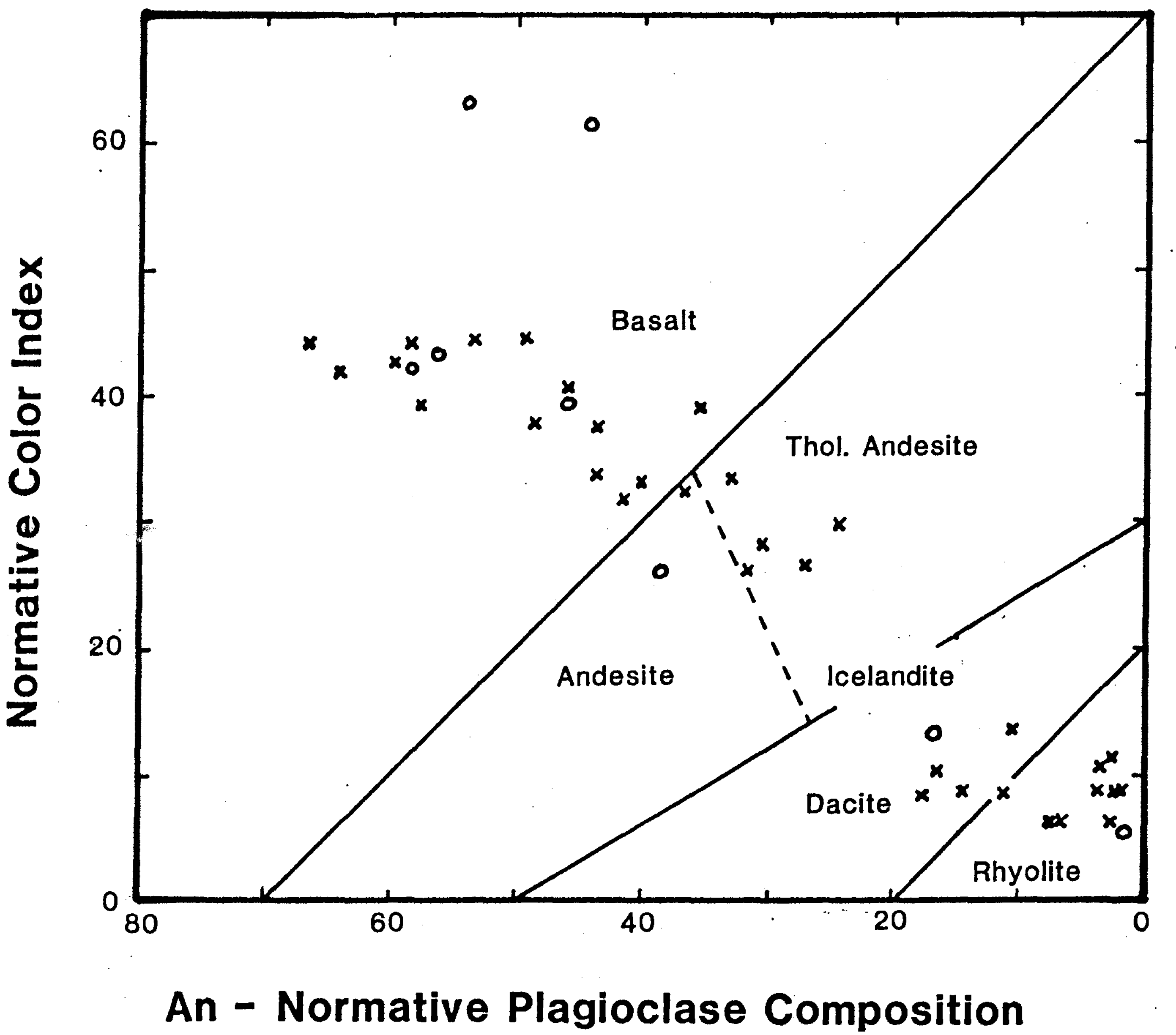

Figure 4. Plot of normative Color Index against normative plagioclase composition for LGC Keweenawan lavas, showing rock names according to Irvine and Baragar (1971). Symbols as in Fig. 3. Samples with C.I. over 60 are "tholeiitic hawaiites" of Grand Portage area.

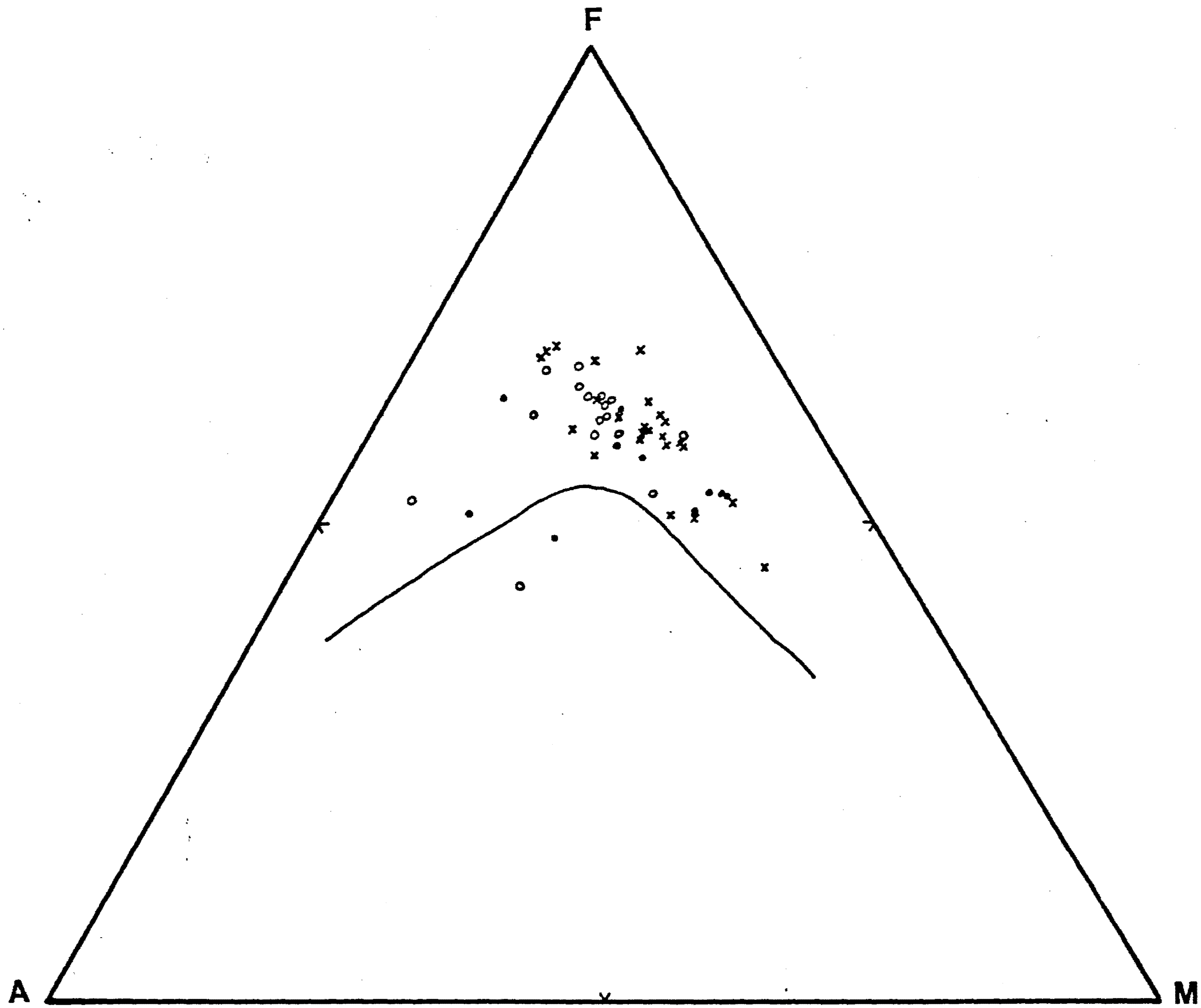

Figure 5. AFM diagram of LGC Keweenawan dikes. Symbols as in Fig. 3; solid dots are dikes of undetermined magnetic polarity.

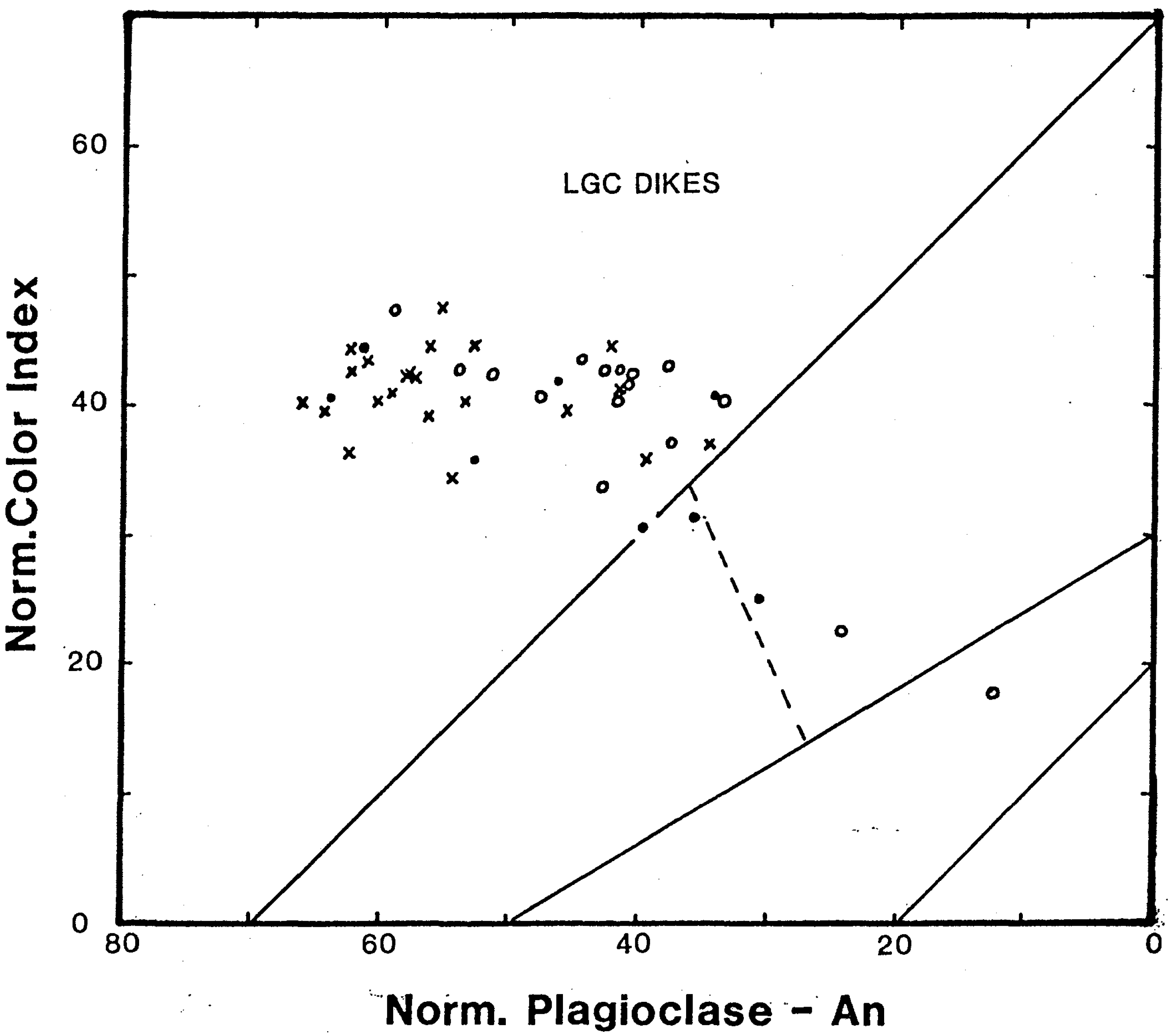

Figure 6. Plot of Color Index against plagioclase composition (as in Fig. 4.) for Keweenawan dikes. Symbols as in Fig. 5.

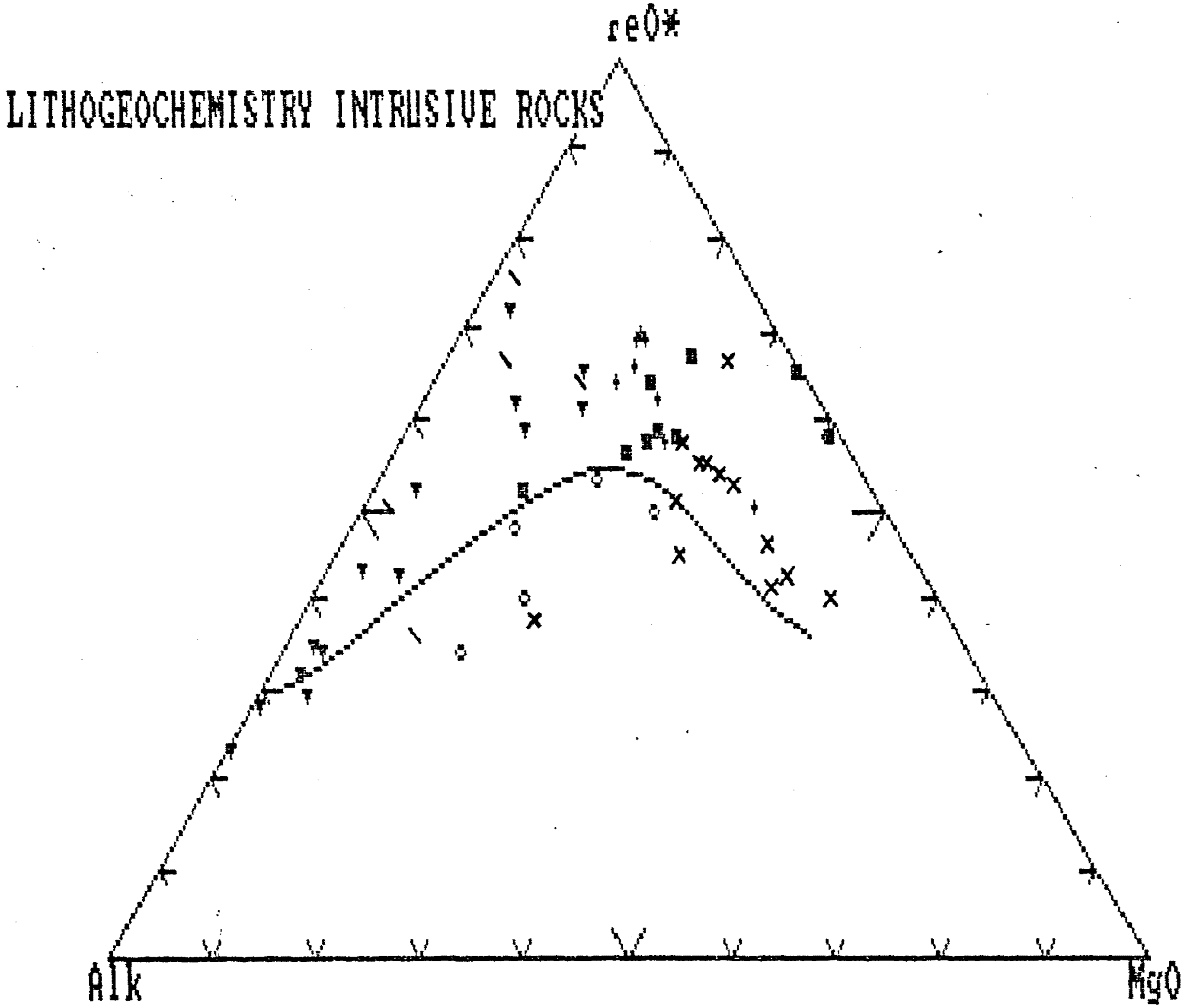

Figure 7. AFM diagram for other LGC Keweenawan intrusive rocks. Symbols X = troctolitic series, Duluth Complex; O = anorthositic series, Duluth Complex; ▼ = intermediate and felsic rocks, Duluth Complex; ■ = other mafic rocks, Duluth Complex; + = mafic rocks not assigned to Duluth Complex; \ = intermediate and felsic rocks not assigned to the Duluth Complex. Several anorthositic and troctolitic rocks plot in calcalkaline field because they are largely cumulate combinations of magnesian mafic minerals and plagioclase.

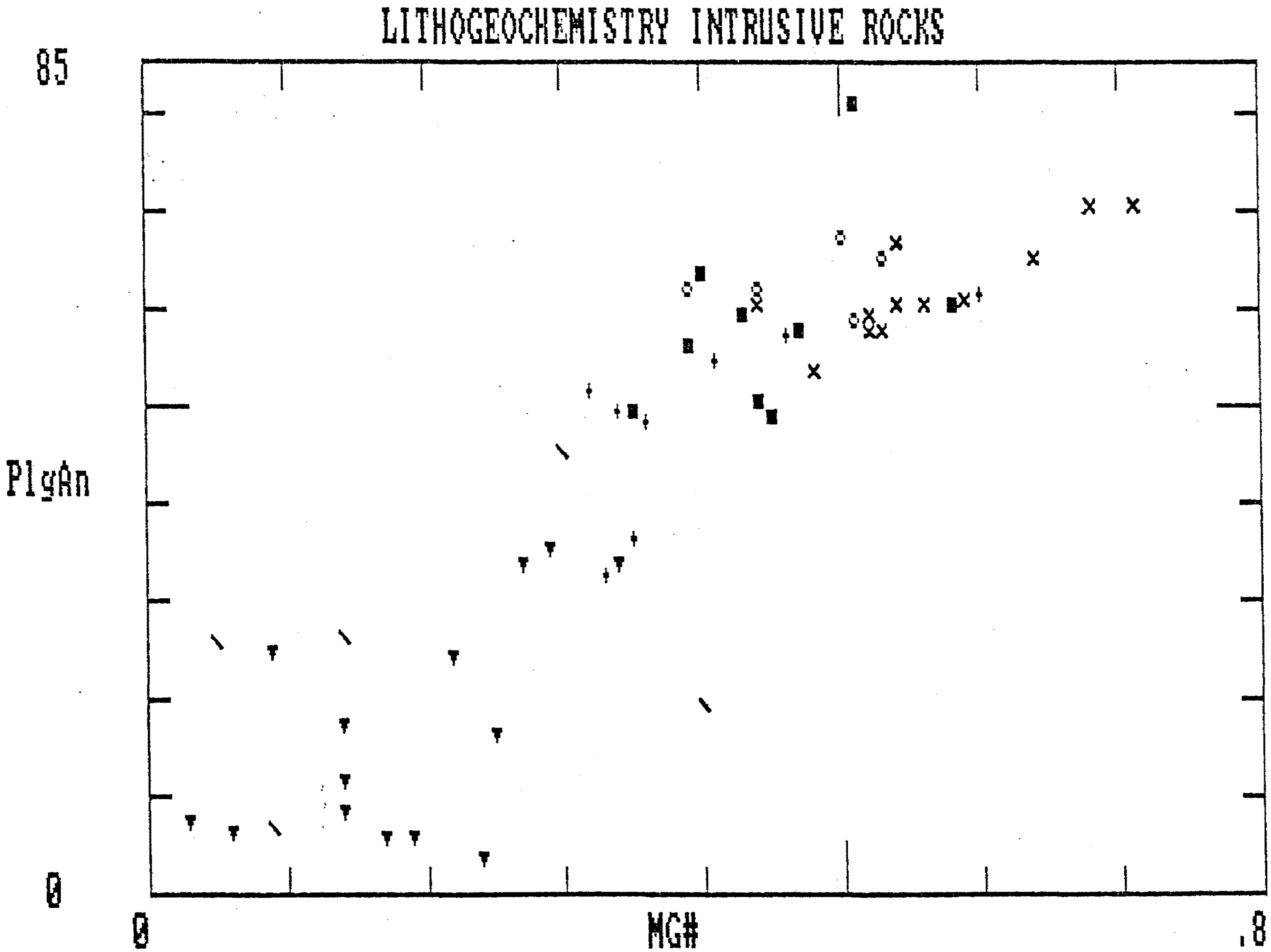

Figure 8. Plot of normative plagioclase composition against Mg# for LGC intrusive rocks, as indices of differentiation. Mg# = atomic ratio Mg / (Mg + 0.9 Fe). Symbols same as for Fig. 7.

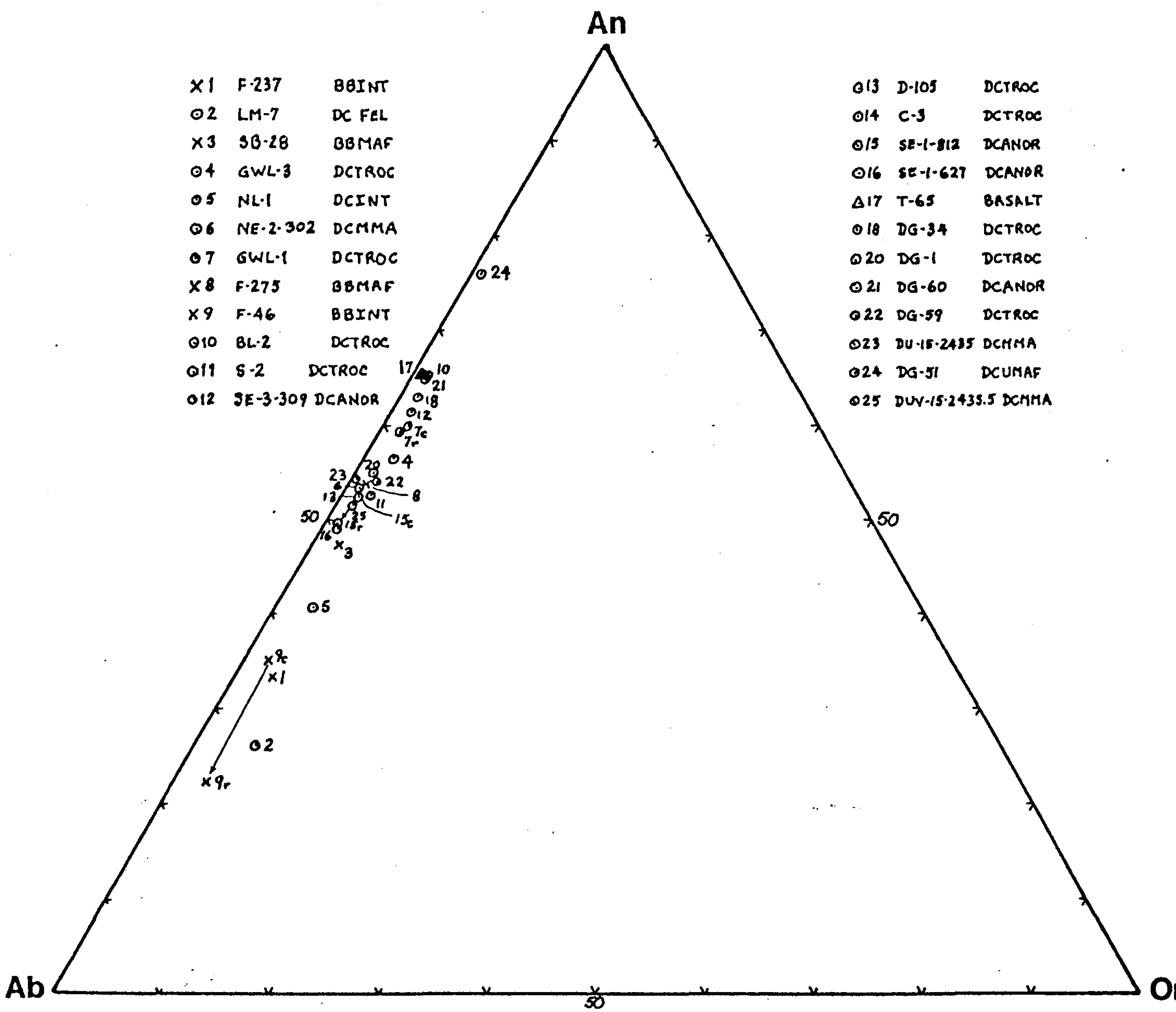

Figure 9 Plagioclase compositions from LGC Keweenawan rocks determined by electron microprobe (T. Fitz, analyst). Subscripts after some sample identification numbers refer to cores (c) and rims (r)of crystals.

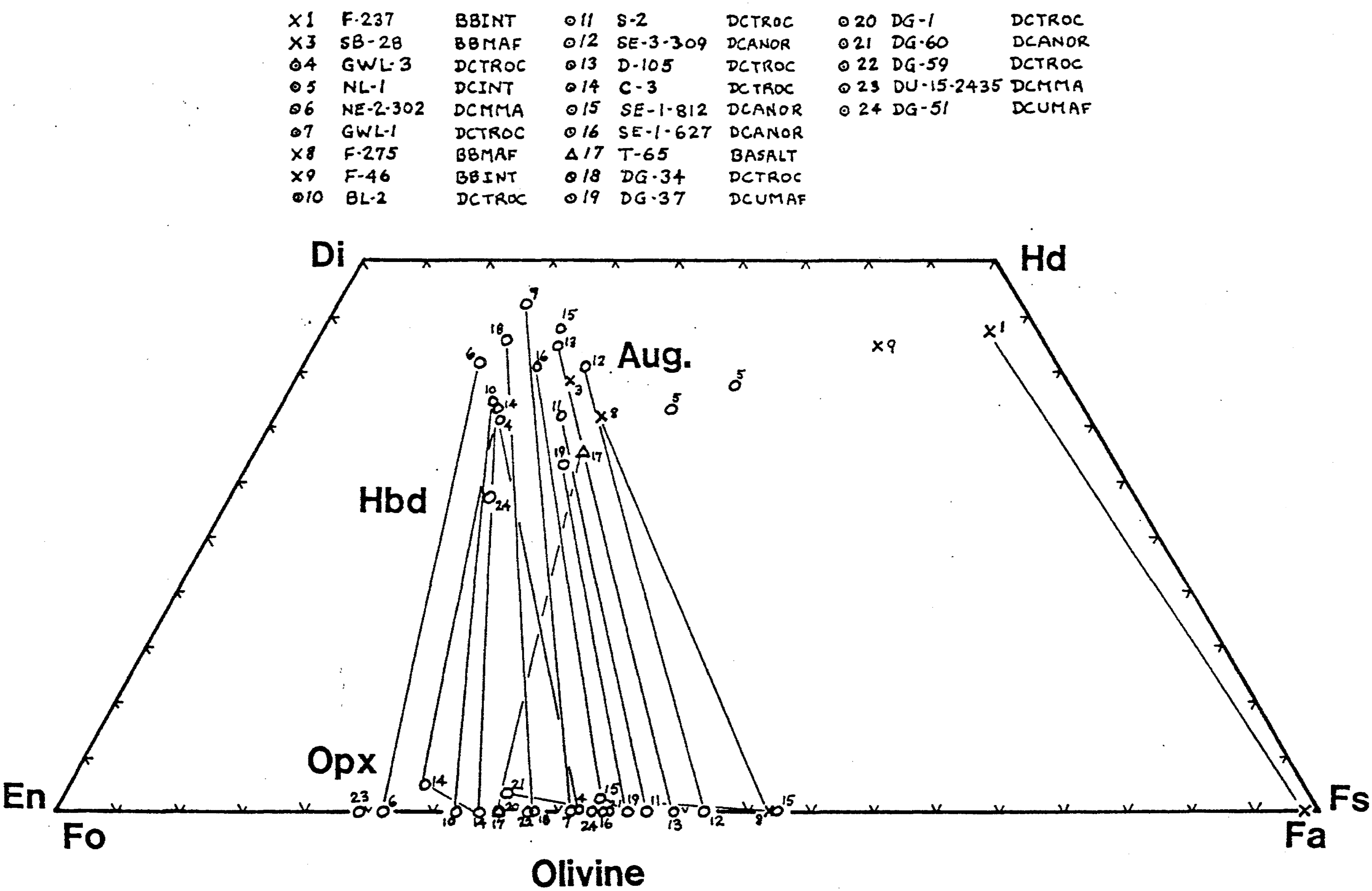

Figure 10. Pyroxene and olivine compositions from LGC Keweenawan rocks determined by microprobe (T. Fitz, analyst). Tie-lines show coexisting minerals. Symbols: O = Duluth Complex; X = Beaver Bay Complex; Δ = North Shore Volcanic Group.

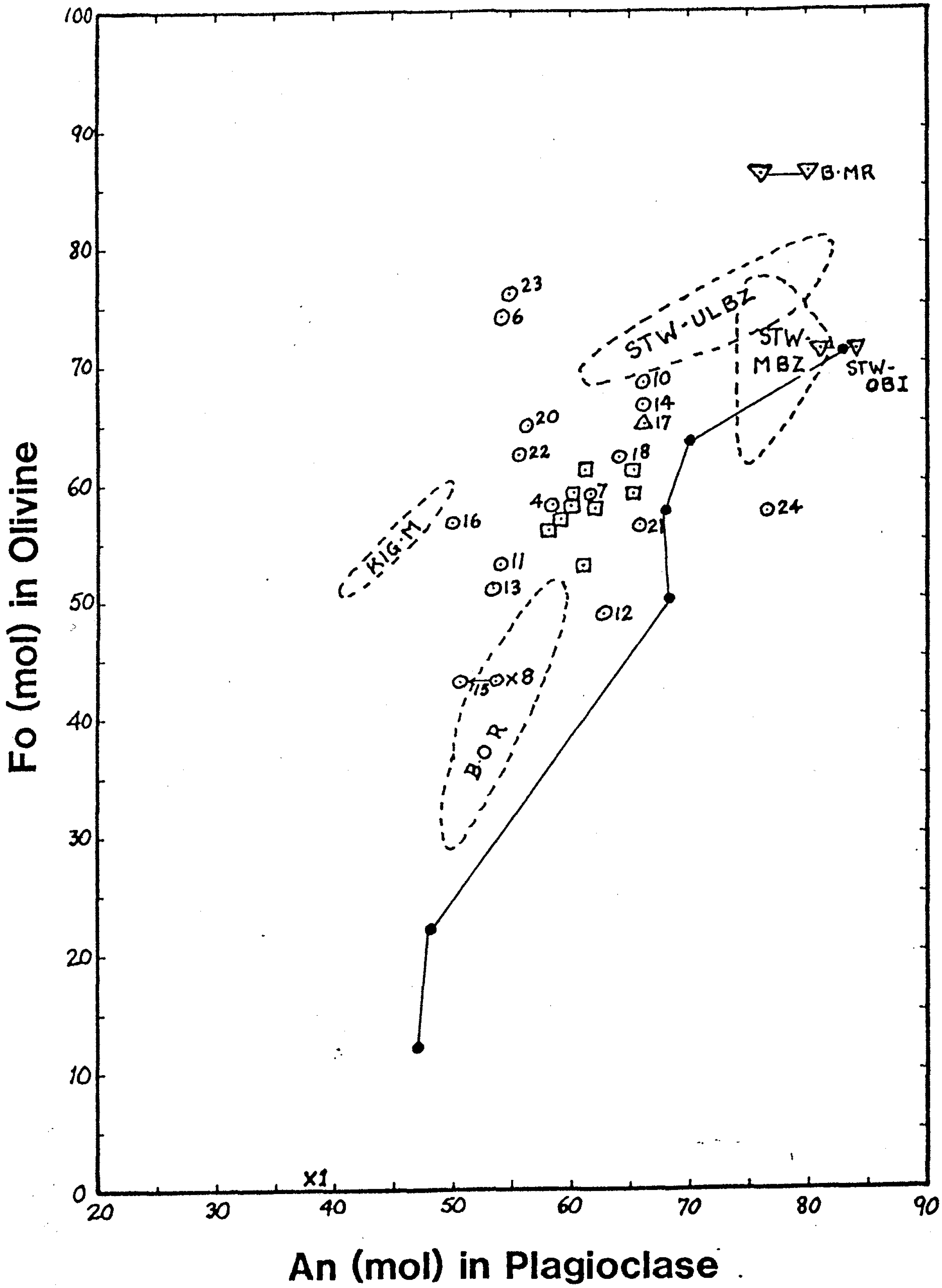

Figure 11. Comparison of compositions of olivine and plagioclase pairs from Keweenawan rocks with those of other layered mafic intrusions. Symbols: Θ = Duluth and Beaver Bay complexes, new analyses; ● = Sonju Lake intrusion; B.MR, Bushveld Complex, Merensky Reef; BOR, Bushveld Complex, Upper Zone; STW-ULZB, Stillwater Complex, upper and lower Banded Zones; STW-MBZ, Stillwater Complex, Middle Banded Zone; STW-OBI, Stillwater, OBI layer;
KIG.M, Kiglapait Intrusion, magnetite-bearing zone. References: Taylor, 1964; von Gruenewald, 1973; Cameron, 1970; Raedeke and McCallum, 1980; Wager and Brown, 1967; Morse, 1979; Stevenson, 1974.

TABLE IA

INVENTORY OF ANALYZED SAMPLES OF MAFIC INTRUSIVE ROCKS

Sample	Unit	Location Twp	Ra	Sec.	¼	Quad.	Description	Comments
ALN-1	OKIMAF	59N	14W	21	A	Allen	v. fine-gr. black basalt	sill in Biwabik IF
BAB-1	OKIMAF	60N	12W	3	A	Babbitt NE	fine-med. gr. granoblastic microgabbro	sill in Biwabik IF
BAB-9	DCMMA	60N	12W	3	A	Babbitt NE	fine-med. gr. granoblastic microgabbro	"chilled" base of Dul. Complex
C-3	DCTROC	60N	6W	33	A	Wilson L.	med. gr. troctolite	repres. of troctolites
C-4	DCMMA	60N	6W	29	D	Wilson L.	plag-porph gabbro	repres. of miscellaneous
C-13	DCMMA	60N	5W	31	D	Wilson L.	olivine gabbro	repres. of miscellaneous
CD-6	OKIMAF	65N	1E	31	D	Croc. Lake	med.-gr. gabbro	Logan sill
D-40	OKIMAF	50N	14W	23	D	DULUTH	fine-gr. black basalt	chill of Endion sill
D-102	DCANOR	49N	14W	27	C	DULUTH	coarse gabbroic anorthosite	repres. of anorthositic series
D-105	DCTROC	49N	15W	1	C	Dul.Hts.	fol'd ilm.-ol. gabbro	Fe-rich, layered series
D-106	DCANOR	49N	14W	6	A	Dul.Hts.	fol'd ol.-gabbroic anorthosite	repres. of anorthositic series
D-110	DCANOR	50N	14W	8	D	Dul.Hts.	coarse gabbroic anorthosite	repres. of anorthositic series
DG-8	DCTROC	61N	10W	18	B	Bogberry L.	foliated troctolite	repres. of troctolitic series
DG-32	DCMMA	59N	13W	18	D	Allen	ophitic norite	basal chill, Dul. Complex
DG-34	DCTROC	59N	13W	11	B	Babbitt SW	fol'd troctol. anorthosite	repres. of troctolitic series
DG-37	DCUMAF	60N	12W	33		Babbitt NE	med.-gr. peridotite	peridotite nr. base
DG-48	DCTROC	60N	12W	15	B	Babbitt NE	med.-gr. troctolite	repres. of troctolitic series
DG-51	DCUMAF	49N	15W	33	D	West Dul.	black, med.-coarse perid.	peridotite, Bardons Peak
DG-53	DCTROC	59N	10W	06	C	Greenwood Lk.	fol'd olivine gabbro	Greenwood Lk intrusion
DG-55	DCTROC	51N	15W	09	W	Fredenberg	fol'd anorthos. troctolite	repres. of troctolitic series
DG-60	DCANOR	61N	8W	30	?	Isabella	fol'd troctolitic anorthosite	troctolitic anorthosite

TABLE IA (continued)

INVENTORY OF ANALYZED SAMPLES OF MAFIC INTRUSIVE ROCKS

Sample	Unit	Location Twp	Ra	Sec.	¼	Quad.	Description	Comments
ES-23	DCTROC	49N	15W	21	B/C	ESKO	med.-gr. ol. gabbro	basal zone, Dul. Complex
F-237	BBMAF	56N	7W	28	B	Illgen City	dark, foliated ferrodiorite	repres. of miscellaneous
F-256	BBMAF	56N	7W	4	D	Illgen City	weakly porph. oph. ol. diabase	Victor's Head sill (?)
F-275	BBMAF	57N	6W	4	A	Lit. Marais	olivine gabbro	E. of Manitou R.
KL-1	DCANOR	62N	6W	27	C	Kawish. Lk.	gabbroic anorthosite	repres. of anorthositic series
KL-4	DCMMA	62N	6W	23	B	Kawish. Lk.	mafic qtz diorite	repres. of miscellaneous
M-7358	DCTROC	63N	9W	19	C	Ojibway L.	nonophitic ol. gabbro	nr base of Dul. Complex
M-7392	DCTROC	62N	10W	3	C	Ojibway L.	ophitic ol. gabbro	repres. of troctolitic series
M-7671	DCTROC	62N	11W	24	D	Bogberry L.	ophitic ol. diabase	basal chill, Dul. Complex
NL-3	DCMMA	63N	2E	05	C	Nor. Light Lake	plag.-porph. gabbro	repres. of miscellaneous
PW-5B	DCMMA	64N	2E	17	D	Pine Lk. W.	med.-gr. ophitic gabbro	Gunflint Prong gabbro
S-2	DCTROC	49N	15W	14	B	W. Duluth	foliated ol. gabbro	repres. of troctolitic series
SB-28	BBMAF	56N	7W	29	D	Illgen City	black, med.-gr. ferrodiab.	repres. of miscellaneous
TH-62	DCTROC	55N	10W	30	B	Highland	foliated troctolite	repres. of troctolitic series
3001-21.4	BBMAF	56N	8W	22	D	Silver Bay	fine-gr. ol. diabase	repres. of miscellaneous

TABLE IB

INVENTORY OF ANALYZED SAMPLES OF MAFIC AND INTERMEDIATE LAVAS

Sample	Unit	Location Twp	Ra	Sec.	¼	Quad.	Description	Comments
C-10	BASALT	58N	5W	06	D	Cramer	ophitic ol. basalt	repres. of ol. tholeiites
C-12	BASAND	58N	6W	01	D	Cramer	intergran. bas. andesite	repres. of basaltic andesites
C-14	ANDES	60N	5W	31	D	Wilson L.	fine-gr. andes. or latite	repres. of basaltic andesites
C-23	ANDES	59N	7W	36	A	Cabin L.	intersert px-latite	repres. of basaltic andesites
D-62	BASALT	51N	13W	32	D	Duluth	weakly porph. basalt	repres. of Fe-rich basalts
D-126	BASALT	50N	14W	15	D	Duluth	weakly porph. basalt	repres. of high Fe thol.?
D-128	BASALT	50N	14W	22	A	Duluth	fine-gr. basalt	repres. of high Fe thol.?
D-130	BASALT	50N	14W	15	C	Duluth	plag-porph. basalt	repres. of olivine tholeiites
ES-19	BASALT	49N	15W	20	D	Esko	ophitic basalt	repres. of Rev. ol. thol.
F-92	BASAND	57N	6W	30	A	Finland	fine-gr. bas. andes.	repres. of basaltic andesites
F-180	BASALT	56N	7W	11	D	Illgen City	fine-gr. basalt	repres. of basalt
F-248	BASAND	56N	7W	10	D	Illgen City	weakly porph. gran. bas.	repres. of basaltic andesites
F-267	BASAND	57N	7W	24	C	Finland	fine-gr. K-andesite	repres. of basaltic andesites
F-289	BASALT	56N	7W	1	B	Illgen City	fine-gr. basalt	repres. of basaltic andesites
F-290	BASALT	58N	5W	29	A	L. Marais	ophitic basalt	repres. of olivine tholeiite
GP-11b	BASALT	63N	6E	10	D	Gd. Portage	porph. basalt	Basal R flow, GP series
GP-16	BASALT	63N	6E	10	D	Gd. Portage	porph. basalt	Basal R flow, GP series
GP-20a	BASALT	63N	6E	10	D	Gd. Portage	intersertal basalt	repres. of Rev. GP series
GP-24	BASALT	63N	5E	24	D	Gd. Portage	fine-gr. ophitic basalt	repres. of Rev. GP series
LM-9	ANDES	64N	1W	36	B/C	Lima Mtn.	porph. andesite	repres. of Rev. andesites
ML-34	ANDES	62N	2W	14	B	Mark Lake	aphyric andesite	repres. of Norm andesites
ML-37	BASALT	62N	2W	18	A	Mark Lake	fine-gr. basalt	repres. of basalts

TABLE IB (continued)

INVENTORY OF ANALYZED SAMPLES OF MAFIC AND INTERMEDIATE LAVAS

Sample	Unit	Location					Description	Comments
		Twp	Ra	Sec.	¼	Quad.		
T-65	BASALT	59N	4W	1	B	Tofte	oph. olivine tholeiite	fresh olivine tholeiite
T-86	BASALT	59N	3W	6	D	Tofte	fine-gr. porph. basalt	repres. of basalts
T-96	ANDES	59N	5W	11	C	Honeymoon Mtn.	weakly proph. andesite	repres. of andesites
TL-8	BASALT	61N	3W	01	C	Tait Lake	intergranular K-basalt	repres. of basaltic andesites
TL-13	BASALT	62N	2W	18	C	Tait Lake	ophitic basalt	repres. of olivine tholeiites
TL-14	BASALT	62N	2W	18	C	Tait Lake	porphyritic basalt	repres. of basalts

TABLE IC

INVENTORY OF ANALYZED SAMPLES OF FELSIC LAVAS

Sample	Unit	Twp	Rge	Sec	Qtr	Quad	Description	Comments
C-9	RHYO	59N	5W	20	B	Cramer	porphyritic rhyolite	cf Palisades, Manitou?
C-31	RHYO	58N	6W	5	B	Cramer	vesicular rhyolite	anal. for Sn, W only
D-42	RHYO	50N	14W	13	A	Duluth	weakly porph. dense felsite	repres. of lg. ignimbrite
DT-9	RHYO	62N	1W	25	A	Devil Track Lake	porph. poikil. rhyolite	repres. of lg. ignimbrite -Kimball Ck.
DT-11	RHYO	62N	1W	14	C	Devil Tr. Lake	vesic; porph. rhyolite	anal. for Sn, W only
DT-24	RHYO	62N	1W	36	A	Devil Track Lake	streaky, porph. rhyo.	repres. of rhyolite-Kimball Ck.
F-125a	RHYO	58N	6W	33	A	L. Marais	porph. rhyo.	repres. of rhyolites-Manitou
F-278	RHYO	56N	7W	22	B	Illgen City	granular banded aphyric felsite	repres. of rhyolites-Baptism
GM-21	RHYO	61N	1E	14	D	Gr. Marais	vesic., porph. rhyolite	anal. for Sn, W only
GM-31	RHYO	62N	1E	32	B	Gr. Marais	vesic., porph. rhyolite	anal. for Sn, W only
GM-52	RHYO	61N	1E	14	C	Gr. Marais	porph. felsite	repres. of rhyolites
H-15	RHYO	62N	4E	09	D	Hovland	porph. rhyo.	repres. of rhyolites
I-13	RHYO	60N	7W	32	B	Sawbill Landing	vesic., porph. felsite	anal. for Sn, W only
KC-47	RHYO	61N	2E	7	D	Kadunce Ck.	vesic., porph. rhyolite	anal. for Sn, W only
KC-60	RHYO	61N	2E			Kadunce Ck.	vesic., altered felsite	anal. for Sn, W only
LM-17a	RHYO	63N	1W	2	A	Lima Mtn.	porph. rhyo. breccia	anal. for Sn, W only
LW-6	RHYO	50N	13W	3	B	Lakewood	vesic., porph. felsite	anal. for Sn, W only
LW-8	RHYO	50N	13W	3	B	Lakewood	spherul. porph. felsite	anal. for Sn, W only
MC-1	RHYO	62N	4E	12	A	Mineral Center	porph., spherul. rhyo.	anal. for Sn, W only
MCC-13	ICELND	53N	11W	06	A	McCarthy Ck	weakly porph felsite	thick, granular unit
MI-11	RHYO	62N	3E	27	D	Marr Island	vuggy, porph. rhyolite	anal. for Sn, W only
MI-26	RHYO	62N	3E	27	A	Marr Island	red, porph. rhyo. banded	Brule R. rhyolites
MI-28	RHYO	62N	3E	22	C	Marr Island	spherulitic felsite	Brule R. rhyolites

TABLE IC (continued)

INVENTORY OF ANALYZED SAMPLES OF FELSIC LAVAS

Sample	Unit	Twp	Rge	Sec	Qtr	Quad	Description	Comments
MI-40	RHYO	62N	3E	14	C	Marr Isl.	porph. felsite	Brule R. rhyolites
ML-1	RHYO	61N	2W	02	D	Mark Lake	granular felsite	Devil Track rhyolite
ML-12	RHYO	62N	2W	25		Mark Lake	porph. felsite	Kimball Ck felsite
ML-32	RHYO	62N	2W	14	B	Mark Lake	porph. rhyo.	repres. of rhyolites-Cascade River
NL-2	ICELND	63N	2E	07	B	Nor. Lts. Lake	banded, porph. rhyolite	repres. of icelandites
TL-27A	RHYO	61N	2W	18	C	Tait Lake	granular felsite	Devil Track rhyolite
TM-12	RHYO	63N	3E	15	B	Tom Lake	porph. rhyo.	repres. of rhyolites

TABLE ID

INVENTORY OF INTERMEDIATE AND FELSIC INTRUSIVE ROCKS

Sample	Unit	Twp	Rge	Sec	Qtr	Quad	Description	Comments
BRL-1	DCFEL	63N	3W	25	A	Brule Lake	red granophyre	Brule Lookout felsite
C-6	DCFEL	60N	6W	20	C	Silver Is. Lake	Micrographic granite	repres. of granophyres
D-103	DCINT	50N	14W	33	A	Duluth	fine-gr. qtz monzonite	repres. of intermediate rocks
D-138	DCFEL	51N	13W	19	D	Arnold	fine-gr. porph. felsite	Roof of Dul. Cpx-intrus. or lava?
DG-30	DCINT	50N	14W	29	A	Duluth	med.-gr. granodiorite	repres. of intermediate rocks
DG-65	DCINT	63N	5W	10	C/D	Kelso Mtn.	med.-gr. red granodiorite	repres. of intermediate - Wine L.
DG-66	DCFEL	50N	14W	15	D	Duluth	pink Hbl adamellite	repres. of granophyres
EM-1	DCFEL	63N	2W	34	A	Eagle Mtn.	porph. granophyre	repres. of granophyres - Eagle Mtn.
F-35	BBFEL	58N	6W	31	B	Finland	red, porph. felsite	repres. of felsic-intermediate rocks
F-46	BBINT	58N	6W	29	A/B	L. Marais	coarse, skeletal red rock	repres. of intermediate rocks
LM-7	DCFEL	64N	1W	36	B/C	Lima Mtn.	porphyritic, spherulitic granophyre	repres. of granophyres-Lima Mtn.
PM-1	DCINT	63N	1E	36	A	Pine Mtn.	augite syenodiorite	repres. of intermediate rocks
PM-2	DCFEL	63N	1E	34	C	Pine Mtn.	miarolitic granophyre	repres. of granophyres-Pine Mtn.
PW-1A	DCINT	64N	2E	21	A	Pine Lk W.	aug.-hb-qtz. monzonite	repres. of intermediate rocks
PW-6	DCFEL	64N	2E	30	A	Pine Lk W.	red augite granophyre	repres. of granophyres
SB-105	BBFEL	57N	8W	15	B	Doyle Lake	red, med.-gr. granite	repres. of granophyres
TH-63	OKIINT	55N	10W	26	C	Two Hbrs. NE	coarse ferrodiorite	repres. of intermediate rocks
WHY-2	DCFEL	58N	10W	30	B	Mt. Weber	red granophyre	repres. of granophyres-Mt. Weber

TABLE IE

INVENTORY OF MAFIC DIKE ROCKS

Sample	Unit	Twp	Rge	Sec	Qtr	Quad	Description	Comments
CQ-1	DIKECC	48N	16W	5	C	Cloquet	fine-med. gr. diabase	St. Louis R.-Rev.
CQ-2	DIKECC	48N	16W	5	C	Cloquet	fine-med. ol. diabase	St. Louis R.-Rev.
CQ-3	DIKECC	48N	16W	6	D	Cloquet	fine-gr. basalt	Cloquet/Thomson - Rev.: fresh
CQ-4	DIKECC	48N	16W	6	D	Cloquet	suboph. ol. diabase	Cloquet/Thomson - Rev.
CQ-5	DIKECC	48N	16W	6	D	Cloquet	intergran. diabase	Cloquet/Thomson - Rev.
CQ-6	DIKECC	48N	16W	5	C	Cloquet	v. fine-gr. basalt	Cloquet/Thomson - Rev.
CQ-8	DIKECC	48N	16W	6	C	Cloquet	fine-gr. diabase	Cloquet/Thomson - Rev.
CQ-10	DIKECC	49N	16W	19	C	Cloquet	weak. porph. basalt	St. Louis R. - Rev.
D-25	DIKEDU	49N	14W	6	A	Dul.Hts.	subophitic ol. diabase	Cuts anorthositic gabbro-Skyline
D-108	DIKEDU	50N	14W	28	C	Duluth	fine-gr. black diabase	cuts granophyre-Twin Lakes
D-112	DIKEDU	50N	14W	23	C	Duluth	fine-gr. inter gran. basalt	cuts NSVG
D-118	DIKEDU	50N	14W	23	D	Duluth	fine-suboph. basalt	cuts NSVG
D-121	DIKEDU	50N	13W	7	D	Duluth	fine-gr. ol. diabase	cuts NSVG
D-122	DIKEDU	50N	13W	8	B	Duluth	fine-med. gr. diabase	cuts NSVG
D-125	DIKEDU	50N	13W	5	D	Duluth	fine-gr. ol. basalt	cuts NSVG
D-152	DIKEDU	50N	13W	7	B	Duluth	fine-gr. basalt	cuts NSVG
D-162	DIKEDU	50N	14W	23	B/C	Duluth	v. fine-gr. basalt	cuts NSVG
D-168	DIKEDU	50N	13W	5	B	Duluth	v. fine-gr. weak. porph. basalt	cuts NSVG
D-170	DIKEDU	50N	13W	5	B	Duluth	v. fine-gr. weak. porph. basalt	cuts NSVG
D-172	DIKEDU	51N	13W	32	D	Duluth	fine-gr. diabase	cuts NSVG - altered
D-176	DIKEDU	50N	14W	13	A/D	Duluth	fine-med. gr. diabase	cuts NSVG
DC-121B	DIKETC	58N	13W	8	B	Allen	porphyritic microgabbro	cuts olivine gabbro
ES-21	DIKECC	49N	15W	32	B	Esko	plag-porph. basalt	cuts Elys Pk basalts-Rev.

TABLE IE (continued)

INVENTORY OF MAFIC DIKE ROCKS

Sample	Unit	Twp	Rge	Sec	Qtr	Quad	Description	Comments
ES-22	DIKECC	49N	15W	33	C	Esko	weak. porph. basalt	cuts Elys Pk basalts-Nor.
ES-26	DIKECC	48N	16W	10	D	Esko	fine-gr. diabase	St. Louis R.-Rev.
ES-27	DIKECC	48N	16W	10	C	Esko	fine-gr. diabase	St. Louis R.-Rev.
ES-29	DIKECC	48N	16W	10	C/D	Esko	fine-med. gr. diabase	St. Louis R.-Rev.
F-257	DIKETC	56N	7W	4	D	Illgen City	black diabase	Baptism R.-cuts NSVG
GBL-2	DIKETC	63N	10W	3	A	Ojibway L.	suboph. ol. diabase	cuts Knife Lk.
GBL-5	DIKETC	63N	10W	9	B	Ojibway L.	fine-gran. ol. diabase	cuts Ely Greenstone
GP-30	DIKEGP	63N	6E	19	C	Grd. Portage	fine-gr. basalt	NE of Hollow Rock
GP-47	DIKEGP	63N	5E	25	A	Grd. Portage	porph. basalt	NE of Deronda Bay
GP-60	DIKEPR	64N	6E	34	A	Grd. Portage	aphanitic black basalt	thin, inside Mt. Josephine megadike
H-6	DIKEGP	62N	4E	12	A	Hovland	porph. fine-gr. diabase	cuts Hovland lavas
KV-128	DIKETC	-	-	-	-		fine-gr. basalt	cuts Mellen granite, WI
LW-28	DIKEDU	50N	13W	4	A	Lakewood	black basalt	cuts NSVG
LW-56	DIKEDU	50N	13W	4	A	Lakewood	black basalt	cuts Lester R. sill
LW-57	DIKEDU	51N	13W	34	D	Lakewood	suboph. ol. basalt	cuts NSVG
LW-58	DIKEDU	50N	13W	3	B	Lakewood	fine-gr. basalt	cuts NSVG felsite
M-7129	DIKETC	64N	10W	36	A	Ojibway L.	fine-gr. diabase	cuts Knife Lake
M-7268	DIKETC	64N	9W	29	A	Ojibway L.	fine-gr. diabase	cuts Knife Lake
M-7359	DIKETC	63N	9W	19	C	Ojibway L.	fine-gr. diabase	cuts Giants R. granite
M-7402	DIKETC	63N	10W	9	B	Ojibway L.	massive, dark diabase	cuts Ely Greenstone
ML-36	DIKETC	62N	2W	8	C	Mark Lake	porph. basalt	cuts NSVG
PP-7	DIKEGP	63N	7E	08	B	Pigeon Pt.	black diabase	Lucille I - cuts NSVG
PP-15	DIKEGP	63N	7E	04	C	Pigeon Pt.	porph. diabase	Lucille I - cuts NSVG

TABLE IE (continued)

INVENTORY OF MAFIC DIKE ROCKS

Sample	Unit	Twp	Rge	Sec	Qtr	Quad	Description	Comments
PP-34	DIKEGP	-	-	-	-	-	intergran. diabase	cuts Rove; Canada 61-R
PP-35	DIKEPR	-	-	-	-	-	med.-gr. ol. diabase	cuts Rove; Logan; in Crystal Ck
PP-36	DIKEPR	64N	7E	19	D	Pigeon Pt.	ophitic ol. diabase	cuts Rove, High Falls Pigeon R.
VC-221	DIKECC	49N	17W	36	D	Cloquet	weak. porph. basalt	St. Louis R.-R - fresh
VC-226	DIKECC	48N	16W	8	C	Cloquet	intersert Fe-diabase	St. Louis R.-R - fresh
VC-227	DIKECC	49N	17W	13	D	Cloquet	intersert ol. diabase	St. Louis R.-R - fresh
VC-230	DIKECC	48N	16W	9	D	Esko	fine-gr. diabase	St. Louis R.-N
20-3-C	DIKECC	46N	19W	20		Moose L.	fine-gr. basalt	Moose Lake RR cut

TABLE II

KEY TO LETTER DESIGNATIONS FOR ROCK UNITS SAMPLED

Duluth Complex	
Anorthositic series	DCANOR
Troctolitic series	DCTROC
Ultramafic rocks	DCUMAF
Other (miscellaneous) mafic rocks	DCMMA
Intermediate rocks	DCINT
Felsic rocks	DCFEL
Beaver Bay Complex	
Mafic rocks	BBMAF
Intermediate rocks	BBINT
Felsic rocks	BBFEL
Other Keweenawan Intrusions (except dikes)	
Mafic rocks	OKIMAF
Intermediate rocks	OKIINT
Felsic rocks	OKIFEL
Dikes	
Carlton County swarm	DIKECC
Duluth swarm	DIKEDU
Grand Portage swarm	DIKEGP
Pigeon River group	DIKEPR
Others	DIKETC
North Shore Volcanic Group	
Basalts	BASALT
Basaltic andesites	BASAND
Andesites	ANDES
Icelandites	ICELND
Rhyolites	RHYO

Table III

Trace-element concentrations* of economic interest in basalts and felsites.

	Cr	Ni	As	Sb	U	W	Cu	Zn	Mo	Au	Ag
Most Primitive Basalts											
GP-11	670	207					129	107			
GP-16	711	204					199	117			
GP-20a	97	70	<2	<0.2	1.1	<3	120	98	<5	<20	<0.5
C-10	200	150	<2	<0.2	0.5	<3	67	110	<5	10	<0.5
ES-19	130	80	<2	<0.2	1.0	<3	57	92	<5	<20	<0.5
D-130	190	130	<2	<0.2	<0.5	<3	170	130	<5	<10	<0.5
TL-13	330	250	8	0.3	<0.5	<3	94	83	<5	10	<0.5
F-290	140	220	<2	<0.2	<0.5	<3	110	98	<5	<20	<0.5
T-65	90	120	<2	<0.2	<0.5	<3	120	130	<5	<10	<0.5
ML-37	300	160	5	0.2	<0.5	<3	5	98	<5	<10	<0.5
Felsic Volcanics											
McC-13			<2	0.5	3.5	<3	120	140	<5	<10	<0.5
NL-2			<2	0.3	1.6	<3	16	140	<5	10	<0.5
D-42			7	1.2	6.3	3	100	190	<5	<10	<0.5
MI-28			<2	0.2	3.5	<3	430	78	<5	<10	<0.5
F-278			<2	<0.2	3.3	<3	20	110	<5	10	<0.5
F-125a			15	0.8	3.3	<3	6.5	150	<5	10	<0.5
GM-52			4	0.6	2.5	<3	14	110	<5	<10	<0.5
DT-9			12	0.8	3.6	<3	16	140	<5	<10	<0.5
DT-24			<4	0.7	7.8	<12	16	140	7	<10	<0.5
ML-1			<2	0.2	3.3	<3	6.5	130	<5	<10	<0.5
ML-12			7	0.6	3.3	3	25	150	<5	<10	<0.5
MI-40			<2	<0.2	3.6	<3	19	160	<5	<10	<0.5
C-9			6	0.3	2.5	<3	20	170	<5	<10	<0.5
MI-26			110	1.7	4.3	42	10	64	<5	<10	<0.5
H-15			2	0.4	3.3	210	7	76	5	<10	<0.5
TL-27a			<2	<0.2	3.0	<3	25	110	<5	<10	<0.5

* Values in ppm except for Au (in ppb)

TABLE IV

SAMPLES ANALYZED SEPARATELY FOR TIN AND TUNGSTEN
(XRAL, Toronto)

Sample No.	Unit	Location	Sn, ppm	W, ppm
C-31	RHYO	NW 1/4 Sec. 5, T.58N,R.6W.	5	2
D-138	DCFEL	SE 1/4 Sec. 19,T.51N,R.13W.	5	3
DT-11	RHYO	SW 1/4 Sec. 14,T.62N,R.1W.	3	1
DT-24	RHYO	NE 1/4 Sec. 36,T.62N,R.1W.	<3	1
GM-21	RHYO	SE 1/4 Sec. 14,T.61N,R.1E.	<3	1
GM-31	RHYO	NW 1/4 Sec. 32,T.62N,R.1E.	3	1
I-13	RHYO	NW 1/4 Sec. 32,T.60N,R.7W.	3	1
KC-47	RHYO	SE 1/4 Sec. 7,T.61N,R.2E.	3	1
KC-60	RHYO	SE 1/4 Sec. 35,T.62N,R.2E.	3	1
LM-17A	RHYO	NE 1/4 Sec. 2,T.63N,R.1W.	3	1
LW-6	RHYO	NW 1/4 Sec. 3,T.50N,R.13W.	20	1
LW-8	RHYO	NW 1/4 Sec. 3,T.50N,R.13W.	25	1
MC-1	RHYO	NE 1/4 Sec. 12,T.62N,R.4E.	3	2
MI-11	RHYO	SE 1/4 Sec. 27,T.62N,R.3E.	<3	1
ML-1	RHYO	SE 1/4 Sec. 2,T.61N,R.2W.	<3	<1
WHY-2	DCFEL	NW 1/4 Sec. 30,T.58N,R.11W.	<3	3

TABLE V

Selected trace-element characteristics of Keweenawan felsic rocks compared to tin-bearing South African granite.

	I/E*	Rb	Sr	Ba	La	Ce	Y	Zr	Zn	Sn
C-9	E	190	10	1280	54.8	134	50	610	170	
D-42	E	220	40	320	102	214	110	580	190	
DT-24	E	160	50	1100	111	256	120	640	140	
DT-9	E	180	70	1120	84.9	206	70	650	140	
F-125a	E	190	70	1380	74.4	172	70	680	150	
F-278	E	140	40	1130	145	225	90	580	110	
GM-52	E	170	200	1050	87.9	198	100	660	110	
H-15	E	160	50	780	16.3	225	90	600	76	
MI-26	E	190	70	1090	76.6	290	280	530	64	
MI-28	E	50	50	540	35.4	74	20	340	78	
MI-40	E	100	140	1400	92.8	221	40	810	160	
ML-1	E	120	30	1550	56.3	138	60	600	130	
ML-12	E	190	80	1140	97.6	195	80	650	150	
ML-32	E	130	30	2250	86.6	169	60	620	56	
TL-27a	E	130	40	1440	38	220	40	600	110	
TM-12	E	170	180	910	43.6	91	70	460	90	
McC-13	E	120	120	760	72.3	168	100	720	140	
NL-2	E	90	430	900	105	215	70	660	140	
BRL-1	I	150	140	1100	89.7	183	80	580	160	
C-6	I	220	44	930			80	580	113	
D-138	I	150	160	1060	91.5	199	130	1160	290	5
DG-66	I	140	219	780			63	720	112	
EM-1	I	160	140	1000	77.2	150	50	450	130	
LM-7	I	190	170	1100	129	266	110	960	200	
PM-2	I	170	90	1170	70.8	152	80	520	96	
PW-6	I	240	60	1070	120	237	120	950	140	
WHY-2	I	110	80	1350	59.7	141	60	570	110	<3
F-35	I	150	160	830	76.7	161	70	460	120	
SB-105	I	90	150	1110	90.2	193	110	730	170	
A*	E	176	70	1100	72	100	56	395	125	<5
B*	I	225	40	890	100	139	97	433	91	6.5
C*	I	408	7	260	118	150	146	328	26	9

*Explanation: I = intrusive rocks; E = extrusive; A = Rooiberg felsites, B = stratiform Bushveld granites; C = tin-bearing Bobbejaankop granite (Lenthall and Hunter, 1977)

APPENDIX A

WHOLE ROCK ANALYSIS - % MAJORS & MINORS - XRF - PW 1600 - REFERENCE STANDARDS

	MRG-1	SY-2	G-2	NBS-1c*	NBS-97a	NBS-99a	BX-N	GS-N	NIM-D	NIM-N	
SiO_2	38.9 (39.32)	60.0 (60.10)	68.8 (69.22)	7.24 (6.84)	43.2 (43.67)	65.3 (65.2)	7.44 (7.39)	65.9 (65.98)	38.3 (38.96)	52.7 (52.64)	SiO_2
Al_2O_3	8.41 (8.50)	12.1 (12.12)	15.4 (15.40)	1.40 (1.30)	38.7 (38.79)	20.7 (20.5)	54.0 (54.53)	14.8 (14.71)	0.25 (0.3?)	16.3 (16.50)	Al_2O_3
CaO	14.8 (14.77)	8.01 (7.98)	1.95 (1.96)	50.6 (50.3)	0.10 (0.11)	2.15 (2.14)	0.16 (0.17)	2.55 (2.51)	0.27 (0.28)	11.7 (11.50)	CaO
MgO	13.4 (13.49)	2.68 (2.70)	0.72 (0.75)	0.40 (0.42)	0.17 (0.15)	0.01 (0.02)	0.11 (0.11)	2.28 (2.31)	43.1 (43.51)	7.34 (7.50)	MgO
Na_2O	0.71 (0.71)	4.31 (4.34)	4.10 (4.06)	0.00 (0.02)	0.04 (0.037)	6.31 (6.2)	0.04 (0.06)	3.84 (3.78)	0.06 (0.04?)	2.39 (2.46)	Na_2O
K_2O	0.18 (0.18)	4.50 (4.48)	4.40 (4.46)	0.27 (0.28)	0.52 (0.50)	5.28 (5.2)	0.06 (0.07)	4.68 (4.64)	0.04 (0.01?)	0.24 (0.25)	K_2O
Fe_2O_3	17.7 (17.82)	6.20 (6.28)	2.70 (2.69)	0.65 (0.55)	0.45 (0.45)	0.08 (0.065)	23.3 (23.27)	3.70 (3.76)	16.5 (16.96)	8.84 (8.91)	Fe_2O_3
MnO	0.16 (0.17)	0.32 (0.32)	0.03 (0.03)	0.01 (0.025)	0.00 (-)	0.00 (-)	0.04 (0.05)	0.05 (0.056)	0.23 (0.22)	0.18 (0.18)	MnO
TiO_2	3.65 (3.69)	0.14 (0.14)	0.50 (0.48)	0.07 (0.07)	1.88 (1.90)	0.02 (0.007)	2.35 (2.41)	0.66 (0.68)	0.03 (0.02)	0.19 (0.20)	TiO_2
P_2O_5	0.06 (0.06)	0.42 (0.43)	0.13 (0.13)	0.04 (0.04)	0.35 (0.36)	0.02 (0.02)	0.13 (0.13)	0.27 (0.28)	0.01 (0.02?)	0.02 (0.03)	P_2O_5
Cr_2O_3	0.06 (0.07)	0.00 (0.002)	0.00 (0.00)	0.00 (-)	0.03 (0.03)	0.00 (-)	0.04 (0.04)	0.01 (0.01)	0.40 (0.42)	0.01 (0.005)	Cr_2O_3

NOTE: ( ) are usable values as per Sydney Abbey, 1979 - (-) indicates no values available. This represents only part of the group of 50 reference materials used for calibrating the simultaneous spectrometer. Others are available on request.
* ( ) values are certified NBS values.

INSTRUMENT STABILITY

(10 replicate analyses)

	Mean (%)	SC(%)	Mean (%)	SD(%)
SiO_2	39.5	0.06	65.1	0.07
Al_2O_3	2.92	0.01	18.8	0.03
CaO	1.20	0.005	0.10	0.005
MgO	34.8	0.08	0.10	0.005
Na_2O	0.13	0.01	2.56	0.03
K_2O	0.02	0.005	12.9	0.02
Fe_2O_3	8.52	0.015	0.12	0.005
MnO	0.13	0.00	0.00	0.00
TiO_2	0.12	0.005	0.03	0.00
P_2O_5	0.04	0.00	0.02	0.00
Cr_2O_3	0.33	0.001	0.00	0.00

SAMPLE PREPARATION REPRODUCIBILITY

(42 replicate analyses)

Mean (%)	SD(%)	Mean (%)	SD(%)	
80.7	0.25	65.9	0.25	SiO_2
8.21	0.06	13.0	0.06	Al_2O_3
0.05	0.005	0.72	0.005	CaO
1.79	0.02	6.08	0.04	MgO
0.13	0.01	0.60	0.02	Na_2O
1.89	0.01	2.51	0.01	K_2O
4.87	0.03	7.14	0.03	Fe_2O_3
0.08	0.005	0.14	0.005	MnO
0.19	0.005	0.33	0.005	TiO_2
0.05	0.00	0.10	0.00	P_2O_5
0.02	0.00	0.02	0.00	Cr_2O_3
1.59	0.08	2.95	0.09	L.O.I.

NOTE: Mean is the arithmetic mean
SD is standard deviation

USGS HAWIIAN BASALT

BHVO-1
DR. J. C. GREEN
DILUTION FACTOR = 9988

			CONC.	PRED. SD.	OBS. SD.
2	SiO2	49.90	49.8 %WT	0.41 %WT	0.28 %WT
3	P205	0.28	0.23 %WT	0.074 %WT	0.065 %WT
4	TiO2	2.69	2.75 %WT	0.025 %WT	0.025 %WT
7	MnO	0.17	0.1653 %WTERROR CODE = 5		
ERROR LINE = 27775					
10	MgO	7.31	7.29 %WT	0.059 %WT	0.028 %WT
12	Sr	420	417 PPM	4.8 PPM	1.9 PPM
14	Al203	13.85	13.74 %WT	0.114 %WT	0.053 %WT
15	Fe203T	12.23	12.34 %WT	0.107 %WT	0.043 %WT
16	K20	0.54	0.572 %WT	0.0138 %WT	0.0058 %WT
17	Na20	2.29	2.17 %WT	0.023 %WT	0.013 %WT
19	CaO	11.33	11.38 %WT	0.092 %WT	0.049 %WT
20	Ba	135	139 PPM	2.8 PPM	1.8 PPM

BHVO-1-2
DR. J. C. GREEN
DILUTION FACTOR = 199.71 MULTIELELMENT STOCK DILUTION FACTOR = 19.?

			CONC.	OBS. SD.
1	Be	1.2?	1.40 PPM	0.014 PPM
2	MnO	0.17	0.183 %WT	0.0054 %WT
3	Zn	105	106 PPM	1.3 PPM
4	Cu	140	146 PPM	1.9 PPM
6	Au		0.6 PPM	0.66 PPM
8	Sc	31	36.2 PPM	0.66 PPM
9	Co	45	47 PPM	1.9 PPM
12	Sr	420	446 PPM	12.7 PPM
13	Pb		-27 PPM	5.4 PPM
14	Ni	120	116 PPM	1.7 PPM
16	Ba	135	134 PPM	1.7 PPM
17	Th	1.0	-1 PPM	1.3 PPM
18	Cr	300	289 PPM	4.5 PPM
19	Rb	10	7.6 PPM	1.04 PPM
20	V	320	302 PPM	5.0 PPM

BHVO-1-1
DR. J. C. GREEN
DILUTION FACTOR = 199.71 MULTIELELMENT STOCK DILUTION FACTOR = 19 ?

			CONC.	OBS. SD.
~~1~~	~~U~~		~~27 PPM~~	~~4.0 PPM~~
3	P_2O_5	0.28	0.268 %WT	0.0090 %WT
~~5~~	~~Sn~~		~~149 PPM~~	~~62.0 PPM~~
6	Hf	4.3	17 PPM	1.4 PPM
7	MnO	0.17	0.19 %WT	0.011 %WT
8	Zr	180	171 PPM	4.2 PPM
~~9~~	~~Mo~~		~~36 PPM~~	~~4.5 PPM~~
11	Y	27?	25.9 PPM	0.51 PPM
12	Sr	420	442 PPM	17.4 PPM
~~13~~	~~Nb~~		~~86 PPM~~	~~27.7 PPM~~
~~16~~	~~K_2O~~		~~414 PPM~~	~~6595.5 PPM~~
18	Ga	21?	61 PPM	2.0 PPM
20	Ba	135	145 PPM	3.1 PPM

USGS BASALT

BCR-1
DR. J. C. GREEN
DILUTION FACTOR = 10023

			CONC.	PRED. SD.	OBS. SD.
2	Si02	54.53	54.7 %WT	0.45 %WT	0.45 %WT
3	P205	0.36	0.36 %WT	0.070 %WT	0.052 %WT
4	Ti02	2.26	2.29 %WT	0.021 %WT	0.018 %WT
7	Mn0	0.18	0.1789 %WTERROR CODE = 5		

ERROR LINE = 27775

			CONC.	PRED. SD.	OBS. SD.
10	Mg0	3.48	3.59 %WT	0.029 %WT	0.019 %WT
12	Sr	330	349 PPM	4.1 PPM	2.3 PPM
14	Al203	13.72	13.68 %WT	0.113 %WT	0.105 %WT
15	Fe203T	13.41	13.53 %WT	0.116 %WT	0.068 %WT
16	K20	1.70	1.72 %WT	0.023 %WT	0.016 %WT
17	Na20	3.30	3.28 %WT	0.032 %WT	0.022 %WT
19	Ca0	6.97	7.12 %WT	0.058 %WT	0.052 %WT
20	Ba	680	743 PPM	7.4 PPM	2.9 PPM

BCR-1-2
DR. J. C. GREEN
DILUTION FACTOR = 200.35 MULTIELELMENT STOCK DILUTION FACTOR = 19.8

			CONC.	OBS. SD.
1	Be	1.6?	1.81 PPM	0.020 PPM
2	MnO	0.18	0.181 %WT	0.0060 %WT
3	Zn	125	134 PPM	1.7 PPM
4	Cu	16	14.9 PPM	0.30 PPM
6	Au		0.4 PPM	0.46 PPM
8	Sc	33	35.1 PPM	0.85 PPM
9	Co	36	38 PPM	2.5 PPM
12	Sr	330	331 PPM	8.6 PPM
13	(Pb)	14	-4 PPM	4.8 PPM
14	Ni	10	9.4 PPM	1.01 PPM
16	Ba	680	688 PPM	35.7 PPM
17	(Th)	6.1	4 PPM	1.8 PPM
18	Cr	15	9.6 PPM	0.43 PPM
19	Rb	47	41 PPM	1.5 PPM
20	V	420	374 PPM	12.5 PPM

BCR-1-1
DR. J. C. GREEN
DILUTION FACTOR = 200.35 MULTIELELMENT STOCK DILUTION FACTOR = 19.8

			CONC.	OBS. SD.
~~1~~	~~U~~		~~25 PPM~~	~~6.3 PPM~~
3	P_2O_5	0.36	0.34 %WT	0.012 %WT
~~5~~	~~Sm~~		~~133 PPM~~	~~22.3 PPM~~
6	(Hf)	5	9 PPM	1.1 PPM
7	MnO	0.18	0.180 %WT	0.0051 %WT
8	Zr	185	176 PPM	3.8 PPM
~~9~~	~~Mo~~		~~29 PPM~~	~~8.5 PPM~~
11	Y	40	32.4 PPM	0.40 PPM
12	Sr	330	335 PPM	8.7 PPM
~~13~~	~~Nb~~		~~37 PPM~~	~~10.4 PPM~~
~~16~~	~~K_2O~~		~~-3714 PPM~~	~~6242.3 PPM~~
18	(Ga)	22	103 PPM	5.0 PPM
20	Ba	680	673 PPM	26.7 PPM

USGS ANDESITE

AGV-1
DR. J. C. GREEN
DILUTION FACTOR = 10002

			CONC.	PRED. SD.	OBS. SD.
2	SiO_2	59.61	59.3 %WT	0.53 %WT	0.65 %WT
3	P_2O_5	0.51	0.47 %WT	0.084 %WT	0.022 %WT
4	TiO_2	1.06	1.05 %WT	0.011 %WT	0.012 %WT
7	MnO	0.10	931 PPM	17.5 PPM	10.5 PPM
10	MgO	1.52	1.52 %WT	0.013 %WT	0.012 %WT
12	Sr	660	678 PPM	7.9 PPM	6.4 PPM
14	Al_2O_3	17.19	17.1 %WT	0.15 %WT	0.17 %WT
15	Fe_2O_3T	6.78	6.49 %WT	0.064 %WT	0.052 %WT
16	K_2O	2.92	2.85 %WT	0.038 %WT	0.029 %WT
17	Na_2O	4.32	4.26 %WT	0.045 %WT	0.041 %WT
19	CaO	4.94	4.83 %WT	0.042 %WT	0.049 %WT
20	Ba	0.12	0.130 %WT	0.0014 %WT	0.0013 %WT

AGV-1-2
DR. J. C. GREEN
DILUTION FACTOR = 200.01 MULTIELELMENT STOCK DILUTION FACTOR = 1

			CONC.	OBS. SD.
1	Be	2.2?	2.26 PPM	0.040 PPM
2	MnO	0.10	931 PPM	40.7 PPM
3	Zn	86	93 PPM	1.3 PPM
4	Cu	59	62 PPM	1.9 PPM
6	Au		0.7 PPM	0.40 PPM
8	Sc	12.5	13.6 PPM	0.28 PPM
9	Co	16	15 PPM	1.2 PPM
13	Pb	33	55 PPM	7.6 PPM
14	Ni	15	13.3 PPM	0.38 PPM
16	Ba	0.12	0.13 %WT	0.014 %WT
17	Th	6.4	2 PPM	3.3 PPM
18	Cr	10	8.4 PPM	0.37 PPM
19	Rb	67	65 PPM	2.7 PPM
20	V	125	109 PPM	3.6 PPM

AGV-1-1
DR. J. C. GREEN
DILUTION FACTOR = 200.01 MULTIELELMENT STOCK DILUTION FACTOR = 19.

			CONC.	OBS. SD.
~~1~~	~~U~~		~~190 PPM~~	~~104.3 PPM~~
3	P_2O_5	0.51	0.68 %WT	0.023 %WT
~~5~~	~~Sn~~		~~27 PPM~~	~~10.5 PPM~~
6	Hf	5?	21 PPM	3.7 PPM
7	MnO	0.10	994 PPM	25.3 PPM
8	Zr	230-	2177 PPM	359.7 PPM
~~9~~	~~Mo~~		~~24 PPM~~	~~4.1 PPM~~
11	Y	19	18.8 PPM	0.27 PPM
12	Sr	660	701 PPM	10.9 PPM
~~13~~	~~Nb~~		~~47 PPM~~	~~7.7 PPM~~
~~16~~	~~K_2O~~		~~0 %WT~~	~~2.0 %WT~~
18	Ga	21	46 PPM	1.9 PPM
20	Ba	0.12	0.17 %WT	0.016 %WT

GSJ JAPANESE GRANODIORITE

JG-1
DR. J. C. GREEN
DILUTION FACTOR = 9991

			CONC.	PRED. SD.	OBS. SD.
2	SiO2	72.36	71.5 %WT	0.59 %WT	0.24 %WT
3	P2O5	0.09	0.11 %WT	0.070 %WT	0.044 %WT
4	TiO2	0.27	0.247 %WT	0.0043 %WT	0.0020 %WT
7	MnO	0.06	615 PPM	13.7 PPM	7.3 PPM
10	MgO	0.76	0.738 %WT	0.0060 %WT	0.0025 %WT
12	Sr	185	179 PPM	3.0 PPM	1.3 PPM
14	Al2O3	14.20	14.07 %WT	0.117 %WT	0.059 %WT
15	Fe2O3T	2.16	2.060 %WT	0.0226 %WT	0.0068 %WT
16	K2O	3.96	3.82 %WT	0.044 %WT	0.026 %WT
17	Na2O	3.39	3.26 %WT	0.032 %WT	0.017 %WT
19	CaO	2.17	2.114 %WT	0.0173 %WT	0.0103 %WT
20	Ba	460	514 PPM	5.7 PPM	2.8 PPM

JG-1-2
DR. J. C. GREEN
DILUTION FACTOR = 199.75 MULTIELELMENT STOCK DILUTION FACTOR = 19.8

			CONC.	OBS. SD.
1	Be	3.2?	3.3 PPM	0.13 PPM
2	MnO	0.06	653 PPM	46.6 PPM
3	Zn	40	42 PPM	1.8 PPM
4	Cu	4	0.9 PPM	0.60 PPM
6	Au		-0.3 PPM	0.22 PPM
8	Sc		7.1 PPM	0.32 PPM
9	Co	6.4	4 PPM	1.9 PPM
12	Sr	185	194 PPM	11.2 PPM
13	Pb	26	14 PPM	12.3 PPM
14	Ni	8.2	4.8 PPM	1.02 PPM
16	Ba	460	545 PPM	69.0 PPM
17	Th	13.5	8 PPM	4.7 PPM
18	Cr	53	47 PPM	2.8 PPM
19	Rb	185	194 PPM	21.9 PPM
20	V	24	17 PPM	2.1 PPM

JG-1-1
DR. J. C. GREEN
DILUTION FACTOR = 199.75 MULTIELELMENT STOCK DILUTION FACTOR = 19.8

			CONC.	OBS. SD.
~~1~~	~~U~~		~~11 PPM~~	~~5.3 PPM~~
3	P_2O_5	0.09	854 PPM	50.3 PPM
~~5~~	~~Sn~~		~~71 PPM~~	~~102.2 PPM~~
6	Hf		7 PPM	1.1 PPM
7	MnO	0.06	575 PPM	18.1 PPM
8	Zr	110?	123 PPM	2.9 PPM
~~9~~	~~Mo~~		~~3 PPM~~	~~13.0 PPM~~
11	Y	31?	26.7 PPM	0.51 PPM
12	Sr	185	173 PPM	4.6 PPM
~~13~~	~~Nb~~		~~15 PPM~~	~~12.1 PPM~~
~~16~~	~~K_2O~~		~~3 %WT~~	~~3.7 %WT~~
18	Ga	15?	22 PPM	4.7 PPM
20	Ba	460	482 PPM	22.4 PPM

APPENDIX C

Results of Blind Analyses of Geochemical Standards

	A1	A2	B1	B2	C1	C2	D1	D2	E1	E2	F1	F2
SiO_2	54.9,54.7	54.53	69.5	69.96	38.3	38.4	69.4	69.96	58.8	59.61	41.6	42.10
TiO_2	2.24,2.27	2.26	0.34	0.38	2.63	2.61	0.36	0.38	1.06	1.06	0.02	0.01
Al_2O_3	13.7,13.7	13.72	14.7	14.51	9.75	10.25	14.9	14.51	17.3	17.19	0.62	0.73
Fe_2O_3	3.7,3.7	3.48	1.1	1.36	12.8^t	12.94^t	2.68^t	2.83^t	6.76^t	4.56	8.22^t	2.54?
FeO	8.7	8.96	1.5	1.32						2.03		5.17?
MnO	0.187,0.179	0.18	0.087	0.09	0.19	0.20	0.08	0.09	0.09	0.10	0.13	0.12
MgO	3.62,3.59	3.48	0.92	0.95	13.0	13.35	0.93	0.95	1.62	1.52	42.9	43.50
CaO	7.12,7.12	6.97	2.43	2.45	13.5	13.87	2.49	2.45	5.07	4.94	0.53	0.55
Na_2O	3.33,3.31	3.30	3.47	3.55	2.79	3.07	3.72	3.55	4.33	4.32	0.10	0.01
K_2O	1.71,1.71	1.70	3.95	4.03	1.37	1.41	4.10	4.03	2.92	2.92	0.01	0.00
P_2O_5	0.35,0.34	0.36	0.115	0.12	1.07	1.05	0.13	0.12	0.49	0.51	0.01	0.01
H_2O^+		0.67		0.87	2.70	2.31	1.19	0.87	1.77	0.78	5.08	4.70
CO_2		0.02		0.11		0.86		0.11		0.02		0.18
Total	99.6,99.3	99.85?	98.1	99.97?	98.3	100.32	100.0	99.85	100.5	99.90?	99.7	100.38?

Trace Elements

	A1	A2	B1	B2	C1	C2	D1	D2	E1	E2	F1	F2
Ag					0.5	-	<0.5	-	<0.5	.095?	0.5	.010?
As					2	-	<2	-	<2	0.8?	<2	0.05?
Au*					<20	-	<20	-	10	0.6?	<10	0.7?
Ba	690,710	680	840	850	1200	1050	900	850	1230	1200	130	4?
Be	1.9,1.7	1.6?	3.7	3.6								
Bi					<0.5	-	<0.5	-	0.5	0.05?	<0.5	0.01?
Br					2	-	2	-	1	0.5?	<1	0.6?
Cd					<0.2	-	<0.2	-	<0.2	0.09?	<0.2	0.1?
Ce					160	-	86	70	70	71	<3	-
Co	36,38	36	4	5	63	50	6	5	16	16	1	110
Cr	9,10	15	6	12	350	380	9	12	20	10	2990	2800
Cs					1.5	-	6.7	6	1.8	1.3?	<0.5	0.025?
Cu	14,15	16	21	16	86.0	72	26.0	16	69	59	8	8
Eu					3.4	3.7?	1.0	-	1.3	1.6?	<0.2	0.002?

APPENDIX C (Cont'd)

Trace Elements

	A1	A2	B1	B2	C1	C2	D1	D2	E1	E2	F1	F2
Hf					6	-	5	-	4	5?	<1	-
La					95.3	80	46.1	38	41.5	36	<0.5	0.15?
Lu					0.32	-	0.44	-	0.29	0.3?	<0.05	-
Mo					<5	3?	<5	-	<5	3?	<5	0.5?
Nb					90	100?	30	10?	20	16?	10	1?
Nd					70	60?	30	25?	27	37?	<5	-
Ni	9,9	10	3.8	7	270	260	8	7	20	15	2500	2400
Pb					30	-	30	30	28	33	<2	11
Rb	41,41	47	174	175	50	47	170	175	70	67	10	0.3?
Sb					<0.2	-	<0.2	-	4.8	4.3?	1.7	1.4?
Sc	35,35	33	7.8	7?	27.0	26?	8.3	7?	13.0	12.5	9.4	9?
Sm					12.4	12?	5.4	5?	5.7	5.9	<0.1	0.008?
Sr	343,349	330	308	310	1240	1300	360	310	730	660	<10	0.4
Ta					5	-	<1	-	<1	1.4?	<1	-
Th					11.0	12?	18.0	17	6.4	6.4	<0.5	0.01?
U					3.0	3?	4.9	4?	2.1	1.95	<0.5	0.005?
V	370,390	420	32	38								
W					4	-	<3	-	<3	0.55?	<3	0.06
Y	35,36	40	21	21	<10	30	30	21	20	19	<10	-
Yb					2	2?	2	2?	1.8	1.9	<0.2	0.02
Zn	135,127	125	70	80	200	150	84.0	80	110	86	39	41
Zr	180,180	185	160	150	290	250	160	150	220	230	<10	7?

Key: Samples ending in "1" are blind analyses from lab, those ending in "2" are "usable values" for each standard from Abbey, 1980. (-) = no data.

A1: duplicate analyses on different runs of BCR-1 basalt (USGS); B: GA granite (CRPG); C: BR basalt (CRPG); D: GA granite; E: AGV-1 andesite (USGS); F: PCC-1 peridotite (USGS). Analysts: R.L. Knoche - A,B; XRAL - C,D,E,F.

*Au in ppb: all others in ppm.

tTotal Fe as Fe_2O_3.

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Sample No.		Sample No.	Unit	Date Coll.	Pol	Analyst	SiO2	TiO2
C-14	1	C-14	ANDES	12-09-66	(N)	XRAL	57.8	1.94
C-23	2	C-23	ANDES	02-07-70	(N)	XRAL	56.4	1.95
LM-9	3	LM-9	ANDES	27-06-84	(R)	XRAL	53.6	2.46
ML-34	4	ML-34	ANDES	10-08-84	(N)	XRAL	56.6	2.34
T-96	5	T-96	ANDES	30-06-70	(N)	XRAL	59.2	1.96
C-10	6	C-10	BASALT	23-08-66	(N)	XRAL	48.8	1.43
D-128	7	D-128	BASALT	03-08-84	(N)	XRAL	49.8	4.19
D-130	8	D-130	BASALT	03-08-84	(N)	XRAL	48.2	0.91
D-62	9	D-62	BASALT	10-07-80	(N)	XRAL	47.5	3.97
ES-19	10	ES-19	BASALT	29-05-77	(R)	XRAL	51.6	1.24
F-290	11	F-290	BASALT	21-10-84	(N)	XRAL	46.4	1.16
GP-11	12	GP-11	BASALT	24-07-68	(R)	KNOCHE	44.5	2.24
GP-16	13	GP-16	BASALT	24-07-68	(R)	KNOCHE	46.3	2.38
GP-20a	14	GP-20a	BASALT	24-07-68	R	XRAL	50.5	1.29
GP-24	15	GP-24	BASALT	30-07-68	(R)	KNOCHE	47.5	3.14
ML-37	16	ML-37	BASALT	10-08-84	(N)	XRAL	50	1.01
T-65	17	T-65	BASALT	07-09-67	(N)	XRAL	49.3	1.71
T-86	18	T-86	BASALT	26-06-70	(N)	XRAL	49.8	2.62
TL-13	19	TL-13	BASALT	24-06-70	(N)	XRAL	47.3	1.12
TL-14	20	TL-14	BASALT	24-06-70	(N)	XRAL	48.5	1.62
C-12	21	C-12	BASAND	23-08-66	(N)	XRAL	51.4	2.29
D-126	22	D-126	BASAND	03-08-84	(N)	XRAL	53.9	2.45
F-180	23	F-180	BASAND	29-06-68	(N)	XRAL	52.6	2.57
F-248	24	F-248	BASAND	19-07-76	(N)	XRAL	54.6	1.74
F-267	25	F-267	BASAND	23-07-76	(N)	KNOCHE	53.5	2.51
F-289	26	F-289	BASAND	21-10-84	(N)	XRAL	54.3	2.04
F-92	27	F-92	BASAND	28-06-66	(N)	XRAL	55.2	2.09
TL-8	28	TL-8	BASAND	23-06-70	(N)	XRAL	51.8	2.87
McC-13	129	McC-13	ICELND	04-08-84	(N)	XRAL	58	1.69
NL-2	130	NL-2	ICELND	09-07-70	(R)	XRAL	66.2	0.55
C-9	138	C-9	RHYO	22-09-65	(N)	XRAL	74.1	0.36
D-42	139	D-42	RHYO	17-06-75	(N)	XRAL	69	0.8
DT-24	140	DT-24	RHYO	28-06-84	(N)	XRAL	69.1	0.55
DT-9	141	DT-9	RHYO	19-06-70	(N)	XRAL	70	0.53
F-125a	142	F-125a	RHYO	03-09-67	(N)	XRAL	72.3	0.42
F-278	143	F-278	RHYO	25-06-77	(N)	XRAL	72.8	0.39
GM-52	144	GM-52	RHYO	02-09-76	(N)	XRAL	70.7	0.54
H-15	145	H-15	RHYO	01-09-76	(R)	XRAL	75	0.32
MI-26	146	MI-26	RHYO	11-07-69	(N)	XRAL	73.3	0.32
MI-28	147	MI-28	RHYO	11-07-69	(N)	XRAL	80	0.77
MI-40	148	MI-40	RHYO	09-07-70	(N)	XRAL	71.2	0.48
ML-1	149	ML-1	RHYO	19-06-70	(N)	XRAL	73	0.38
ML-12	150	ML-12	RHYO	84		XRAL	70.8	0.54
ML-32	151	ML-32	RHYO	10-08-84	(N)	XRAL	77.2	0.29
TL-27a	152	TL-27a	RHYO	84	(N)	XRAL	74	0.38
TM-12	153	TM-12	RHYO	84	(R)	XRAL	73.7	0.34

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Sample No.	Al_2O_3	Fe_2O_3	FeO	Fe_2O_3R	FeOR	MnO	MgO	CaO	Na_2O	K_2O
C-14	12.2	12.7		2.54	9.14	0.16	1.74	4.71	3.03	2.82
C-23	12.8	12.9		2.58	9.29	0.18	2.74	6	3.1	1.93
LM-9	16.4	10.9		2.18	7.85	0.09	2.46	6.21	4	1.81
ML-34	13.1	12.5		2.5	9	0.15	2.59	4.53	3.8	2.8
T-96	12.6	11.9		2.38	8.57	0.18	1.89	5.02	3.37	2.01
C-10	15.9	11.8		2.36	8.49	0.13	6.71	10	2.52	0.5
D-128	12.6	17.6		3.52	12.67	0.23	3.31	5.05	2.94	2.53
D-130	15.7	12.6		2.52	9.07	0.18	7.14	11.2	2.53	0.42
D-62	12.3	15.8		3.16	11.37	0.26	4.38	8.71	2.11	1.21
ES-19	14.5	11.5		2.3	8.28	0.17	6.68	9.68	2.42	0.85
F-290	16	11.2		2.24	8.06	0.16	8.49	10.6	2.01	0.32
GP-11	8.9	4.7	8.4	2.82	10.16	0.23	9.4	10.5	1.55	0.68
GP-16	9.1	5	8.4	2.9	10.45	0.25	9.4	9.5	2.02	0.74
GP-20a	14.3	11.5		2.3	8.28	0.16	5.91	9.77	2.25	0.79
GP-24	14.4	5.6	7.3	2.76	9.93	0.17	4.72	7.05	3.01	1.45
ML-37	16.1	10.3		2.06	7.41	0.12	7.23	6.52	3.9	1.44
T-65	16.3	12.7		2.56	9.19	0.16	5.15	9.72	2.67	0.62
T-86	13	15.4		3.08	11.09	0.18	4.98	8.05	2.57	0.98
TL-13	16.5	11.3		2.26	8.13	0.13	7.61	11.2	2.19	0.72
TL-14	15.7	11.9		2.38	8.57	0.16	6.34	9.31	2.91	0.94
C-12	12.9	15.6		3.12	11.23	0.12	3.71	7.62	2.63	1.5
D-126	12.2	15.3		3.06	11.01	0.18	2.24	4.96	3.35	3.32
F-180	12.5	15.1		3.02	10.87	0.18	3.89	6.52	2.4	1.42
F-248	13.4	11.8		2.36	8.48	0.17	4.18	5.06	3.58	1.89
F-267	13.1	8.3	5.9	2.98	10.73	0.16	3.47	7.08	2.86	1.43
F-289	13	12.7		2.54	9.14	0.15	4.21	5.45	2.85	1.34
F-92	13.5	11.1		2.22	7.99	0.2	3.99	5.86	3.01	1.74
TL-8	12.6	15.6		3.12	11.23	0.2	3.99	7.72	2.73	1.26
McC-13	12.7	12.4		2.48	8.93	0.14	1.66	4.11	3.02	3.95
NL-2	14.9	6.81		1.36	4.9	0.1	1.1	1.7	4.6	2.57
C-9	11.4	4.02		0.8	2.89	0.04	0.52	0.15	0.92	7.65
D-42	12.9	5.2		1.04	3.74	0.07	0.95	1.09	3.32	5.39
DT-24	12.3	6.65		1.33	4.79	0.13	0.24	0.25	2.44	6.41
DT-9	12.7	5.45		1.09	3.92	0.07	1.16	0.26	3.44	5.3
F-125a	11.5	5.24		1.05	3.77	0.06	0.37	0.64	1.98	6.6
F-278	11.3	4.5		0.9	3.24	0.04	0.58	0.86	2.16	4.95
GM-52	12.7	5.31		1.06	3.82	0.08	0.21	0.9	3.8	4.53
H-15	11.7	3.2		0.64	2.3	0.03	0.21	0.14	3.68	4.61
MI-26	12.1	3.41		0.68	2.45	0.09	0.43	0.43	3.16	5.56
MI-28	7.13	5.16		1.03	3.71	0.07	0.92	0.64	2.36	1.83
MI-40	12.6	4.85		0.97	3.49	0.07	0.46	0.23	4.54	3.71
ML-1	11.8	4.65		0.93	3.35	0.06	0.71	0.23	2.52	5.57
ML-12	12.7	5.39		1.08	3.88	0.06	0.21	0.21	2.74	6.32
ML-32	10.5	3.04		0.61	2.19	0	0.3	0.48	2.74	4.8
TL-27a	12.1	3.22		0.64	2.32	0.03	0.48	0.21	2.97	5.43
TM-12	12.1	3.05		0.61	2.2	0	0.79	0.89	3.15	5.16

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Sample No.	P2O5	L.O.I.	TotalA	Mg#	PlgAn	C.I.	D.I.	Li	Rb	Cs
C-14	0.45	1.85	99.5	0.23	30.7	28.1	58.2		90	2.8
C-23	0.34	1.16	99.6	0.32	36.9	32	50.6		50	4.2
LM-9	0.4	1.08	99.6	0.33	38.8	26	50.3		60	6
ML-34	0.38	1.31	100.1	0.31	24.5	29.8	57.8	10	70	1.7
T-96	0.72	1.47	100.5	0.26	31.8	26.1	57.9		60	1.6
C-10	0.17	2.39	100.3	0.56	58.9	42.6	24.8	20	10	2.3
D-128	0.57	1.23	100.3	0.29	35.5	39	44.5		70	3
D-130	0.11	1.47	100.5	0.55	58.6	44	24.2		20	<1
D-62	0.68	3.08	100.1	0.38	53.5	44.4	31.6		40	<1.1
ES-19	0.17	0.77	99.7	0.56	56.1	43.1	29.1		20	1.7
F-290	0.13	3.39	99.9	0.63	66.4	44.2	19.6		10	<0.5
GP-11	0.25		91.3	0.6	54	63	18.5		8	
GP-16	0.27		93.4	0.59	44.2	61.3	22.6		6	
GP-20a	0.19	3.54	100.3	0.53	58.3	42	29.1		10	1.5
GP-24	0.36		94.7	0.43	46	39.2	36.3		27	
ML-37	0.11	3.31	100.1	0.61	40.2	33	42.9	20	50	4.1
T-65	0.24	1.62	100.3	0.47	57.6	39.2	28.1		10	2
T-86	0.3	2.54	100.5	0.42	49.2	44.6	32.6		30	<1.1
TL-13	0.11	2.08	100.2	0.6	64.1	42	23.2	10	20	<0.7
TL-14	0.18	2.08	99.7	0.54	52.3	40	30.9	20	20	<0.5
C-12	0.26	2.08	100.1	0.34	46	40.6	38.2	20	60	1.6
D-126	0.9	0.62	99.6	0.24	23	33.6	54.6	20	100	2.2
F-180	0.48	2.39	100	0.36	48.5	37.7	40.4	20	50	<0.5
F-248	0.2	2.85	99.4	0.44	33	33.1	50	20	60	<0.5
F-267	0.45		98.8	0.34	43.5	37.2	42		19	
F-289	0.31	3.77	100.1	0.42	43.7	33.6	45.2	30	30	<0.6
F-92	0.31	2.93	100.1	0.44	41.7	31.6	48		40	1.7
TL-8	0.56	0.47	99.9	0.36	44.3	40.8	38.2	20	40	<0.5
McC-13	0.53	1.77	100.2	0.23	27	26.5	61.7		120	1.4
NL-2	0.09	1.23	100.1	0.26	16.9	13.1	76.5		90	1.8
C-9	0.04	0.85	100.3	0.22	6.1	7.3	90.3	20	190	3.1
D-42	0.11	1.16	100.1	0.29	13.5	10.3	84.4	10	220	1.9
DT-24	0.08	1.47	99.7	0.07	3.6	10.8	86.6	10	160	2.5
DT-9	0.08	1.23	100.4	0.32	2.74	11.2	86.4	40	180	2.2
F-125a	0.05	0.7	100.7	0.13	14.7	8.8	87.7		190	3.4
F-278	0.06	2.39	100.2	0.22	17.6	8.3	86.2	20	140	2
GM-52	0.08	1.31	100.4	0.08	11	8.6	86.7	10	170	1.5
H-15	0.03	0.7	99.8	0.13	1.64	5.4	93.3		160	1.9
MI-26	0.03	1.08	100.2	0.22	6.8	6.3	91.2		190	2.8
MI-28	0.1	1.23	100.3	0.28	11.5	10.2	86.2	40	50	<0.6
MI-40	0.04	1.31	99.7	0.17	2.3	8.6	89.2	20	100	1.2
ML-1	0.05	1.16	100.4	0.25	3.8	8.8	88.5	10	120	2.7
ML-12	0.09	1.08	100.3	0.08	2.2	8.6	89	10	190	1.4
ML-32	0.03	0.62	100.4	0.18	8.6	5.3	92.2	10	130	1.2
TL-27a	0.05	1.08	100.2	0.25	2.9	6.1	91.7	10	130	1.2
TM-12	0.04	0.77	100.2	0.36	12	6.7	89.3	20	170	2.1

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Sample No.	Be	Sr	Ba	B	Sc	Y	La	Ce	Nd	Sm
C-14		220	800		29	40	50.3	110	50	10.8
C-23		240	570		32	30	37	80	37	8.2
LM-9		1370	500		13	30	59.2	122	50	10.8
ML-34	<10	230	730	70	25	40	46.1	100	43	9
T-96		310	800		26	50	61.4	125	59	11.7
C-10	<10	230	200	50	32	20	19.5	88	19	4.2
D-128		350	900		30	50	51.3	114	67	12.8
D-130		140	140		42	10	4.9	12	9	2.2
D-62		150	350		42	50	48.2	111	65	13.3
ES-19		340	300		32	20	24.1	47	20	4.3
F-290		230	<150		33	10	10.2	25	10	3.1
GP-11	2.2	760	239		33	24				
GP-16	2.7	790	259		33	26				
GP-20a		300	400		31	10	25.7	50	20	4.6
GP-24	2.4	920	540		22	29				
ML-37	<10	350	390	60	33	10	7.7	23	11	2.4
T-65		290	280		31	20	25.4	55	24	5.6
T-86		210	340		41	30	32.9	75	44	8.6
TL-13	<10	210	100	50	34	20	6.9	18	10	2.6
TL-14	<10	250	200	40	36	20	14.1	35	18	4.4
C-12	<10	160	380	60	39	40	28.7	69	33	7.5
D-126	<10	340	710	40	26	60	74.5	157	88	17.7
F-180	<10	250	630	60	33	40	47.6	104	50	10.7
F-248	<10	200	510	50	29	70	40.4	94	44	10.5
F-267	1.8	294	690		32	49				
F-289	<10	310	630	50	29	20	37.9	83	33	7.3
F-92		260	620		32	30	36.1	74	33	7.3
TL-8	<10	240	570	30	33	30	41.6	87	37	8.4
McC-13		120	760		21	100	72.3	168	73	19
NL-2		430	900		7.1	70	105	215	105	19.8
C-9	<10	10	1280	40	3.8	50	54.8	134	44	8.6
D-42	<10	40	320	50	6.5	110	102	214	89	20.8
DT-24	<10	50	1100	50	9.3	120	111	256	100	21
DT-9	<10	70	1120	50	7.2	70	84.9	206	60	12.3
F-125a		70	1380		4.6	70	74.4	172	70	14.3
F-278	<10	40	1130	40	4.7	90	145	225	106	19
GM-52	<10	200	1050	50	7.7	100	87.9	198	70	15
H-15		50	780		2.3	90	16.3	225	14	4.7
MI-26		70	1090		2.3	280	76.6	290	84	23.9
MI-28	<10	50	540	50	11	20	35.4	74	38	6.8
MI-40	<10	140	1400	40	3.9	40	92.8	221	67	11.6
ML-1	<10	30	1550	40	4.9	60	56.3	138	43	8
ML-12	<10	80	1140	50	7.8	80	97.6	195	90	17.5
ML-32	<10	30	2250	10	1.8	60	86.8	169	69	14.1
TL-27a	<10	40	1440	40	4.1	40	38	220	30	6.4
TM-12	<10	180	910	20	5	70	43.6	91	58	13.7

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Sample No.	Eu	Tb	Yb	Lu	Zr	Hf	Th	U	V	Nb
C-14	2.7		6	0.84	310	10	8.4	2.5		30
C-23	1.8		3.8	0.62	230	6	7.2	2		50
LM-9	3.5		3	0.32	360	9	5.9	1.5		40
ML-34	2		3.6	0.61	280	6	5.8	1.7	260	50
T-96	3.3		4.3	0.69	350	9	5.7	1.4		50
C-10	1.5		2.3	0.43	140	3	1.4	0.5	270	30
D-128	3.5		4.9	0.72	380	9	6.9	2.3		40
D-130	0.9		2.2	0.37	50	2	0.5	<0.5		30
D-62	3.3		6.8	1.05	390	10	6.5	2.5		40
ES-19	1.3		2	0.34	110	3	3.1	1		40
F-290	1.3		2	0.32	70	2	0.8	<0.5		20
GP-11					230		<10		280	20
GP-16					260		10		270	30
GP-20a	1.5		2	0.28	140	4	3.3	1.1		30
GP-24					250		<10		300	30
ML-37	1.5		1.7	0.26	60	1	0.5	<0.5	270	10
T-65	1.7		2.9	0.46	150	4	2.3	<0.5		20
T-86	2.2		5	0.78	250	7	4.2	0.9		20
TL-13	0.8		1.6	0.27	60	2	0.5	<.5	250	20
TL-14	1.1		2.9	0.35	130	3	1.3	0.5	300	30
C-12	2.1		4.2	0.68	220	5	4.2	0.8	380	40
D-126	3		6.4	0.9	490	12	9.5	3.9	130	60
F-180	3.3		5	0.76	300	7	4.2	1	360	30
F-248	2.3		6.6	1.05	370	9	6.3	1.5	260	20
F-267					260		<10		330	<10
F-289	1.6		3.4	0.54	210	5	3.9	0.6	290	30
F-92	2.2		3.6	0.53	210	5	3.4	0.9		20
TL-8	2.3		3.3	0.52	260	5	3.6	0.5	350	30
McC-13	4.2		10.7	1.66	720	19	12	3.5		50
NL-2	5.1		4.5	0.65	660	17	16	1.6		60
C-9	1.1		6.9	1.05	610	17	12	2.5	22	30
D-42	1.3		11	1.74	580	16	20	6.3	52	70
DT-24	3.4		14	2	640	24	17	7.8	14	40
DT-9	1.8		8.2	1.24	650	18	15	3.6	4	50
F-125a	2.8		7.4	1.14	680	19	11	3.3		50
F-278	2.5		8.8	1.26	580	15	17	3.3	20	50
GM-52	2.2		8.7	1.36	660	22	16	2.5	10	50
H-15	0.7		9.3	1.53	600	18	19	3.3		60
MI-26	2.9		14.9	2.21	530	18	20	4.3		70
MI-28	1		3.7	0.6	340	9	9.1	3.5	68	40
MI-40	1.1		7.8	1.19	810	17	17	3.6	4	40
ML-1	1.4		5.6	0.99	600	23	10	3.3	6	60
ML-12	2.5		8.3	1.23	650	19	16	3.3	10	40
ML-32	2.3		7.5	1	620	16	9.6	2.5	<10	40
TL-27a	0.8		6.7	1.12	600	20	17	3	6	50
TM-12	1.3		5.9	0.86	460	13	15	4.1	20	40

LITHOGEOCHEMISTRY NORTH SHORE VOLCANICS ANALYSES, 1985

Sample No.	Ta	Cr	Mo	W	Mn	Co	Ni	Cu	Zn	Cd
C-14	<1	10	<5	<3		26	10	55	170	<0.2
C-23	<1	30	5	<3		30	30	120	170	<0.2
LM-9	2	20	<5	<3		34	44	240	160	<0.2
ML-34	<1	10	<5	<3	1200	33	32	96	170	<0.2
T-96	<1	10	<5	<3		21	6	26	170	<0.2
C-10	<1	200	<5	<3	1000	50	150	67	110	<0.2
D-128	2	30	<5	<3		48	73	540	240	<0.2
D-130	<1	190	<5	<3		51	130	170	130	<0.2
D-62	1	70	<5	<3		44	83	420	200	<0.2
ES-19	<1	130	<5	<3		46	80	57	92	<0.2
F-290	<1	140	<5	<3		52	220	110	98	<0.2
GP-11		670				60	207	129	107	
GP-16		711				69	204	199	117	
GP-20a	1	97	<5	<3		48	70	120	98	<0.2
GP-24		11				53	23	22	133	
ML-37	<1	300	<5	<3	890	40	160	5	98	<0.2
T-65	<1	90	<5	<3		50	120	120	130	<0.2
T-86	2	50	<5	<3		48	45	200	150	<0.2
TL-13	<1	330	<5	<3	990	48	250	94	83	<0.2
TL-14	<1	210	<5	<3		45	140	160	130	<0.2
C-12	<1	45	<5	<3	930	44	52	85	140	<0.2
D-126	2	<2	<5	<3		28	15	170	190	<0.2
F-180	1	23	<5	<3	1400	40	38	40	190	<0.2
F-248	2	40	<5	<3	1300	37	53	110	140	<0.2
F-267		18				41	34	59	163	
F-289	<1	40	<5	<3	1200	31	38	64	140	<0.2
F-92	<1	60	<5	<3		40	39	99	150	<0.2
TL-8	1	32	<5	<3		43	54	88	170	<0.2
McC-13	3	10	<5	<3		15	5	120	140	<0.2
NL-2	4	20	<5	<3		2	6	16	140	<0.2
C-9	1	2	<5	<3	280	2	5	20	170	<0.2
D-42	2	33	<5	3	540	8	17	100	190	<0.2
DT-24	2	<2	7	1	1000	3	4	16	140	<0.2
DT-9	2	6	<5	<3	570	5	3	16	140	<0.2
F-125a	2	<10	<5	<3		1	6	6.5	150	<0.2
F-278	2	<2	<5	<3	310	2	5	20	110	<0.2
GM-52	2	<2	<5	<3	600	3	4	14	110	<0.2
H-15	5	20	5	210		37	3	7	76	<0.2
MI-26	3	10	<5	42		3	4	10	64	<0.2
MI-28	1	15	<5	<3	530	8	19	430	78	<0.2
MI-40	2	3	<5	<3	520	2	3	19	160	<0.2
ML-1	2	5	<5	<1	480	2	4	6.5	130	<0.2
ML-12	2	<2	<5	3	460	2	4	25	150	<0.2
ML-32	<1	6	<5	<3		<1	230	17	56	<0.2
TL-27a	1	4	<5	<3	270	2	4	25	110	<0.2
TM-12	2	11	<5	3		3	16	24	90	<0.2

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Sample No.	Ag	Au	Ge	Sn	Pb	As	Sb	Bi	Se	Br
C-14	<0.5	<20			22	8	0.5	<0.5	<3	<1
C-23	<0.5	<10			12	11	0.4	<0.5	<3	2
LM-9	<0.5	<20			26	<2	0.2	<0.5	<3	1
ML-34	<0.5	<10	<10		36	3	0.2	<0.5	<3	1
T-96	<0.5	<10			10	<2	<0.2	<0.5	<3	1
C-10	<0.5	10	<10		28	<2	<0.2	<0.5	<3	<1
D-128	<0.5	10			6	3	0.3	<0.5	<3	1
D-130	<0.5	<10			<2	<2	<0.2	<0.5	<3	1
D-62	<0.5	<10			8	2	0.6	<0.5	<3	<1
ES-19	<0.5	<20			20	<2	<0.2	<0.5	<3	<1
F-290	<0.5	<20			24	<2	<0.2	<0.5	<3	<1
GP-11										
GP-16										
GP-20a	<0.5	<20			18	<2	<0.2	<0.5	<3	<1
GP-24										
ML-37	<0.5	<10	<10		26	5	0.2	<0.5	<3	1
T-65	<0.5	<10			10	<2	<0.2	<0.5	<3	<1
T-86	<0.5	10			10	2	<0.2	<0.5	<3	<1
TL-13	<0.5	10	<10		28	8	0.3	<0.5	<3	<1
TL-14	<0.5	<10	<10		10	2	0.3	<0.5	<3	1
C-12	<0.5	<10	<10		32	<2	<0.2	<0.5	<3	<1
D-126	<0.5	<10	<10		14	<2	0.3	<0.5	<4	2
F-180	<0.5	<10	10		30	<2	<0.2	<0.5	<3	<1
F-248	<0.5	<10	<10		26	<2	<0.2	<0.5	<3	<1
F-267										
F-289	<0.5	<10	<10		26	<2	<0.2	<0.5	<3	<1
F-92	<0.5	<10			8	<2	<0.2	<0.5	<3	1
TL-8	<0.5	<10	<10		14	<2	<0.2	<0.5	<3	<1
McC-13	<0.5	<10			14	<2	0.5	<0.5	<3	1
NL-2	<0.5	10			16	<2	0.3	<0.5	5	1
C-9	<0.5	<10	<10		16	6	0.3	<0.5	<3	1
D-42	<0.5	<10	<10		36	7	1.2	<0.5	<3	1
DT-24	<0.5	<10	<10	<3	22	<4	0.7	<0.5	<3	<1
DT-9	<0.5	<10	<10		12	12	0.8	<0.5	<3	<1
F-125a	<0.5	10			4	15	0.8	<0.5	<3	<1
F-278	<0.5	10	10		26	<2	<0.2	<0.5	<3	2
GM-52	<0.5	<10	<10		26	4	0.6	<0.5	<3	1
H-15	<0.5	<10			14	2	0.4	<0.5	4	<1
MI-26	<0.5	<10			14	110	1.7	0.5	3	1
MI-28	<0.5	<10	<10		16	<2	0.2	<0.5	<3	1
MI-40	<0.5	<10	<10		10	<2	<0.2	<0.5	<3	<1
ML-1	<0.5	<10	<10	<3	12	<2	0.2	<0.5	<3	<1
ML-12	<0.5	<10	<10		24	7	0.6	<0.5	<4	1
ML-32	<0.5	<10	<10		12	<2	<0.2	<0.5	<3	1
TL-27a	<0.5	<10	<10		12	<2	<0.2	<0.5	<3	<1
TM-12	<0.5	<10	<10		18	<2	<0.4	<0.5	<8	1

APPENDIX C

LITHOGEOCHEMISTRY DIKE ANALYSES, 1985

Sample No.		Sample No.	Unit	Date Coll.	Pol	Analyst	SiO_2	TiO_2
20-3-C	76	20-3-C	DIKECC		N	KNOCHE	49.1	2.21
CQ-1	77	CQ-1	DIKECC	29-10-84	R	XRAL	51	3.21
CQ-10	78	CQ-10	DIKECC	29-10-84	R	XRAL	48.9	4.5
CQ-2	79	CQ-2	DIKECC	29-10-84	R	XRAL	49.1	2.21
CQ-3	80	CQ-3	DIKECC	29-10-84	R	KNOCHE	49.5	4.48
CQ-4	81	CQ-4	DIKECC	29-10-84	R	KNOCHE	49.7	4.04
CQ-5	82	CQ-5	DIKECC	29-10-84	R	KNOCHE	48.6	3.88
CQ-6	83	CQ-6	DIKECC	29-10-84	R	KNOCHE	50.2	4.56
CQ-8	84	CQ-8	DIKECC	29-10-84	R	KNOCHE	48.8	4.04
ES-21	85	ES-21	DIKECC	25-06-84	R	KNOCHE	50.3	3.83
ES-22	86	ES-22	DIKECC	25-06-84	N	KNOCHE	54	2.57
ES-26	87	ES-26	DIKECC	29-10-84	R	KNOCHE	49.8	3.27
ES-27	88	ES-27	DIKECC	29-10-84	R	KNOCHE	49.5	4.06
ES-29	89	ES-29	DIKECC	29-10-84	R	KNOCHE	51.9	1.2
VC-221-1	90	VC-221-1	DIKECC	84	R	KNOCHE	52.2	2.92
VC-226-7	91	VC-226-7	DIKECC	84	R	XRAL	48.5	4.24
VC-227-4	92	VC-227-4	DIKECC	84	R	XRAL	66	0.68
VC-230-3	93	VC-230-3	DIKECC	84	N	XRAL	50.6	3.43
D-108	94	D-108	DIKEDU	25-06-84	N	KNOCHE	48	3.97
D-112	95	D-112	DIKEDU	05-07-84	N	KNOCHE	46.4	2.26
D-118	96	D-118	DIKEDU	05-07-84	N	KNOCHE	46.2	3.18
D-121	97	D-121	DIKEDU	05-07-84	N	KNOCHE	48	2.57
D-122	98	D-122	DIKEDU	05-07-84	N	XRAL	44.4	2.31
D-125	99	D-125	DIKEDU	05-07-84	N	KNOCHE	46	2.02
D-152	100	D-152	DIKEDU	10-11-84	N	KNOCHE	46.7	2.61
D-162	101	D-162	DIKEDU	12-11-84	N	KNOCHE	51.3	3.24
D-168	102	D-168	DIKEDU	12-11-84	N	XRAL	48	2.99
D-170	103	D-170	DIKEDU	12-11-84	N	XRAL	48.6	3.21
D-172	104	D-172	DIKEDU	12-11-84	N	XRAL	37.7	2.58
D-176	105	D-176	DIKEDU	12-11-84	N	XRAL	42.6	2.87
D-25	106	D-25	DIKEDU	22-05-71	(N)	XRAL	50.1	2.4
LW-28	107	LW-28	DIKEDU	17-04-76	(N)	KNOCHE	46.2	2.28
LW-56	108	LW-56	DIKEDU	08-08-84	N	KNOCHE	46.5	2.39
LW-57	109	LW-57	DIKEDU	08-08-84	N	KNOCHE	46.5	0.94
LW-58	110	LW-58	DIKEDU	08-08-84	N	KNOCHE	47	2.27
GP-30	111	GP-30	DIKEGP	01-08-68	(R)	KNOCHE	54	2.12
GP-47	112	GP-47	DIKEGP	05-05-71	R	XRAL	60.5	1.33
H-6	113	H-6	DIKEGP	07-07-69	?	XRAL	54.4	2.45
PP-15	114	PP-15	DIKEGP	06-07-69	(R)	KNOCHE	57.6	1.02
PP-34	115	PP-34	DIKEGP	22-08-84	R	KNOCHE	49.5	1.5
PP-7	116	PP-7	DIKEGP	06-07-69	(R)	KNOCHE	47.9	2.62
GP-60	117	GP-60	DIKEPR	22-08-84	N	KNOCHE	47.9	3.66
PP-35	118	PP-35	DIKEPR	22-08-84	N	KNOCHE	51.5	1.25
DC-121b	119	DC-121b	DIKETC	18-10-84	N	XRAL	46	3.56
F-257	120	F-257	DIKETC	20-07-76	(N)	KNOCHE	50.9	2.38
GBL-2	121	GBL-2	DIKETC	25-07-84	?	KNOCHE	47.3	1.63
GBL-5	122	GBL-5	DIKETC	25-07-84	?	XRAL	47.3	1.61
KV-128	123	KV-128	DIKETC	26-05-72	(N)	KNOCHE	45.9	1.39
M-7129	124	M-7129	DIKETC	07-08-62	?	KNOCHE	47.2	3.52
M-7268	125	M-7268	DIKETC	19-07-62	?	KNOCHE	47.6	1.67
M-7359	126	M-7359	DIKETC	07-07-63	?	KNOCHE	46.7	2.99
M-7402	127	M-7402	DIKETC	21-07-63	?	KNOCHE	47.3	1.7

LITHOGEOCHEMISTRY DIKE ANALYSES, 1985

Sample No.	Al2O3	Fe2O3	FeO	Fe2O3R	FeOR	MnO	MgO	CaO	Na2O	K2O
20-3-C	15.4	2.6	10.1			0.16	5.11	8.1	2.58	0.84
CQ-1	15.1	13.7		2.74	9.86	0.14	2.77	7.68	3.36	1.67
CQ-10	12.3	16.1		3.22	11.59	0.17	4.1	7.32	3.08	1.31
CQ-2	14.7	15.3		3.06	11.01	0.19	5.54	8.87	2.72	0.81
CQ-3	12.7	1.6	12.1			0.18	4.37	7.64	2.74	1.24
CQ-4	13	2.3	11.5			0.16	4.42	7.38	3.09	1.26
CQ-5	12.9	3.2	11.7	3.28	11.8	0.19	4.67	7.38	2.8	1.25
CQ-6	12.9	2.6	11.6			0.17	4.61	7.45	3.1	1.22
CQ-8	14	3.1	10	2.85	10.27	0.2	4.86	8.2	4.05	1.01
ES-21	13.6	4.3	11.1	3.37	12.12	0.32	4.49	4.4	2.76	1.54
ES-22	12.6	3.2	11.9			0.21	2.45	6.48	2.91	1.84
ES-26	14	3.6	9.6	2.88	10.38	0.2	4.89	7.79	2.85	1.26
ES-27	13.1	2.9	12.1			0.17	3.76	6.81	2.94	1.59
ES-29	14.3	1.7	9.2			0.18	5.82	9.5	2.67	1.15
VC-221-1	12.5	2.5	12.5			0.19	2.79	6.36	2.98	1.87
VC-226-7	12.3	17.5		3.5	12.6	0.18	3.62	7.19	2.75	1.66
VC-227-4	14.9	6.73		1.35	4.84	0.06	2.97	0.82	2.73	2.27
VC-230-3	12.9	15.2		3.04	10.94	0.24	4.34	3.7	2.3	1.67
D-108	13.5	4.8	11.1	3.47	12.48	0.28	4.5	7.79	3.13	1.31
D-112	16.4	3.9	9.1	2.81	10.1	0.32	6.42	9.7	2.3	0.51
D-118	13.3	10.9	7	3.77	13.57	1.04	4.95	7.37	2.31	0.63
D-121	15.5	4.4	8.7	2.84	10.24	0.23	5.11	9.7	2.5	0.77
D-122	16.6	13.1		2.62	9.43	0.4	5.2	9.94	2.19	0.65
D-125	16.8	3	9.3	2.68	9.65	0.51	7.33	6.83	2.12	2.16
D-152	15.3	2.9	11.9			0.2	6.2	9.5	2.61	0.63
D-162	13.7	8	5.7	2.91	10.46	0.26	3.9	6.08	3.13	1.03
D-168	10.8	15.5		3.1	11.16	0.18	2.3	8.31	2.31	1.8
D-170	11.5	16.3		3.26	11.3	0.21	2.49	7.58	2.21	2.01
D-172	16.1	9.32		1.86	6.71	0.68	1.06	17.7	2.4	0.88
D-176	16	15.8		3.16	11.37	0.92	5.88	5.68	2.05	1.54
D-25	17.2	12		2.4	8.64	0.15	3.93	9.66	2.96	1.1
LW-28	15.8	4.3	9	2.9	10.44	0.21	6.23	9.5	2.33	0.58
LW-56	15.8	4.1	9.9	3.04	10.93	0.2	5.49	9.5	2.55	0.66
LW-57	17.5	4.6	4.6	1.96	7.05	0.41	8.2	10.7	2.24	0.16
LW-58	16.5	3.7	9.2	2.8	10.08	0.22	5.85	9.7	2.6	0.6
GP-30	12.5	3.8	9	2.78	10	0.16	2	6.28	2.93	2.38
GP-47	13.1	9.92		1.98	7.14	0.12	1.23	4.22	3.68	3.16
H-6	16.1	11.3		2.26	8.13	0.13	2.6	4.14	4.33	2.83
PP-15	14	1.3	7.3			0.15	3.9	6.95	3.26	1.92
PP-34	14.3	2.7	10.7			0.2	6.4	10	2.26	0.44
PP-7	14.8	4.2	9.2	2.93	10.55	0.19	5.97	8.2	3.25	0.73
GP-60	11.8	4.5	12	3.59	12.92	0.24	4.04	8.9	2.63	1.29
PP-35	14.6	3.6	6.9	2.28	8.21	0.17	6.78	9.6	2.32	0.88
DC-121b	14.7	16.8		3.36	12.09	0.2	5.55	8.74	2.74	0.59
F-257	15.1	5.5	7.2	2.71	9.76	0.21	4.28	9.9	2.74	0.81
GBL-2	16.1	2.3	9.8			0.18	8	10.2	2.35	0.36
GBL-5	15.8	13.4		2.68	9.65	0.18	7.64	9.64	2.32	0.64
KV-128	16.4	3.4	9.8	2.88	10.38	0.19	7.92	10	2.19	0.35
M-7129	14.6	3.8	11.6	3.36	12.08	0.2	5.17	8.3	2.57	1.49
M-7268	16	2.3	9.9			0.18	7.86	10.1	2.35	0.4
M-7359	13.9	4.2	11	3.32	11.96	0.22	5.87	6.97	4.02	0.88
M-7402	16.4	1.9	9.6			0.18	7.37	8.7	2.1	1.32

LITHOGEOCHEMISTRY DIKE ANALYSES, 1985

Sample No.	P205	L.O.I.	TotalA	Mg#	PlgAn	C.I.	D.I.	Li	Rb	Cs
20-3-C	0.28		96.5	0.45	56.2	39.1	30.7		27	
CQ-1	0.52	1	100.3	0.31	42.7	33.8	42.5		70	3.1
CQ-10	0.48	0.23	98.6	0.36	37.8	43	38.4		50	3
CQ-2	0.27	0.47	100.3	0.44	52.6	44	28.6		30	2.4
CQ-3	0.5		97	0.39	45	41.7	37		23	
CQ-4	0.39		97.2	0.39	40.7	41.8	38.1		28	
CQ-5	0.53		97.1	0.39	44.4	43.5	35		33	
CQ-6	0.41		98.8	0.39	40.4	42.4	37.8		23	
CQ-8	0.67		98.9	0.43	33.3	40.5	39.9		24	
ES-21	0.55		97.2	0.37	44	37.9	41.1		30	
ES-22	0.71		98.9	0.24	39.6	36	45.9		52	
ES-26	0.45		97.7	0.43	47.6	40.6	35.3		35	
ES-27	0.54		97.5	0.33	41.6	40.2	39.4		49	
ES-29	0.15		97.8	0.52	51.4	42.3	64.5		25	
VC-221-1	0.8		97.6	0.27	37.6	37.1	44.5		54	
VC-226-7	0.58	0.93	99.6	0.31	41.2	43	37.7		60	4.7
VC-227-4	0.14	2.77	100.2	0.49	12.3	17.9	71		70	2.4
VC-230-3	0.58	4.23	99.3	0.39	43.4	35.9	43.8	20	60	2.7
D-108	0.58		99	0.36	42	44.6	34.6		51	
D-112	0.27		97.6	0.49	62.4	42.5	23		10	
D-118	0.36		97.2	0.37	55.3	47.6	25.6		10	
D-121	0.32		97.8	0.44	57.7	42.1	27		16	
D-122	0.25	4.31	99.4	0.47	64.4	39.5	23.5		30	2.7
D-125	0.24		96.3	0.55	62.1	36.3	31.4		20	
D-152	0.35		98.9	0.46	56.2	44.5	25.5		13	
D-162	0.5		96.8	0.37	34.7	37	43.2		22	
D-168	0.92	6.08	99.3	0.25	41.4	41.2	40.4		70	3
D-170	1	3.77	99	0.25	45.4	39.7	40.3		70	2.4
D-172	0.32	10.6	99.4	0.2	69.2	31.5	17.6		20	2.6
D-176	0.31	5.47	99.2	0.45	36.4	40.1	28.2		30	2.3
D-25	0.46	0.31	100.4	0.42	54.8	34.2	33.4		40	2.4
LW-28	0.3		96.7	0.49	61.2	43.4	23.6		13	
LW-56	0.28		97.4	0.44	58	42.5	25.7		16	
LW-57	0.09		95.9	0.65	66.3	40.1	20.5		3	
LW-58	0.28		97.9	0.48	59.2	40.9	25.6		11	
GP-30	0.9		96.1	0.24	35.8	31.4	50.9		72	
GP-47	0.27	2.23	100	0.21	24.1	22.5	66		110	4
H-6	0.36	1.39	100.2	0.34	28.5	25	56.9		100	5.8
PP-15	0.2		97.6	0.48	39.5	30.7	49.8		55	
PP-34	0.14		98.1	0.49	59.1	47.2	23.8		15	
PP-7	0.4		97.5	0.47	46.3	41.8	32.1		25	
GP-60	0.53		97.5	0.33	42.8	48.1	32.6		28	
PP-35	0.17		97.8	0.57	57.7	42.6	28.8		16	
DC-121b	0.49	-0.69	98.8	0.42	52.9	44.5	26.8		20	<0.5
F-257	0.28		99.3	0.41	53.4	40.3	31.7		20	
GBL-2	0.16		98.4	0.57	62	44.5	22		6	
GBL-5	0.16	0.93	99.7	0.56	61.1	43.6	23.7		40	2.3
KV-128	0.19		97.7	0.55	64.7	43.7	20.7		11	
M-7129	0.42		98.9	0.4	52.4	43.8	30.3		44	
M-7268	0.16		98.5	0.56	61.7	44.4	22.2		6	
M-7359	0.42		97.2	0.44	34	40.6	39.5		21	
M-7402	0.16		96.7	0.56	63.8	40.6	26.2		54	

LITHOGEOCHEMISTRY DIKE ANALYSES, 1985

Sample No.	Be	Sr	Ba	B	Sc	Y	La	Ce	Nd	Sm
20-3-C	1.8	244	233		36	35				
CQ-1		430	480		27	40	45	100	52	11.3
CQ-10		510	400		29	30	46.4	103	50	11.5
CQ-2		230	320		39	10	19.7	44	22	5.7
CQ-3	2.6	663	273		30	36	43.4	96	58	11.3
CQ-4	2.3	655	358		25	34				
CQ-5	2.4	525	386		35	39				
CQ-6	2.5	667	382		25	37				
CQ-8	3	1460	410		18	25				
ES-21	2.8	342	600		30	48				
ES-22	2.9	335	550		31	55				
ES-26	3.8	436	450		27	40				
ES-27	2.8	424	480		28	51				
ES-29	1.2	258	400		38	29	29.8	56	30	5.02
VC-221-1	2.8	388	580		31	53	52.3	115	61	13.7
VC-226-7		320	480		32	40	54.8	117	62	13.4
VC-227-4		250	620		18	20	32.3	66	25	5.3
VC-230-3	<10	160	590	40	47	50	43.6	91	58	10.3
D-108	2.9	204	282		37	65	46	106	55	12.9
D-112	1.6	224	146		34	37	16.8	42	23	5.63
D-118	1.7	177	200		49	44				
D-121	2.1	208	178		41	43				
D-122		220	200		35	10	15.9	37	20	5
D-125	1.3	226	313		35	29				
D-152	1.6	205	170		38	42				
D-162	2.4	300	1010		42	56				
D-168		120	700		35	70	67.4	151	80	17.6
D-170		150	600		37	80	72.2	164	80	18.5
D-172		230	300		44	30	24.4	62	30	7.8
D-176		140	300		41	40	26.8	59	30	7.3
D-25		240	290		29	40	33.5	79	41	9.2
LW-28	1.3	199	160		35	38				
LW-56	1.4	221	181		34	36	18.2	43	25	5.99
LW-57	0.6	280	72		32	17				
LW-58	1.3	245	175		32	35				
GP-30	3.4	305	670		22	69				
GP-47		300	820		15	80	76.7	157	75	16
H-6		620	900		18	30	43.2	91	40	9.5
PP-15	2.2	446	780		25	40				
PP-34	0.8	195	147		39	26				
PP-7	1.5	504	320		24	30				
GP-60	2.3	359	450		49	60				
PP-35	1.1	379	323		33	22				
DC-121b		210	400		34	30	32.2	72	40	8.5
F-257	1.6	245	239		41	47				
GBL-2	0.9	251	109		34	28				
GBL-5		270	<150		36	10	12.8	32	10	4.1
KV-128	0.7	183	106		33	24				
M-7129	2.2	293	760		36	51				
M-7268	0.8	276	144		34	28				
M-7359	1.9	385	252		31	34				
M-7402	0.8	479	189		36	27				

LITHOGEOCHEMISTRY DIKE ANALYSES, 1985

Sample No.	Eu	Tb	Yb	Lu	Zr	Hf	Th	U	V	Nb
20-3-C					190		<10		280	<10
CQ-1	3.5		4.2	0.68	310	8	6.3	1.6		40
CQ-10	3.5		3	0.5	310	9	4.8	1.8		50
CQ-2	2.1		3.4	0.5	150	4	2.3	<0.5		30
CQ-3	3.26	1.3	2.75	0.39	300		<10		420	20
CQ-4					280		<10		330	<10
CQ-5					270		<10		450	20
CQ-6					310		<10		360	30
CQ-8					270		10		210	30
ES-21					320		<10		330	20
ES-22					310		<10		192	10
ES-26					250		<10		370	30
ES-27					320		<10		330	20
ES-29	1.49	0.8	2.74	0.44	160		<10		260	20
VC-221-1	3.58	1.8	5.06	0.78					210	
VC-226-7	4.3		5.3	0.74	360	10	7.2	2.3		50
VC-227-4	0.7		2.3	0.33	120	4	7.4	2.9		20
VC-230-3	2		4.5	0.63	320	8	6.2	2.5	310	20
D-108	3.39	2.2	6.42	0.98	370		<10		270	20
D-112	1.8	1	3.34	0.5	170		<10		250	<10
D-118					300		<10		380	10
D-121					400		<10		290	<10
D-122	1.8		3	0.45	140	4	1.6	0.6		20
D-125					220		<10		260	10
D-152					340		<10		290	<10
D-162					260		20		290	<10
D-168	4		10	1.48	540	16	9.6	3		60
D-170	4.2		11	1.59	610	17	9.8	2.9		60
D-172	2.6		5	0.69	190	7	2.6	0.9		30
D-176	2.3		4	0.69	190	6	2.1	0.9		30
D-25	2.8		4.8	0.74	290	6	4.6	1.6		40
LW-28					380		<10		260	10
LW-56	1.96	1.1	3.54	0.53	340		<10		34	<10
LW-57					60		<10		220	<10
LW-58					260		<10		230	<10
GP-30					430		10		37	30
GP-47	3		6.2	0.99	570	15	12	4.2		30
H-6	2.8		4	0.57	290	9	5.7	1.7		40
PP-15					290		10		134	20
PP-34					100		<10		360	<10
PP-7					200		<10		310	<10
GP-60					280		<10		300	10
PP-35					120		10		240	10
DC-121b	2.3		5	0.68	180	6	1.1	0.9		50
F-257					230		20		320	<10
GBL-2					120		<10		240	<10
GBL-5	1.5		3	0.39	110	3	1	<0.5		30
KV-128					90				240	
M-7129					120		<10		280	<10
M-7268					120		<10		240	<10
M-7359					230		<10		320	20
M-7402					110		<10		250	10

LITHOGEOCHEMISTRY DIKE ANALYSES, 1985

Sample No.	Ta	Cr	Mo	W	Mn	Co	Ni	Cu	Zn	(Cd)
20-3-C		76				59	101	222	114	
CQ-1	1	10	<5	<3		39	49	390	220	<0.2
CQ-10	<1	40	<5	<3		58	100	290	190	<0.2
CQ-2	<1	90	<5	<7		54	110	250	160	<0.2
CQ-3		48				65	88	280	158	
CQ-4		63				55	84	191	138	
CQ-5		35				60	75	287	160	
CQ-6		44				55	80	231	144	
CQ-8		10				28	10	23	130	
ES-21		17				47	48	290	147	
ES-22		10				34	13	137	176	
ES-26		115				49	100	290	91	
ES-27		40				48	69	350	175	
ES-29		86				42	50	127	100	
VC-221-1		6				39	18	270	176	
VC-226-7	2	30	<5	<3		52	85	390	200	<0.2
VC-227-4	<1	140	<5	<3		21	67	53	110	<0.2
VC-230-3	1	11	<5	<3		46	16	340	59	<0.2
D-108		32				46	62	251	186	
D-112		148				56	178	266	130	
D-118		104				53	58	360	152	
D-121		132				58	112	330	144	
D-122	<1	190	<5	<3		68	180	280	290	<0.2
D-125		111				54	171	230	126	
D-152		144				58	129	360	138	
D-162		57				36	16	178	220	
D-168	2	<10	<5	3		30	22	290	230	<0.2
D-170	2	9	7	<3		31	19	290	220	<0.2
D-172	<1	150	<5	<3		31	92	380	220	<0.2
D-176	<1	170	<5	<3		60	150	400	360	<0.2
D-25	<1	60	<5	<3		35	73	220	150	<0.2
LW-28		150				54	162	280	135	
LW-56		141				52	158	300	134	
LW-57		170				52	230	77	180	
LW-58		147				52	162	250	130	
GP-30		<1				25	5	154	167	
GP-47	2	20	<5	<3		11	11	120	180	<0.2
H-6	1	20	<5	<3		30	41	200	150	<0.2
PP-15		85				30	48	105	124	
PP-34		86				54	85	185	110	
PP-7		109				55	129	101	138	
GP-60		5				50	22	266	181	
PP-35		115				48	84	59	86	
DC-121b	1	120	<5	<3		58	140	580	180	<0.2
F-257		59				46	43	202	133	
GBL-2		207				59	214	140	101	
GBL-5	<1	210	<5	<3		64	190	150	120	<0.2
KV-128		49				64	190	153	107	
M-7129		95				52	106	310	165	
M-7268		204				53	185	135	103	
M-7359		42				54	46	78	109	
M-7402		217				56	191	158	102	

LITHOGEOCHEMISTRY DIKE ANALYSES, 1985

Sample No.	Ag	Au	Ge	Sn	Pb	As	Sb	Bi	Se	Br
20-3-C										
CQ-1	<0.5	20			8	3	0.2	<0.5	<3	<1
CQ-10	<0.5	20			30	3	0.4	<0.5	<3	3
CQ-2	<0.5	<10			4	<2	<0.2	<0.5	<3	<1
CQ-3										
CQ-4										
CQ-5										
CQ-6										
CQ-8										
ES-21										
ES-22										
ES-26										
ES-27										
ES-29										
VC-221-1										
VC-226-7	<0.5	70			10	5	<0.2	<0.5	3	3
VC-227-4	<0.5	10			16	4	0.9	0.5	<3	2
VC-230-3	<0.5	<10	<10		14	4	2.3	<0.5	3	<1
D-108										
D-112										
D-118										
D-121										
D-122	<0.5	<20			96	<2	<0.2	<0.5	<3	2
D-125										
D-152										
D-162										
D-168	0.5	<20			34	10	2	<0.5	<3	2
D-170	0.5	<20			32	45	0.9	<0.5	<3	1
D-172	1	<20			48	<2	0.3	<0.5	<3	3
D-176	0.5	<20			32	370	0.3	<0.5	<3	2
D-25	<0.5	<10			6	2	0.3	<0.5	<3	<1
LW-28										
LW-56										
LW-57										
LW-58										
GP-30										
GP-47	<0.5	10			14	<2	0.3	<0.5	5	<1
H-6	<0.5	<20			24	3	<0.2	<0.5	<3	2
PP-15										
PP-34										
PP-7										
GP-60										
PP-35										
DC-121b	<0.5	<20			30	<2	<0.2	<0.5	<3	<1
F-257										
GBL-2										
GBL-5	<0.5	<20			20	<2	<0.2	<0.5	<3	<1
KV-128										
M-7129										
M-7268										
M-7359										
M-7402										

LITHOGEOCHEMISTRY DULUTH COMPLEX ANALYSES, 1985

Sample No.		Sample No.	Unit	Date Coll.	Pol	Analyst	SiO2	TiO2
Sample No.		Sample No.	Unit	Date Coll.	Pol	Analyst	SiO2	TiO2
D-102	37	D-102	DCANOR	25-06-84	(N)	KNOCHE	49.2	0.84
D-106	38	D-106	DCANOR	25-06-84	(N)	KNOCHE	47.3	1.28
D-110	39	D-110	DCANOR	25-06-84	(N)	KNOCHE	51.5	0.57
DG-60	40	DG-60	DCANOR	06-77	(N)	XRAL	50	0.61
KL-1	41	KL-1	DCANOR	84	(N)	XRAL	49.1	1.15
BRL-1	42	BRL-1	DCFEL	80	(N)	XRAL	67.5	0.8
C-6	43	C-6	DCFEL	25-09-64	(N)	KNOCHE	73.4	0.23
D-138	44	D-138	DCFEL	03-08-84	(N)	XRAL	63.7	1.08
DG-66	45	DG-66	DCFEL	09-77	(N)	KNOCHE	62.3	1.02
EM-1	46	EM-1	DCFEL	09-04-77	(N)	XRAL	70.8	0.53
LM-7	47	LM-7	DCFEL	27-06-84	(N)	XRAL	69	0.46
PM-2	48	PM-2	DCFEL	07-07-70	(N)	XRAL	71.5	0.48
PW-6	49	PW-6	DCFEL	84	(R)	XRAL	70.8	0.42
WHY-2	50	WHY-2	DCFEL	24-07-84	(N)	XRAL	73.6	0.35
D-103	51	D-103	DCINT	25-06-84	(N)	KNOCHE	52.3	1.58
DG-30	52	DG-30	DCINT	26-08-68	(N)	KNOCHE	49.8	3.15
DG-65	53	DG-65	DCINT	09-08-77	(N)	KNOCHE	56.7	2.19
PM-1	54	PM-1	DCINT	07-07-70	(N)	XRAL	56.7	2.04
PW-1a	55	PW-1a	DCINT	84	(R)	XRAL	51.2	3.1
DG-53	56	DG-53	DCMAF	20-05-72	(N)	KNOCHE	48	0.4
KL-4	57	KL-4	DCMAF	84	(N)	XRAL	51.7	2.59
BAB-9	58	BAB-9	DCMMA	07-84	(N)	XRAL	48.1	3.29
C-13	59	C-13	DCMMA	12-09-66	(N)	XRAL	50	1.64
DG-32	60	DG-32	DCMMA	26-10-68	(N)	XRAL	46.8	3.59
PW-5b	61	PW-5b	DCMMA	84	(R)	XRAL	47.1	3.12
C-3	62	C-3	DCTROC	25-09-64	(N)	KNOCHE	46.2	0.6
D-105	63	D-105	DCTROC	25-06-84	(N)	KNOCHE	37.8	12.2
DG-34	64	DG-34	DCTROC	26-10-68	(N)	XRAL	45.9	0.54
DG-48	65	DG-48	DCTROC	26-10-68	(N)	XRAL	46.7	1.56
DG-55	66	DG-55	DCTROC	10-74	(N)	KNOCHE	50.2	0.46
DG-8	67	DG-8	DCTROC	28-08-62	(N)	XRAL	49.2	0.65
ES-23	68	ES-23	DCTROC	25-06-84	(N)	KNOCHE	49.9	1.39
M-7358	69	M-7358	DCTROC	07-07-63	(N)	XRAL	46.9	1.65
M-7392	70	M-7392	DCTROC	18-07-63	(N)	XRAL	46.9	2.9
M-7671	71	M-7671	DCTROC	04-09-64	(N)	KNOCHE	47.5	1.66
S-2	72	S-2	DCTROC	25-06-84	(N)	KNOCHE	46.2	5.5
TH-62	73	TH-62	DCTROC	24-07-84	(N)	XRAL	47.1	0.3
DG-37	74	DG-37	DCUMAF	26-10-68	(N)	XRAL	43.1	4.54
DG-51	75	DG-51	DCUMAF	02-61	(N)	XRAL	26.3	16.7

LITHOGEOCHEMISTRY DULUTH COMPLEX ANALYSES, 1985

Sample No.	Al2O3	Fe2O3	FeO	Fe2O3R	FeOR	MnO	MgO	CaO	Na2O	K2O
Sample No.	Al2O3	Fe2O3	FeO	Fe2O3R	FeOR	MnO	MgO	CaO	Na2O	K2O
D-102	23.9	1.3	4.8	1.35	4.85	0.08	1.98	10.8	3.49	1.12
D-106	22.9	1.6	6.5	1.78	6.42	0.1	4.52	10.3	3.03	0.57
D-110	25.8	0.9	2.6	0.76	2.73	0.04	1.77	11.1	4.29	0.62
DG-60	27.2	4.23		0.85	3.04	0.04	1.96	12.3	3.37	0.4
KL-1	23	9.12		1.82	6.57	0.11	3.24	10.2	3.34	0.66
BRL-1	12.5	7.11		1.42	5.12	0.11	0.52	2.39	4	3.99
C-6	12.2	1.2	1.5	0.58	2.07	0.04	0.04	0.68	3.72	4.78
D-138	12.5	9.96		1.99	7.17	0.25	0.73	3.41	3.61	3.91
DG-66	15.2	3.7	3.6	1.56	5.62	0.11	1.18	2.44	4.69	3.59
EM-1	12.4	4.97		0.99	3.58	0.08	0.38	1.67	4.13	4.06
LM-7	12.7	5.41		1.08	3.89	0.09	0.59	1.28	4.11	4.75
PM-2	12.4	4.32		0.86	3.11	0.05	0.63	0.31	3.26	5.48
PW-6	12.7	4.82		0.96	3.47	0	0.44	1.09	3.92	5.1
WHY-2	12.5	3.79		0.76	2.73	0.05	0.11	0.62	4.08	4.55
D-103	12.8	8.6	10.1	4	14.41	0.3	0.85	6.87	3.93	2.24
DG-30	11.7	2.6	12.9	3.43	12.34	0.28	3.21	7.44	2.9	2
DG-65	13.5	3.9	8.1	2.6	9.36	0.18	2.22	4.96	3.39	2.5
PM-1	12	14.5		2.9	10.44	0.18	1.88	4.17	3.48	2.64
PW-1a	12.7	14.9		2.98	10.73	0.19	3.45	7.04	3.33	1.81
DG-53	17.3	0.5	7.7	1.52	6.57	0.14	10.2	12.1	1.91	0.19
KL-4	14.3	13.8		2.76	9.93	0.17	5.01	7.96	2.67	1.38
BAB-9	14.4	15.4		3.08	11.09	0.19	5.66	8.66	2.83	1.21
C-13	15.3	13.2		2.64	9.5	0.14	5.37	10.4	2.48	0.76
DG-32	14.4	18.1		3.62	13.03	0.21	5.59	8.43	2	0.39
PW-5b	16.1	15.7		3.14	11.3	0.15	4.6	9.72	2.74	0.61
GRC-3 C-3	21	1.4	7	1,84	6,61	0.12	8.7	10.2	2.35	0.22
D-105	11.1	3.3	16.3	4.32	15.56	0.25	7.74	9.5	1.71	0.17
DG-34	19.5	11.4		2.28	8.21	0.13	9.02	9.2	2.6	0.26
DG-48	17.4	14.4		2.88	10.37	0.17	7.78	8.5	2.64	0.66
DG-55	27	0.5	3.2	,81	2,92	0.05	2.18	12.1	3.44	0.42
DG-8	22.8	8.55		1.71	6.15	0.09	5.69	9.66	3.43	0.4
ES-23	19.7	1.9	8.7	2.33	8.40	0.15	6.02	9	3.25	0.74
M-7358	18.8	14.1		2.82	10.15	0.15	6.83	8.58	2.98	0.44
M-7392	15.6	15.9		3.18	11.45	0.18	6.69	8.03	2.8	0.97
M-7671	16	2.1	9.9	2,66	9,58	0.18	7.67	10.1	2.45	0.51
S-2	15.9	2.1	9.2	2.48	8.44	0.16	6.15	11.5	2.65	0.29
TH-62	22.4	7.99		1.6	5.75	0.09	7.61	10.8	2.48	0.21
DG-37	1.87	22		4.4	15.84	0.31	13.8	13.5	0.29	0.02
DG-51	2.55	35.8		7.16	25.77	0.39	16.7	2.17	0.17	0.05

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Sample No.	P205	L.O.I.	TotalA	Mg#	PlgAn	C.I.	D.I.	Li	Rb	Cs
Sample No.	P205	L.O.I.	TotalA	Mg#	PlgAn	C.I.	D.I.	Li	Rb	Cs
D-102	0.24		97.8	0.39	61.8	15.4	36.5		29	
D-106	0.1		98.2	0.53	64.8	22.1	29.4		14	
D-110	0.15		99.3	0.51	59	10.6	39.3		12	
DG-60	0.11	0.47	100.7	0.5	67	10.8	30.8		10	0.5
KL-1	0.37	-0.23	100.1	0.44	61.8	20.7	32.1		20	<0.6
BRL-1	0.14	0.23	99.4	0.14	11.4	14.9	79.7		150	3.5
C-6	0.01		97.8	0.03	7.6	5	92.3		220	
D-138	0.25	0.47	100	0.14	17.2	20.9	71.4	10	150	7.7
DG-66	0.2		98	0.25	16.5	15.3	73.8		140	
EM-1	0.08	0.54	99.8	0.14	8.6	10.4	85.7		160	3.5
LM-7	0.07	1.23	99.9	0.19	5.9	11.3	85.7		190	2.5
PM-2	0.08	1.16	99.9	0.24	3.7	8.2	89.5	20	170	2
PW-6	0.04	0.47	100.1	0.17	5.67	9.6	88	10	240	1.8
WHY-2	0.03	0.31	100.2	0.06	6.4	6.2	91.1	<10	110	<1
D-103	0.09		99.7	0.09	24.8	40.6	47.2		79	
DG-30	1.29		97.3	0.29	35.1	41.5	41.9		48	
DG-65	0.69		98.3	0.27	33.6	27.7	55.6		70	
PM-1	0.58	1.7	99.9	0.22	24	30.4	57.6	20	100	2.1
PW-1a	0.95	0.39	99.2	0.34	33.8	38	44.1	20	70	3.8
DG-53	0.02		98.5	0.71	70.4	43.9	17.2		2	
KL-4	0.38	0.23	100.3	0.44	50.4	39.4	35.7	30	<10	2.5
BAB-9	0.47	0.16	100.5	0.45	49	43.7	31		50	2.8
C-13	0.3	0.62	100.2	0.47	57.5	42.2	27.5	10	20	2
DG-32	0.49	-0.53	99.6	0.4	63.3	45.4	22.8		10	1.2
PW-5b	0.19	0	100.1	0.39	56.3	41.7	26.8		30	2.5
C-3	0.06		97.8	0.68	70.1	31	21.6		4	
D-105	0.08		100.1	0.44	60.5	62.3	15.5		3	
DG-34	0.04	0	98.7	0.64	65	33.8	23.9		<10	<0.5
DG-48	0.26	-0.38	99.8	0.54	60.1	38.4	26.2		30	2
DG-55	0.11		99.7	0.54	66.4	10.9	31.6		6	
DG-8	0.07	-0.07	100.5	0.59	61.1	22.6	31.2		10	0.7
ES-23	0.11		100.9	0.53	57.7	31.4	31.4		19	
M-7358	0.13	-0.46	100.2	0.52	59.2	34.5	27.6		10	1
M-7392	0.38	-0.5	99.9	0.48	53.4	41.5	29.3		40	2.5
M-7671	0.15		98.2	0.56	60.1	43.7	23.8		9	
S-2	0.05		99.7	0.52	57.9	45	24.2		3	
TH-62	0.3	0.93	100	0.68	70.2	27	22.4		<10	0.5
DG-37	0.03	0.08	99.6	0.58	60.4	91.8	2.6		<10	<1
DG-51	0.03	-0.77	100.2	0.51	80.8	89.4	1.7		<10	<0.5

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Sample No.	Be	Sr	Ba	B	Sc	Y	La	Ce	Nd	Sm
Sample No.	Be	Sr	Ba	B	Sc	Y	La	Ce	Nd	Sm
D-102	1.4	436	216		10	27				
D-106	0.8	386	167		7.1	13				
D-110	0.8	468	185		5.7	12				
DG-60		430	<150		4.2	<10	6.9	15	10	1.5
KL-1		350	180		6.2	20	19.1	44	23	5.1
BRL-1		140	1100		11	80	89.7	183	90	16.5
C-6	4.9	44	930		1.3	80				
D-138	<10	160	1060	50	18	130	91.5	199	101	22.3
DG-66	3.6	219	780		16	63				
EM-1		140	1000		7	50	77.2	150	60	12.2
LM-7		170	1100		6.7	110	129	266	120	23.3
PM-2	<10	90	1170	40	6.1	80	70.8	152	59	12.9
PW-6	<10	60	1070	20	4.3	120	120	237	134	21.5
WHY-2	<10	80	1350	40	3.7	60	59.7	141	68	13.8
D-103	3.1	331	680		40	78				
DG-30	3.7	248	650		37	120				
DG-65	2.9	238	680		24	71				
PM-1	<10	130	850	60	23	60	67.8	146	69	15.6
PW-1a	<10	260	510	30	31	60	67.2	145	87	14.7
DG-53	0.3	343	71		31	8				
KL-4	<10	230	370	40	29	30	30.9	63	34	7.3
BAB-9		190	350		37	20	34.2	79	37	9.3
C-13	<10	220	260	40	37	30	25.5	59	29	6.9
DG-32		200	400		36	40	31.9	71	40	8.5
PW-5b		300	210		32	10	16.1	35	22	4.1
C-3	0.4	291	70		9	9				
D-105	1.5	163	84		66	20				
DG-34		270	<150		8.7	<10	3.5	7	<10	0.7
DG-48		260	200		17	<10	17.6	38	20	4.3
DG-55	0.6	386	127		3.8	8				
DG-8		390	200		4.2	<10	0.6	<3	<10	<0.1
ES-23	1.4	272	204		14	20				
M-7358		330	200		13	<10	8	18	10	1.8
M-7392		230	300		26	20	28	61	30	7.1
M-7671	1	267	120		34	26				
S-2	1	247	101		50	17				
TH-62		290	<150		6.5	20	3.6	7	<10	0.8
DG-37		<10	50		100	20	2.4	15	11	3.8
DG-51		<10	150		40	<10	1.2	6	<5	0.6

LITHOGEOCHEMISTRY DULUTH COMPLEX ANALYSES, 1985

Sample No.	Eu	Tb	Yb	Lu	Zr	Hf	Th	U	V	Nb
Sample No.	Eu	Tb	Yb	Lu	Zr	Hf	Th	U	V	Nb
D-102					180				47	
D-106					95				230	
D-110					120				33	
DG-60	1.4		1	0.13	50	1	0.7	<0.5		10
KL-1	1.3		2.4	0.38	100	2	1.9	0.5		30
BRL-1	2.8		9	1.3	580	18	14	3.9		50
C-6					580		<10		<5	40
D-138	4.7		13.3	2.15	1160	27	16	4.3	22	70
DG-66					720		20		25	20
EM-1	1.9		6	0.88	450	13	13	4.1		30
LM-7	3.7		12	1.78	960	27	20	6.8		90
PM-2	2.3		6.7	1.05	520	13	13	3.9	12	40
PW-6	2.9		10	1.38	950	23	19	4.9	<10	90
WHY-2	2.3		5.7	0.85	570	16	8	2.7	4	40
D-103					120		10		4	30
DG-30					680		<10		169	30
DG-65					390		<10		46	20
PM-1	3.2		7.7	1.13	510	12	9.5	2.5	22	60
PW-1a	3.1		5.9	0.87	430	10	9.2	2.6	220	60
DG-53					22				200	
KL-4	1.7		3.7	0.56	230	6	4	1.1	310	30
BAB-9	2.5		4.5	0.73	280	7	6.5	1.6		40
C-13	1.5		3.8	0.53	160	5	2.8	0.6	270	30
DG-32	2.7		5	0.76	290	8	2.4	0.8		30
PW-5b	1.6		1.9	0.27	100	3	1.9	<0.5		20
C-3					41				71	
D-105					115				940	
DG-34	0.6		<1	0.08	10	1	<0.5	<0.5		10
DG-48	1.4		2	0.35	120	3	2.3	0.7		20
DG-55					50				33	
DG-8	<0.2		<1	<0.5	10	<1	<0.5	<0.5		10
ES-23					150		<10		143	<10
M-7358	1.2		1	0.18	40	1	0.8	<0.5		30
M-7392	2.3		4	0.58	210	5	3.5	1		40
M-7671					110		<10		230	<10
S-2					80				480	
TH-62	0.6		<1	0.08	10	1	0.5	<0.5		<10
DG-37	0.9		2.8	0.36	40	2	<0.5	<0.5		30
DG-51	0.3		1	0.18	70	3	<0.5	<0.5		50

LITHOGEOCHEMISTRY DULUTH COMPLEX ANALYSES, 1985

Sample No.	Ta	Cr	Mo	W	Mn	Co	Ni	Cu	Zn	Cd
Sample No.	Ta	Cr	Mo	W	Mn	Co	Ni	Cu	Zn	Cd
D-102		34				18	44	108	52	
D-106		480				38	138	49	91	
D-110		54				19	52	16	23	
DG-60	<1	90	<5	<3		17	69	97	48	<0.2
KL-1	1	10	<5	<3		33	76	210	96	<0.2
BRL-1	2	<10	<5	<3		7	8	39	160	<0.2
C-6		1.4				<5	5	14	113	
D-138	3	<2	5	3	1900	6	10	59	290	<0.2
DG-66		<1				10	2.5	69	112	
EM-1	2	10	<5	<3		5	10	26	130	<0.2
LM-7	5	<2	<5	<3		<5	5	28	200	<0.2
PM-2	2	<10	<5	<3	380	4	10	33	96	<.2
PW-6	3	<2	<5	3		1	5	24	140	<0.2
WHY-2	1	<2	<5	3	400	2	4	20	110	<0.2
D-103		2				7	2.8	38	132	
DG-30		4				33	20	310	199	
DG-65		3.4				22	3.9	73	163	
PM-1	2	<10	<5	3	1400	21	9	82	210	<0.2
PW-1a	2	17	<5	<3		34	38	200	190	<0.2
DG-53		270				50	210	15	55	
KL-4	1	100	<5	<3		45	120	230	160	<0.2
BAB-9	<1	130	<5	3		55	130	310	180	<0.2
C-13	<1	130	<5	3	1100	48	67	100	120	<0.2
DG-32	1	150	5	<3		57	120	330	210	<0.2
PW-5b	<1	20	<5	<3		51	160	51	170	<0.2
C-3		10				62	260	53	69	
D-105		570				75	199	320	124	
DG-34	<1	210	<5	<3		69	310	130	93	<0.2
DG-48	<1	140	<5	<3		69	240	140	160	<0.2
DG-55		44				16	62	105	36	
DG-8	<1	52	8	<3		49	150	42	70	<0.2
ES-23		5				48	140	160	101	
M-7358	<1	200	<5	<3		66	180	250	110	<0.2
M-7392	<1	190	<5	<3		67	210	280	180	<0.2
M-7671		202				54	180	138	101	
S-2		144				49	110	450	72	
TH-62	<1	20	<5	<3		55	230	36	66	<0.2
DG-37	1	520	<5	<3		100	410	2200	150	<0.2
DG-51	2	680	<5	<3		170	3	82	280	<0.2

LITHOGEOCHEMISTRY DULUTH COMPLEX ANALYSES, 1985

Sample No.	Ag	Au	Ge	Sn	Pb	As	Sb	Bi	Se	Br
Sample No.	Ag	Au	Ge	Sn	Pb	As	Sb	Bi	Se	Br
D-102										
D-106										
D-110										
DG-60	<0.5	<20			22	<2	<0.2	<0.5	<3	<1
KL-1	<0.5	<10			6	<2	<0.2	<0.5	<3	<1
BRL-1	<0.5	<20			30	3	0.2	<0.5	<3	1
C-6										
D-138	<0.5	<10	<10	5	50	5	1	<0.5	3	1
DG-66										
EM-1	<0.5	<20			24	2	0.3	<0.5	<3	1
LM-7	<0.5	<20			34	2	0.4	<0.5	<3	<1
PM-2	<.5	<10	<10		14	<2	0.3	<.5	<3	<1
PW-6	<0.5	<10	<10		24	<2	0.2	<0.5	<8	1
WHY-2	<0.5	<10	<10	<3	26	<2	0.2	<0.5	<3	1
D-103										
DG-30										
DG-65										
PM-1	<0.5	<10	<10		30	3	0.2	<0.5	<3	1
PW-1a	<0.5	<10	<10		16	3	0.3	<0.5	<3	2
DG-53										
KL-4	<0.5	<10	<10		14	<2	<0.2	<0.5	<3	1
BAB-9	<0.5	10			10	2	0.4	0.5	3	2
C-13	<0.5	<10	<10		28	<2	<0.2	<0.5	<3	<1
DG-32	0.5	<20			30	<2	<0.2	<0.5	<3	<1
PW-5b	0.5	<10			4	<2	0.2	<0.5	<3	<1
C-3										
D-105										
DG-34	<0.5	<20			20	<2	<0.2	0.5	<3	2
DG-48	<0.5	<20			24	2	<0.2	<0.5	<3	2
DG-55										
DG-8	<0.5	<20			18	<2	<0.2	<0.5	<3	<1
ES-23										
M-7358	<0.5	<20			20	<2	<0.2	<0.5	<3	<1
M-7392	<0.5	<20			28	2	0.3	<0.5	<3	1
M-7671										
S-2										
TH-62	<0.5	<20			22	<2	<0.2	<0.5	<3	1
DG-37	1.5	20			10	<2	<0.2	1	3	1
DG-51	0.5	30			8	<2	0.3	<0.5	<3	<1

APPENDIX G

LGC BEAVER BAY CPX AND OTHER KEWEENAWAN INTRUSIONS

Sample No.		Sample No.	Unit	Date Coll.	Pol	Analyst	SiO2	TiO2
F-35	29	F-35	BBFEL	31-08-65	(N)	XRAL	66.2	1.17
SB-105	30	SB-105	BBFEL	08-08-84	(N)	XRAL	65.6	0.8
F-237	31	F-237	BBINT	14-07-76	(N)	XRAL	53.5	1.64
F-46	32	F-46	BBINT	12-09-65	(N)	XRAL	57.6	1.81
3001-21.4	33	3001-21.4	BBMAF	12-10-74	(N)	XRAL	47.9	1.35
F-256	34	F-256	BBMAF	20-07-76	(N)	XRAL	50.2	1.81
F-275	35	F-275	BBMAF	27-07-76	(N)	XRAL	47.7	2.32
SB-28	36	SB-28	BBMAF	14-07-75	(N)	XRAL	47.4	3.99
TH-65	131	TH-65	OKIINT	26-07-84	(N)	XRAL	51.3	2.52
ALN-1	132	ALN-1	OKIMAF	01-06-84	?	XRAL	47.4	3.97
BAB-1	133	BAB-1	OKIMAF	01-06-84	(N)	KNOCHE	45.6	4.58
C-4	134	C-4	OKIMAF	25-09-64	(N)	XRAL	49.5	2.22
CD-6	135	CD-6	OKIMAF	84	(R)	XRAL	47.2	5.13
D-40	136	D-40	OKIMAF	16-06-75	(N)	KNOCHE	49.5	3.67
NL-3	137	NL-3	OKIMAF	09-07-70	(R)	XRAL	53	1.96

LGC BEAVER BAY CPX AND OTHER KEWEENAWAN INTRUSIONS

Sample No.	Al_2O_3	Fe_2O_3	FeO	Fe_2O_3R	FeOR	MnO	MgO	CaO	Na_2O	K_2O
F-35	12.3	5.58		1.12	4.02	0.11	1.69	2.57	3.37	3.95
SB-105	12.3	9.42		1.88	6.78	0.13	0.42	2.63	4.64	3.3
F-237	10.6	18.7		3.74	13.46	0.34	0.44	6.58	3.19	1.78
F-46	11.4	14.7		2.94	10.58	0.22	1.13	5.57	3.22	2.34
3001-21.4	16	12.4		2.48	8.93	0.17	8.31	10.6	2.39	0.34
F-256	16	12.6		2.52	9.07	0.13	4.94	9.7	2.62	0.71
F-275	15.7	16.3		3.26	11.73	0.19	5.21	7.8	2.78	0.79
SB-28	12.8	18.2		3.64	13.1	0.21	3.96	8.11	2.4	0.92
TH-65	14.6	14.3		2.86	10.29	0.21	2.77	8.76	3.19	1.18
ALN-1	12.4	16		3.2	11.52	0.18	3.53	6.55	2.62	0.11
BAB-1	13.7	2.8	14.8			0.22	4.5	8.3	2.82	0.5
C-4	18.3	11.1		2.22	7.99	0.14	3.88	9.81	2.81	0.99
CD-6	11.9	16.9		3.38	12.17	0.2	4.13	7.63	3.1	1.24
D-40	13.5	5.5	9.3	3.19	11.47	0.64	4	7.65	2.86	0.6
NL-3	19.7	8.9		1.78	6.41	0.09	2.2	8.16	3.94	1.18

LGC BEAVER BAY CPX AND OTHER KEWEENAWAN INTRUSIONS

Sample No.	P2O5	L.O.I.	TotalA	Mg#	PlgAn	C.I.	D.I.	Li	Rb	Cs
F-35	0.26	1.93	99.2	0.4	19.2	15.1	76.9	30	150	3.3
SB-105	0.11	0.85	100.5	0.09	7.07	19.2	76.8		90	1.6
F-237	0.27	3.08	100.3	0.05	25.7	39.4	48.8		60	1.9
F-46	0.45	1.93	100.3	0.14	26.3	31.8	56.1	10	70	3
3001-21.4	0.14	-0.07	99.6	0.6	61.2	44.3	22.3		10	<0.5
F-256	0.27	1.31	100.3	0.46	57.3	38.6	29.7	10	30	2.3
F-275	0.21	1	100.1	0.41	54.4	41.4	28.5		40	2.2
SB-28	0.16	1.54	99.6	0.32	51.4	45.9	30.4	10	30	2.4
TH-65	0.33	0.62	99.9	0.3	44.9	37	38.8		40	2.8
ALN-1	0.47	6.31	99.6	0.33	32.7	39.2	35		10	0.9
BAB-1	0.54		98.4	0.34	49.5	47.1	27.1		5	
C-4	0.3	1.16	100.3	0.43	59.1	32.1	31.6		40	6
CD-6	0.4	0.85	98.8	0.35	36.2	46	36.5	30	60	2.3
D-40	0.72		97.9	0.36	48.1	40.3	34.4		20	
NL-3	0.27	0.93	100.4	0.35	49.4	21.8	44.1	20	50	2.8

LGC BEAVER BAY CPX AND OTHER KEWEENAWAN INTRUSIONS

Sample No.	Be	Sr	Ba	B	Sc	Y	La	Ce	Nd	Sm
F-35	<10	160	830	40	14	70	76.7	161	74	14.5
SB-105		150	1110		11	110	90.2	193	94	20.1
F-237		190	620		33	80	75.8	166	90	20.6
F-46	<10	190	610	50	26	70	68	165	70	17.2
3001-21.4		240	200		33	10	12.1	30	10	3.7
F-256	<10	260	360	50	31	30	28.8	58	28	6
F-275		210	240		21	30	20	45	22	5.3
SB-28	<10	160	360	70	41	30	19.7	45	22	5.3
TH-65		180	300		39	50	31	73	30	9
ALN-1		330	200		27	20	39.2	90	40	9.5
BAB-1	1.9	517	267		34	47				
C-4		260	260		27	20	24.8	56	27	6
CD-6	<10	350	340	30	41	20	33.4	76	39	9
D-40	4.1	166	257		41	70				
NL-3	<10	710	360	100	15	30	24.2	53	27	5.8

LGC BEAVER BAY CPX AND OTHER KEWEENAWAN INTRUSIONS

Sample No.	Eu	Tb	Yb	Lu	Zr	Hf	Th	U	V	Nb
F-35	2.9		7.4	1.1	460	13	12	2.9	62	30
SB-105	4.8		11.8	1.75	730	19	14	3.2		70
F-237	5.5		10.5	1.65	490	13	6.9	1.8		50
F-46	4.2		9.9	1.52	570	15	9.2	2.6	8	60
3001-21.4	1.4		3	0.33	90	3	1.1	<0.5		40
F-256	1.9		3.1	0.53	170	4	2.8	<0.5	290	20
F-275	1.6		3.1	0.48	180	5	2.8	0.9		20
SB-28	1.9		4.4	0.7	620	15	3.2	0.9	750	40
TH-65	2.2		6	0.86	260	8	4.4	1.7		30
ALN-1	2.9		4	0.61	280	8	5.1	1.7		50
BAB-1					320		<10		390	20
C-4	2		3.2	0.49	160	5	3.4	1.4		40
CD-6	2.2		3.4	0.47	240	6	3.6	1.5	500	50
D-40					400		10		214	20
NL-3	2.3		1.9	0.36	150	4	3	1.2	180	30

LGC BEAVER BAY CPX AND OTHER KEWEENAWAN INTRUSIONS

Sample No.	Ta	Cr	Mo	W	Mn	Co	Ni	Cu	Zn	Cd
F-35	<1	<2	<5	<3	880	9	6	91	120	<0.2
SB-105	2	10	<5	<3		3	3	16	170	<0.2
F-237	3	10	<5	<3		8	440	910	200	<0.2
F-46	3	<10	<5	<3	1700	18	8	220	240	<0.2
3001-21.4	<1	200	<5	<3		60	200	110	150	<0.5
F-256	<1	100	<5	<3	1000	45	110	120	130	<0.2
F-275	<1	300	<5	<3		57	100	200	160	<0.2
SB-28	<1	24	<5	<3	1600	56	43	140	220	<0.2
TH-65	<1	40	<5	<3		34	20	190	170	<0.2
ALN-1	1	40	<5	<3		48	76	340	190	<0.2
BAB-1		21				59	64	410	182	
C-4	<1	140	<5	<3		35	79	220	140	<0.2
CD-6	1	4	<5	<3		45	46	140	260	<0.2
D-40		5				37	24	360	240	
NL-3	<1	18	<5	<3	680	25	39	190	93	<0.2

LGC BEAVER BAY CPX AND OTHER KEWEENAWAN INTRUSIONS

Sample No.	Ag	Au	Ge	Sn	Pb	As	Sb	Bi	Se	Br
F-35	<0.5	<10	<10		24	4	0.5	<0.5	<3	2
SB-105	<0.5	10	0		6	<2	<0.2	<0.5	<3	2
F-237	<0.5	<10			4	<2	<0.2	<0.5	<3	<1
F-46	<0.5	20	<10		30	4	0.2	<0.5	<3	<1
3001-21.4	<0.5	<20			28	<2	<0.2	<0.5	<3	1
F-256	<0.5	<10	<10		26	<2	<0.2	<0.5	<3	<1
F-275	<0.5	10			6	<2	<0.2	<0.5	<3	<1
SB-28	<0.5	<10	<10		32	2	<0.2	<0.5	<3	<1
TH-65	<0.5	<20			24	<2	0.2	<0.5	<3	<1
ALN-1	0.5	<20			26	5	0.2	<0.5	<3	1
BAB-1										
C-4	<0.5	50			8	3	0.3	<0.5	<3	<1
CD-6	<0.5	<10	<10		14	<2	0.7	0.5	<5	3
D-40										
NL-3	<0.5	<10	<10		28	<2	<0.2	<0.5	<3	<1

APPENDIX H

MICROPROBE MINERAL ANALYSES
(T. Fitz - May '85 - Madison, WI)

	SiO_2	Al_2O_3	Na_2O	CaO	FeO	MgO	TiO_2	MnO	Cr_2O_3	NiO	K_2O	Total
F-237	BBINT			CPX								
(3)	45.31	0.79	0.25	19.02	29.34	1.23	0.92	0.70	0.0	(0.0)		97.56
				OLV								
(4)	29.80	0.00	0.08	0.52	67.18	0.40	0.08	1.69	0.01	(0.0)		99.77
				MAG								
(3)	0.41	0.21	0.12	0.21	82.54	0.02	7.23	0.32	0.0	(0.0)		91.07
LM-7	DCFEL			CPX								
(3)	46.15	1.52	0.62	19.15	15.38	7.15	0.37	0.66	0.0	(0.0)		91.00
SB-28	BBMAF			MAG								
(3)	0.25	2.10	0.09	0.20	77.60	0.12	5.94	0.76	0.10	0.06		87.22
				CPX								
(2)	49.40	1.62	0.34	17.91	12.65	12.98	0.89	0.33	0.01	0.00		96.41
GWL-3	DCTROC			OLV								
(3)	34.64	0.02	0.07	0.18	34.43	27.15	0.03	0.48	0.02	0.09		97.11
F-237	BBINT			PLG								
(3)	58.88	26.01	7.54	7.26	0.28	0.00					0.62	100.58
LM-7	DCFEL			PLG								
(3)	57.75	21.85	7.78	5.40	0.67	0.00					1.02	94.48
SB-28	BBMAF			PLG zoned								
(4)	54.89	27.83	5.86	10.04	0.35	0.01					0.45	99.43
GWL-3	DCTROC			PLG								
(3)	52.40	30.07	4.68	11.80	0.19	0.04					0.49	99.67
NE-2-302	DCMMA			PLG								
(5)	53.90	30.02	5.20	11.11	0.08	0.00					0.23	100.54
GWL-1	DCTROC			PLG rim								
(5)	53.99	29.68	4.44	12.26	0.43	0.13					0.35	101.29
				PLG intermed.								
(3)	52.96	30.37	4.26	12.32	0.33	0.09					0.40	100.73
				PLG core								
(5)	52.45	30.52	4.26	12.30	0.32	0.09					0.41	100.35
F-275	BBMAF			PLG								
(6)	54.46	28.77	5.15	11.30	0.49	0.09					0.31	100.56
NL-1	DCINT			CPX								
(1)	51.37	1.45	0.31	17.03	16.77	12.11					0.04	99.07
				PLG								
(3)	57.69	26.43	6.47	8.57	0.44	0.09					0.60	100.28

APPENDIX H (continued)

MICROPROBE MINERAL ANALYSES

Sample	Mineral		SiO_2	Al_2O_3	Na_2O	CaO	FeO	MgO	TiO_2	MnO	Cr_2O_3	NiO	K_2O	Total
GKF-46 BBINT	PLG rim	(5)	62.67	23.08	8.90	4.88	0.47	0.05					0.58	100.84
	PLG core	(4)	58.42	26.10	7.31	7.42	0.47	0.09					0.40	100.20
NE-2-302 DCMMA	CPX	(4)	49.48	2.77	0.49	19.85	8.40	15.96	1.01	0.29	0.06	0.04		98.35
	OLV	(3)	38.07	.02	.07	.09	23.79	38.16	.03	.50	.04	.05		100.81
	MAG	(3)	0.10	2.92	.10	.22	72.72	3.05	15.40	.55	1.95	.11		97.11
	ILM	(3)	.05	.08	.06	.10	43.63	4.45	50.55	.78	.10	.04		99.84
GWL-1 DCTROC	CPX	(3)	51.49	2.82	.47	21.66	9.00	13.22	1.22	.22	.14	.00		100.26
	OLV	(3)	37.26	.05	.08	.12	34.56	28.21	.03	.48	.00	.06		100.84
F-275 BBMAF	OLV	(3)	33.98	.03	.09	.25	47.78	20.46	.05	.67	.00	.00		103.30
	CPX	(6)	51.41	1.19	.34	17.10	15.77	13.14	.73	.49	.00	.00		100.17
NL-1 DCINT	CPX small	(5)	48.31	1.36	.31	17.43	18.97	11.20	.84	.43	.02	.00		98.89
	CPX large	(3)	48.70	1.06	.29	18.05	20.92	8.87	.76	.48	.00	.00		99.13
GKF-46 BBINT	CPX	(3)	49.33	.67	.33	19.08	25.81	4.32	.66	.56	.01	.00		100.76
BL-2 DCTROC	CPX rim on ol.	(3)	49.59	2.73	.35	17.87	10.14	16.04	1.37	.23	.36	.00		98.71
	OLV	(3)	37.35	.00	.08	.10	28.14	34.09	.00	.40	.00	.08		100.24
S-2 DCTROC	CPX	(3)	51.25	1.74	.35	17.04	13.62	14.26	.99	.32	.05	.00		99.63
	OLV	(3)	35.85	.00	.09	.13	39.11	24.69	.02	.55	.01	.09		100.53
	ILM	(3)	.08	.13	.10	.09	45.99	2.76	51.60	.42	.11	.04		101.34
SE-3-309 DCMMA	CPX	(5)	49.79	1.83	.46	19.22	13.51	12.80	1.10	.29	.04	.02		99.05
	OLV	(3)	35.35	.04	.08	.39	42.37	22.72	.06	.62	.00	.09		101.72

APPENDIX H (continued)

MICROPROBE MINERAL ANALYSES

	SiO_2	Al_2O_3	Na_2O	CaO	FeO	MgO	TiO_2	MnO	Cr_2O_3	NiO	K_2O	Total
D-105	DCTROC			OLV								
(3)	35.46	.05	.08	.12	41.39	24.16	.04	.52	.02	.03		101.87
				CPX								
(3)	50.28	1.96	.37	20.13	11.66	13.37	.89	.33	.08	.06		99.13
C-3	DCTROC			CPX zoned?								
(5)	51.58	1.83	.34	17.87	10.68	16.26	.72	.29	.03	.04		99.64
				OLV								
(3)	37.09	.00	.07	.12	30.52	34.04	.05	.41	.03	.08		102.43
				OPX rim on ol.								
(3)	53.28	1.21	.07	1.34	17.78	24.67	.38	.41	.02	.03		99.18
BL-2	DCTROC			PLG								
(5)	51.22	29.99	3.76	13.44	.63	.30					.27	99.61
S-2	DCTROC			PLG								
(4)	54.86	28.07	5.19	11.16	.37	.03					.47	100.15
SE-3-309	DCANOR			PLG								
(3)	52.45	29.61	4.29	12.96	.50	.12					.33	100.26
D-105	DCTROC			PLG								
(5)	55.02	27.81	5.41	11.19	.33	.09					.31	100.16
C-3	DCTROC			PLG								
(3)	52.36	29.48	3.91	13.77	.54	.08					.20	100.34
SE-1-812	DCANOR			PLG								
(2)	54.80	28.02	5.76	10.59	.34	.09					.20	99.80
				PLG rim								
(3)	54.78	27.87	5.75	10.46	.30	.03					.21	99.40
				PLG core								
(3)	54.58	28.63	5.31	11.15	.26	.05					.26	100.24
SE-1-627	DCANOR			PLG								
(3)	54.94	28.38	5.77	10.38	.22	.11					.26	100.07
T-65	BASALT			PLG pheno.								
(3)	51.46	30.07	3.86	13.53	.54	.21					.17	99.84
				PLG laths								
(6)	51.23	28.97	3.84	13.31	1.09	.32					.16	98.91
SE-1-812	DCANOR			OLV								
(3)	33.91	.02	.08	.09	46.49	19.73	.02	.62	.02	.02		101.00
				OPX rim on ol.								
(3)	51.61	.58	.08	.57	25.62	19.11	.06	.54	.03	.02		98.21

APPENDIX H (continued)

MICROPROBE MINERAL ANALYSES

	SiO_2	Al_2O_3	Na_2O	CaO	FeO	MgO	TiO_2	MnO	Cr_2O_3	NiO	K_2O	Total
				CPX								
(3)	49.61	2.01	.34	20.90	11.31	12.96	.70	.28	.01	.02		98.14
				BIO								
(4)	37.90	13.65	.25	.09	13.97	15.68	3.50	.03	.00	.02	(n.a.)	85.09
				MAG								
(2)	.17	2.22	.11	.11	85.61	.15	5.95	.21	.23	.05		94.80
SE-1-627 DCANOR				OLV								
(3)	35.70	.00	.08	.08	36.98	27.11	.02	.52	.05	.09		100.62
				CPX								
(5)	50.49	1.69	.44	19.05	11.07	14.06	.89	.24	.03	.03		98.00
				BIO								
(2)	38.75	12.52	.24	.02	11.06	17.66	2.69	.06	.00	.07	(n.a.)	83.06
T-65	BASALT			OLV								
(3)	36.66	.00	.08	.37	30.51	31.65	.00	.43	.00	.11		99.81
				CPX zoned								
(3)	50.16	1.74	.34	15.15	15.37	13.95	1.14	.39	.05	.03		98.33
DG-34	DCTROC			CPX zoned								
(5)	51.69	2.22	.42	20.81	9.12	14.86	.71	.23	.07	.06		100.19
				OLV								
(3)	36.36	.24	.09	.09	33.04	30.32	.00	.45	.03	.11		100.73
				BIO								
(3)	37.59	15.66	.22	.04	10.52	15.02	4.80	.03	.18	.08	(n.a.)	87.15
				ILM								
(2)	.09	.11	.10	.11	46.60	2.52	50.02	.44	.18	.05		100.23
DG-37	DCUMAF			OLV								
(3)	35.76	.00	.09	.12	38.30	26.19	.00	.53	.00	.08		101.08
				CPX zoned, variable								
(5)	50.46	2.03	.33	15.37	15.46	15.31	.66	.35	.10	.04		100.10
				ILM								
(3)	.07	.05	.10	.12	47.85	1.64	49.18	.52	.13	.00		99.64
DG-1	DCTROC			OLV								
(3)	37.08	.15	.10	.16	31.94	33.07	.00	.43	.00	.07		103.00
DG-60	DCANOR			OPX								
(3)	52.65	.87	.08	.92	22.11	22.48	.18	.49	.00	.00		99.77
				OLV								
(3)	35.76	.09	.09	.09	37.81	27.09	.00	.53	.00	.10		101.55
DG-59	DCTROC			OLV								
(3)	36.58	.00	.10	.12	33.03	30.46	.03	.47	.00	.09		100.88

APPENDIX H (continued)

MICROPROBE MINERAL ANALYSES

		SiO_2	Al_2O_3	Na_2O	CaO	FeO	MgO	TiO_2	MnO	Cr_2O_3	NiO	K_2O	Total
DG-34	DCTROC				PLG								
(3)		52.21	30.41	4.10	13.28	.33	.24					.32	100.88
DG-1	DCTROC				PLG								
(3)		53.93	28.21	5.06	11.68	.47	.16					.33	99.85
DG-60	DCANOR				PLG								
(5)		51.85	29.81	3.95	13.72	.41	.01					.20	99.96
DG-59	DCTROC				PLG								
(4)		54.12	27.77	5.10	11.45	.24	.00					.42	99.09
DG-51	DCUMAF				PLG								
(5)		49.22	32.16	2.66	15.77	.18	.07					.15	100.21
					OLV								
(3)		35.65	.00	.08	.21	35.65	26.92	.04	.47	.00	.07		99.09
DU-15-2435	DCMMA				PLG								
(4)		53.51	28.24	5.20	11.37	.44	.13					.07	98.96
DUV-15-2435.5	DCMMA				PLG zoned, variable								
(5)		54.97	28.01	5.42	10.88	.20	.07					.24	99.79
DU-15-2435	DCMMA				OLV								
(3)		38.26	.09	.08	.08	21.94	38.74	.02	.26	.00	.15		99.61
					ILM								
(2)		.11	.00	.10	.11	41.69	4.62	50.89	.49	.15	.05		98.21
					MAG (Al, Ti, Cr-rich)								
(2)		.07	4.90	.09	.11	70.99	2.01	9.00	.31	7.41	.17		95.07
DU-15-2435	DCMMA				SPN								
(1)		.06	49.04	.09	.06	27.25	11.55	.31	.16	8.45	.19		97.16
DG-51	DCUMAF				ILM								
(1)		.10	.19	.10	.08	41.65	3.22	51.55	.49	.35	.05		97.76
DUV-15-2435.5	DCMMA				MAG (Al, Ti, Cr-rich)								
(1)		.15	4.93	.09	.09	72.32	1.70	9.01	.33	6.11	.15		94.88
					ILM								
(2)		.07	.00	.09	.10	41.88	4.20	50.99	.48	.15	.03		97.99
DG-51	DCUMAF				HBL								
(3)		43.53	9.86	2.73	11.15	10.20	14.38	2.50	.12	.40	.04		94.90

APPENDIX H (continued)

MICROPROBE MINERAL ANALYSES

SULFIDES

	Fe	As	S	Co	Ni	Cu	Mn	Total
DG-37	DCUMAF			PYRHOTITE				
(2)	62.82	0.00	36.58	0.03	0.00	0.00	0.02	99.45
DUV-15-2435.5		DCMMA		CHALCOPYRITE				
(2)	29.79	0.35	34.27	0.03	0.01	32.53	0.01	96.97

(X): number in parentheses is the number of spot analyses averaged to give the following values

CPX: clinopyroxene (augite)
OPX: orthopyroxene
OLV: olivine
PLG: plagioclase
MAG: magnetite
ILM: ilmenite
BIO: biotite
HBL: hornblende
SPN: spinel (Cr-hercynite)

(n.a.): not analyzed

APPENDIX I

Analytical Reports from LGC Analytical Labs

A: R. Knoche, Univ. of Minnesota

B: XRAL, Toronto

R. L. Knoche

	Troctolite	Granite	Basalt	Basalt	Troctolitic Gabbro	Basalt	Troctolite	Intermediate (Quartz) Monzonite	Anorthosite	Intermediate (Quartz) Monzonite
	ORC-3	C-6	ES 21	LS-22	LS 23	[illegible]	DS-55	DS 65	D 102	D 103
	1	2	3	4	5	6	7	8	9	10
% wt.										
SiO_2	46.2	73.4	50.3	54.0	49.9	54.9 / 54.7	50.2	56.7	49.2	52.3
TiO_2	0.60	0.234	3.83	2.57	1.39	2.24 / 2.27	0.46	2.19	0.84	1.58
Al_2O_3	21.0	12.2	13.6	12.6	19.7	13.7 / 13.7	27.0	13.5	23.9	12.8
Fe_2O_3	1.4	1.2	4.3	3.2	1.9	3.7 / 3.7	0.5	3.9	1.3	8.6
FeO	7.0	1.5	11.1	11.9	8.7	8.7	3.2	8.1	4.8	10.1
MnO	0.115	0.044	0.319	0.209	0.146	0.187 / 0.179	0.046	0.177	0.075	0.298
MgO	8.7	0.043	4.49	2.45	6.02	3.62 / 3.59	2.18	2.22	1.98	0.85
CaO	10.2	0.68	4.40	6.48	9.0	7.12 / 7.12	12.1	4.96	10.8	6.87
Na_2O	2.35	3.72	2.76	2.91	3.25	3.33 / 3.31	3.44	3.39	3.49	3.93
K_2O	0.22	4.78	1.54	1.84	0.74	1.71 / 1.71	0.42	2.50	1.12	2.24
H_2O^+										
CO_2										
P_2O_5	0.056	0.010	0.55	0.71	0.114	0.35 / 0.34	0.109	0.69	0.24	0.035
Total	97.8	97.8	97.2	98.9	100.9	99.6 / 99.3	99.7	98.3	97.8	99.7
Total Fe as Fe_2O_3	9.1	2.91	16.7	16.5	11.6	13.4 / 13.4	4.02	12.9	6.65	19.8

ppm	1	2	3	4	5	6	7	8	9	10
Be	0.4	4.9	2.8	2.9	1.4	1.9 / 1.7	0.6	2.9	1.4	3.1
Sc	9	1.3	30.	31	14	35 / 35	3.8	24	10.	40.
V	71	<5	330	192	143	370 / 390	33	46	47	4
Cr	10.	1.4	17	10.	5	9 / 10.	44	3.4	34	2.0
Co	62	<5	47	34	48	36 / 38	16	22	18	7
Ni	260	5	48	13	140.	9 / 9	62	3.9	44	2.8
Cu	53	14	290	137	160	14 / 15	105	73	108	38
Zn	69	113	147	176	101	135 / 127	36	163	52	132
Rb	4	220	30.	52	19	41 / 41	6	70.	29	79
Sr	291	44	342	335	272	33 / 349	386	238	436	331
Y	9	80	48	55	20.	35 / 36	8	71	27	78
Zr	41	580			150	180 / 180	50		180	120
Ba	70.	930	600	550	204	690 / 710	127	680	216	680

R. L. Knoche

	Mafic Troctolite	Anorthosite	basalt / Intermediate (Quartz) Monzonite	Anorthosite	Troctolitic Gabbro	Granite	Intermediate (Quartz) Monzonite	Granite	Basalt	Basalt
	D-105	D-106	D-108	D-110	S-2	DC-66	DC-3	CRPG GA	GP-11	GP-16
	11	12	13	14	15	16	17	18	19	20
% wt.										
SiO_2	37.8	47.3	48.0	51.5	46.2	62.3	49.8	69.5	44.5	46.3
TiO_2	12.2	1.28	3.97	0.57	5.50	1.02	3.15	0.34	2.24	2.38
Al_2O_3	11.1	22.9	13.5	25.8	15.9	15.2	11.7	14.7	8.9	9.1
Fe_2O_3	3.3 (2.32)	1.6	4.8	0.9	2.1 (2.45)	3.7 (1.56)	2.6 (2.43)	1.1	4.7 (2.52)	5.0 (2.90)
FeO	16.3	6.5 (6.42)	11.1 (12.48)	2.6	9.2	3.6 (5.62)	12.9	1.5	8.4 (10.16)	8.4 (10.45)
MnO	0.249	0.104	0.280	0.042	0.155	0.114	0.276	0.087	0.225	0.246
MgO	7.74	4.52	4.50	1.77	6.15	1.18	3.21	0.92	9.4	9.4
CaO	9.5	10.3	7.79	11.1	11.5	2.44	7.44	2.43	10.5	9.5
Na_2O	1.71	3.03	3.13	4.29	2.65	4.69	2.90	3.47	1.55	2.02
K_2O	0.17	0.57	1.31	0.62	0.29	3.59	2.00	3.95	0.68	0.74
H_2O^+										
CO_2										
P_2O_5	0.079	0.104	0.58	0.15	0.051	0.20	1.29	0.115	0.25	0.27
Total	100.1	98.2	99.0	99.3	99.7	98.0	97.3	98.1	91.3	93.4
Total Fe as Fe_2O_3	21.4	8.8	17.2	3.76	12.3	7.	17.0	2.69	14.0	14.4
ppm										
Be	1.5	0.8	2.9	0.8	1.0	3.6	3.7	3.7	2.2	2.7
Sc	66	7.1	37	5.7	50.	16	37	7.8	33	33
V	940	230	270	33	480	25	169	32	280	270
Cr	570	480	32	54	144	< 1	4	6	670	711
Co	75	38	46	19	49	10.	33	4	60.	69
Ni	199	138	62	52	110.	2.5	20.	3.8	207	204
Cu	320	49	251	16	450	69	310	21	129	199
Zn	124	91	186	23	72	112	199	70.	107	117
Rb	3	14	51	12	3	140	48	174	8	6
Sr	163	386	204	468	247	219	248	308	760	790
Y	20.	13	65	12	17	63	120	21	24	26
Zr	115	95		120	80	720		160	230	260
Ba	84	167	282	185	101	780	650	840	239	259

K. L. Knoche

	Basalt	Basalt	Basalt	Basalt	Basalt	Diabase	Basalt	Andesite	Basalt	Basalt
	GP-24	GP 30	GP-60	PP-7	PP-15	PP-36	F-257	F-267	GBL-2	D-40
	21	22	23	24	25	26	27	28	29	30
% wt.										
SiO_2	47.5	54.0	47.9	47.9	57.6	47.7	50.9	53.5	47.3	49.5
TiO_2	3.14	2.12	3.66	2.62	1.02	1.44	2.38	2.51	1.63	3.67
Al_2O_3	14.4	12.5	11.8	14.8	14.0	16.3	15.1	13.1	16.1	13.5
Fe_2O_3	5.6 (2.76)	3.8 (2.75)	4.5 (3.59)	4.2 (2.93)	1.3 (1.69)	1.9 (2.61)	5.5 (2.71)	8.3 (2.93)	2.3 ([illegible])	5.5 (3.19)
FeO	7.3 (9.13)	9.0 (10.00)	12.0 (12.92)	9.2 (10.55)	7.3 (6.52)	9.9 (9.40)	7.2 (9.76)	5.9 (10.73)	9.8 (9.80)	9.3 (11.47)
MnO	0.169	0.160	0.239	0.190	0.146	0.171	0.214	0.163	0.175	0.636
MgO	4.72	2.00	4.04	5.97	3.90	8.1	4.28	3.47	8.0	4.00
CaO	7.05	6.28	8.9	8.2	6.95	10.7	9.9	7.08	10.2	7.65
Na_2O	3.01	2.93	2.63	3.25	3.26	2.36	2.74	2.86	2.35	2.86
K_2O	1.45	2.38	1.29	0.73	1.92	0.27	0.81	1.43	0.36	0.60
H_2O^+										
CO_2										
P_2O_5	0.36	0.9	0.53	0.40	0.20	0.127	0.28	0.45	0.16	0.72
Total	94.7	96.1	97.5	97.5	97.6	99.0	99.3	98.8	98.4	97.9
Total Fe as Fe_2O_3	13.7	13.8	17.8	14.5	9.4	12.9	13.5	14.8	13.2	15.8
ppm										
Be	2.4	3.4	2.3	1.5	2.2	0.8	1.6	1.8	0.9	4.1
Sc	22	22	49	24	25	34	41	32	34	41
V	300	37	300	310	134	250	320	330	240	214
Cr	11	<1	5	109	85	180	59	18	207	5
Co	53	25	50.	55	30.	59	46	41	59	37
Ni	23	5	22	129	48	184	43	34	214	24
Cu	22	154	266	101	105	125	202	59	140.	360
Zn	133	167	181	138	124	98	133	163	101	240
Rb	27	72	28	25	55	2	20.	19	6	20.
Sr	920	305	359	504	446	259	245	294	251	166
Y	29	69	60.	30.	40.	21	47	49	28	70.
Zr	250				290	95	230		120	
Ba	540	670	450	320.	780	113	239	690	109	257

R. L. Knoche

	Diabase	Basalt	Basalt	Basalt	Diabase	Basalt	Basalt	Olivine Gabbro	Basalt	Basalt
	BAB-1	M-7359	M-7268	M-7482	M-7124	M-7611	PP-35	DG-53		
	31	32	33	34	35	36	37	38	D-112	D-118
% wt.										
SiO_2	45.6	46.7	47.6	47.3	47.2	47.5	51.5	48.0	46.4	46.2
TiO_2	4.58	2.99	1.67	1.70	3.52	1.66	1.25	0.395	2.26	3.18
Al_2O_3	13.7	13.9	16.0	16.4	14.6	16.0	14.6	17.3	16.4	13.3
Fe_2O_3	2.8 (3.90)	4.2 (3.32)	2.3 (2.69)	1.9 (2.55)	3.8 (3.36)	2.1 (2.66)	3.6 (2.25)	0.5 (1.52)	3.9 (2.81)	10.9 (3.77)
FeO	14.8 (14.02)	11.0 (11.96)	9.9 (9.67)	9.6 (9.19)	11.6 (12.08)	9.9 ([illegible])	6.9 (6.21)	7.7 (6.57)	9.1 (10.10)	7.0 (13.57)
MnO	0.216	0.219	0.178	0.176	0.202	0.175	0.168	0.135	0.320	1.04
MgO	4.50	5.87	7.86	7.37	5.17	7.67	6.78	10.2	6.42	4.95
CaO	8.3	6.97	10.1	8.7	8.3	10.1	9.6	12.1	9.7	7.37
Na_2O	2.82	4.02	2.35	2.10	2.57	2.45	2.32	1.91	2.30	2.31
K_2O	0.50	0.88	0.40	1.32	1.49	0.51	0.88	0.19	0.51	0.63
H_2O^+										
CO_2										
P_2O_5	0.57	0.42	0.16	0.16	0.42	0.15	0.17	0.024	0.27	0.36
Total	98.4	97.2	98.5	96.7	98.9	98.2	97.8	98.5	97.6	97.2
Total Fe as Fe_2O_3	19.3	16.5	13.3	12.6	16.6	13.2	11.3	9.1	14.0	18.7
ppm										
Be	1.9	1.9	0.8	0.8	2.2	1.0	1.1	0.3	1.6	1.7
Sc	34	31	34	36	36	34	33	31	34	49
V	390	320	240	250	280	230	240	200	250	380
Cr	21	42	204	217	95	202	115	270	148	104
Co	59	54	53	56	52	54	48	50.	56	53
Ni	64	46	185	191	106	180	84	210	178	58
Cu	410	78	135	158	310	138	59	15	266	360
Zn	182	109	103	102	165	101	86	55	130.	152
Rb	5	21	6	54	44	9	16	2	10.	10.
Sr	517	385	276	479	293	267	379	343	224	177
Y	47	34	28	27	51	26	22	8	37	44
Zr			120	110		110	120	22	170	300
Ba	267	252	144	189	760	120.	323	71	146	200.

R. L. Knoche

	Basalt									
	D-121	D-125	D-152	D-162	LW-28	LW-56	LW-57	LW-58	CQ-3	CQ-4
% wt.										
SiO_2	48.0	46.0	46.7	51.3	46.2	46.5	46.5	47.0	49.5	49.7
TiO_2	2.57	2.02	2.61	3.24	2.28	2.39	0.94	2.27	4.48	4.04
Al_2O_3	15.5	16.8	15.3	13.7	15.8	15.8	17.5	16.5	12.7	13.0
Fe_2O_3	4.4 (2.54)	3.0 (2.68)	2.9 (3.27)	8.0 (2.91)	4.3 (2.90)	4.1 (3.04)	4.6 (1.96)	3.7 (2.50)	1.6 (3.03)	2.3 (3.04)
FeO	8.7 (10.34)	9.3 (9.65)	11.9 (11.16)	5.7 (10.46)	9.0 (10.44)	9.9 ([illegible])	4.6 (7.05)	9.2 (10.08)	12.1 (10.42)	11.5 (10.43)
MnO	0.231	0.509	0.202	0.262	0.205	0.200	0.409	0.222	0.175	0.161
MgO	5.11	7.33	6.20	3.90	6.23	5.49	8.2	5.85	4.37	4.42
CaO	9.7	6.83	9.5	6.08	9.5	9.5	10.7	9.7	7.64	7.38
Na_2O	2.50	2.12	2.61	3.13	2.33	2.55	2.24	2.60	2.74	3.09
K_2O	0.77	2.16	0.63	1.03	0.58	0.66	0.16	0.60	1.24	1.26
H_2O^+										
CO_2										
P_2O_5	0.32	0.24	0.35	0.50	0.3	0.28	0.088	0.28	0.50	0.39
Total	97.8	96.3	98.9	96.8	96.7	97.4	95.9	97.9	97.0	97.2
Total Fe as Fe_2O_3	14.1	13.3	16.2	14.4	14.4	15.1	9.7	13.9	15.0	15.0
ppm										
Be	2.1	1.3	1.6	2.4	1.3	1.4	0.6	1.3	2.6	2.3
Sc	41	35	38	42	35	34	32	32	30.	25
V	290	260	290	290	260	250	220	230	420	330
Cr	132	111	144	57	150.	141	170	147	48	63
Co	58	54	58	36	54	52	52	52	65	55
Ni	112	171	129	16	162	158	230	162	88	84
Cu	330	230	360	178	280	300	77	250	280	191
Zn	144	126	138	220	135	134	180.	130.	158	138
Rb	16	20.	13	22	13	16	3	11	23	28
Sr	208	226	205	300.	199	221	280.	245	663	655
Y	43	29	42	56	38	36	17	35	36	34
Zr	400	220	340		380	340	60	260		
Ba	178	313	170.	1010	160.	181	72	175	273	358

R. L. Knoche

	Basalt									
	CQ-5	CQ-6	CQ-8	ES-26	ES-27	ES-29	PP-34	KV-128	20-3-C	VC-221 -1A
% wt.										
SiO_2	48.6	50.2	48.8	49.8	49.5	51.9	49.5	45.9	49.1	52.2
TiO_2	3.88	4.56	4.04	3.27	4.06	1.20	1.50	1.39	2.21	2.92
Al_2O_3	12.9	12.9	14.0	14.0	13.1	14.3	14.3	16.4	15.4	12.5
Fe_2O_3	3.2 (3.29)	2.6 (3.11)	3.1 (2.85)	3.6 (2.88)	2.9 (3.29)	1.7 (2.42)	2.7 (2.92)	3.4 (2.55)	2.6 (2.78)	2.5 (3.31)
FeO	11.7 (11.80)	11.6 (11.19)	10.0 (10.27)	9.6 (10.38)	12.1 (11.85)	9.2 (8.70)	10.7 (10.34)	9.8 (10.38)	10.1 (10.61)	12.5 (11.91)
MnO	0.193	0.167	0.201	0.196	0.171	0.179	0.199	0.187	0.162	0.191
MgO	4.67	4.61	4.86	4.89	3.76	5.82	6.40	7.92	5.11	2.79
CaO	7.38	7.45	8.2	7.79	6.81	9.5	10.0	10.0	8.1	6.36
Na_2O	2.80	3.10	4.05	2.85	2.94	2.67	2.26	2.19	2.58	2.98
K_2O	1.25	1.22	1.01	1.26	1.59	1.15	0.44	0.35	0.84	1.87
H_2O^+										
CO_2										
P_2O_5	0.53	0.41	0.67	0.45	0.54	0.15	0.14	0.19	0.28	0.8
Total	97.1	98.8	98.9	97.7	97.5	97.8	98.1	97.7	96.5	97.6
Total Fe as Fe_2O_3	16.2	15.4	14.1	14.3	16.3	12.0	14.5	14.3	13.8	16.4
ppm										
Be	2.4	2.5	3.0	3.8	2.8	1.2	0.8	0.7	1.8	2.8
Sc	35	25	18	27	28	38	39	33	36	31
V	450	360	210	370	330	260	360	240	280	210
Cr	35	44	10.	115	40.	86	86	49	76	6
Co	60.	55	28	49	48	42	54	64	59	39
Ni	75	80.	10.	100.	69	50.	85	190	101	18
Cu	287	231	23	290	350	127	185	153	222	270.
Zn	160.	144	130.	91	175	100.	110.	107	114	176
Rb	33	23	24	35	49	25	15	11	27	54
Sr	525	667	1460	436	424	258	195	183	244	388
Y	39	37	25	40.	51	29	26	24	35	53
Zr						160	100	90	190	
Ba	386	382	410	450	480	400	147	106	233	580

```
X     X     RRRRR          A        LL
XX   XX     RR  RR        AAA       LL
 XX XX      RR   RR      AA AA      LL
  XXX       RR  RR      AA   AA     LL
  XXX       RRRRR       AAAAAAA     LL
 XX XX      RR  RR      AA   AA     LL
XX   XX     RR   RR     AA   AA     LLLLLLL
X     X     RR    R     AA   AA     LLLLLLL
```

XRF - WHOLE ROCK ANALYSIS

UNIVERSITY OF MINNESOTA
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GEOLOGY DEPT-LITHOCHEMISTRY
DULUTH, MINNESOTA 55812
USA

CUSTOMER No. 1088

DATE SUBMITTED
21-FEB-85

REPORT 23785 REF. FILE 19391 DATE REPORTED 13-MAR-85

XRF W. R. A. SUMS INCLUDE ALL ELEMENTS DETERMINED.
FOR SUMMATION ELEMENTS ARE CALCULATED AS OXIDES.

SAMPLE	SIO2	AL2O3	CAO	MGO	NA2O	K2O	FE2O3	MNO	TIO2	P2O5	CR2O3	LOI	SUM
3001-21.4 BBMAF	47.9	16.0	10.6	8.31	2.39	0.34	12.4	0.17	1.35	0.14	0.03	-0.07	99.6
ALN-1 CKIMAF	47.4	12.4	6.55	3.53	2.62	0.11	16.0	0.18	3.97	0.47	<0.01	6.31	99.6
BRL-1 DCFEL	67.5	12.5	2.39	0.52	4.00	3.99	7.11	0.11	0.80	0.14	0.02	0.23	99.4
CQ-10 DIKECC	48.9	12.3	7.32	4.10	3.08	1.31	16.1	0.17	4.50	0.48	---	0.23	98.6
ES-19 BASALT	51.6	14.5	9.68	6.68	2.42	0.85	11.5	0.17	1.24	0.17	---	0.77	99.7
D-122 DIKEDU	44.4	16.6	9.94	5.20	2.19	0.65	13.1	0.40	2.31	0.25	0.02	4.31	99.4
D-168 DIKEDU	48.0	10.8	8.31	2.30	2.31	1.80	15.5	0.18	2.99	0.92	<0.01	6.08	99.3
D-170 DIKEDU	48.6	11.5	7.58	2.49	2.21	2.01	16.3	0.21	3.21	1.00	---	3.77	99.0
D-172 DIKEDU	37.7	16.1	17.7	1.06	2.40	0.88	9.32	0.68	2.58	0.32	---	10.6	99.4
D-176 DIKEDU	42.6	16.0	5.68	5.88	2.05	1.54	15.8	0.92	2.87	0.31	0.01	5.47	99.2
DC-121B DIKETC	46.0	14.7	8.74	5.55	2.74	0.59	16.8	0.20	3.56	0.49	---	-0.69	98.8
DG-8 DCTROC	49.2	22.8	9.66	5.69	3.43	0.40	8.55	0.09	0.65	0.07	---	-0.07	100.5
DG-32 DCMMA	46.8	14.4	8.43	5.59	2.00	0.39	18.1	0.21	3.59	0.49	0.03	-0.53	99.6
DG-34 DCTROC	45.9	19.5	9.20	9.02	2.60	0.26	11.4	0.13	0.54	0.04	---	0.00	98.7
DG-48 DCTROC	46.7	17.4	8.50	7.78	2.64	0.66	14.4	0.17	1.56	0.26	---	-0.38	99.8
DG-60 DCANOR	50.0	27.2	12.3	1.96	3.37	0.40	4.23	0.04	0.61	0.11	0.02	0.47	100.7
EM-1 DCFEL	70.8	12.4	1.67	0.38	4.13	4.06	4.97	0.08	0.53	0.08	0.03	0.54	99.8
F-290 BASALT	46.4	16.0	10.6	8.49	2.01	0.32	11.2	0.16	1.16	0.13	0.02	3.39	99.9
(FBR-1)	38.3	9.75	13.5	13.0	2.79	1.37	12.8	0.19	2.63	1.07	---	2.70	98.3
(FGR-1)	69.4	14.9	2.49	0.93	3.72	4.10	2.68	0.08	0.36	0.13	---	1.19	100.0
GBL-5 DIKETC	47.3	15.8	9.64	7.64	2.32	0.64	13.4	0.18	1.61	0.16	---	0.93	99.7
GHC-14 ANDES	57.8	12.2	4.71	1.74	3.03	2.82	12.7	0.16	1.94	0.45	---	1.85	99.5
GP-20A BASALT	50.5	14.3	9.77	5.91	2.25	0.79	11.5	0.16	1.29	0.19	---	3.54	100.3
H-6 DIKEGP	54.4	16.1	4.14	2.60	4.33	2.83	11.3	0.13	2.45	0.36	---	1.39	100.2
LM-7 DCFEL	69.0	12.7	1.28	0.59	4.11	4.75	5.41	0.09	0.46	0.07	---	1.23	99.9
LM-9 ANDES	53.6	16.4	6.21	2.46	4.00	1.81	10.9	0.09	2.46	0.40	<0.01	1.08	99.6
M-7358 DCTROC	46.9	18.8	8.58	6.83	2.98	0.44	14.1	0.15	1.65	0.13	0.04	-0.46	100.2
M-7392 DCTROC	46.9	15.6	8.03	6.69	2.80	0.97	15.9	0.18	2.90	0.38	---	-0.50	99.9
TH-62 DCTROC	47.1	22.4	10.8	7.61	2.48	0.21	7.99	0.09	0.30	0.04	---	0.93	100.0
TH-63 CKINT	51.3	14.6	8.76	2.77	3.19	1.18	14.3	0.21	2.52	0.33	0.01	0.62	99.9

SAMPLE	CR	RB	SR	Y	ZR	NB
3001-21.4	---	10	240	10	90	40
ALN-1	---	10	330	20	280	50
BRL-1	---	150	140	80	580	50
CQ-10	20	50	510	30	310	50
ES-19	100	20	340	20	110	40
D-122	---	30	220	10	140	20
D-168	---	70	120	70	540	60
D-170	<10	70	150	80	610	60
D-172	100	20	230	30	190	30
D-176	---	30	140	40	190	30
DC-121B	90	20	210	30	180	50
DG-8	30	10	390	<10	10	10
DG-32	---	10	200	40	290	30
DG-34	180	<10	270	<10	10	10
DG-48	110	30	260	<10	120	20
DG-60	---	10	430	<10	50	10
EM-1	---	160	140	50	450	30
F-290	---	10	230	10	70	20
FBR-1	310	50	1240	<10	290	90
FGR-1	<10	170	360	30	160	30
GBL-5	170	40	270	10	110	30
GKC-14	<10	90	220	40	310	30
GP-20A	70	10	300	10	140	30
H-6	<10	100	620	30	290	40
LM-7	<10	190	170	110	960	90
LM-9	---	60	1370	30	360	40
M-7358	---	10	330	<10	40	30
M-7392	160	40	230	20	210	40
TH-62	<10	<10	290	20	10	<10
TH-63	---	40	180	50	260	30

X-RAY ASSAY LABORATORIES LIMITED

1885 LESLIE STREET, DON MILLS, ONTARIO M3B 3J4

PHONE 416-445-5755 TELEX 06-986947

CERTIFICATE OF ANALYSIS

TO: UNIVERSITY OF MINNESOTA
ATTN: J.C. GREEN
GEOLOGY DEPT-LITHOCHEMISTRY
DULUTH, MINNESOTA 55812
USA

CUSTOMER NO. 108(

DATE SUBMITTED
21-FEB-85

REPORT 23785

REF. FILE 19391-S5

13 C.PULPS,17 PULPS REQ.#344432 P.O. 816105

WERE ANALYSED AS FOLLOWS:

	METHOD	DETECTION LIMIT
AU PPB	NA	20.000
NA PPM	NA	100.000
WRMAJ %	WR	0.010
SC PPM	NA	0.100
CR PPM	NA	2.000
WRMIN PPM	WR	10.000
MN PPM	DCP	2.000
FE %	NA	0.050
CO PPM	NA	1.000
NI PPM	DCP	1.000
CU PPM	DCP	0.500
ZN PPM	DCP	0.500
AS PPM	NA	2.000
SE PPM	NA	3.000
BR PPM	NA	1.000
RB PPM	NA	20.000
SR PPM	NA	500.000
MO PPM	NA	5.000
AG PPM	DCP	0.500
CD PPM	DCP	0.200
SB PPM	NA	0.200
CS PPM	NA	0.500
BA PPM	NA	150.000
LA PPM	NA	0.500
CE PPM	NA	3.000
ND PPM	NA	10.000
SM PPM	NA	0.100
EU PPM	NA	0.200
YB PPM	NA	1.000
LU PPM	NA	0.050

	METHOD	DETECTION LIMIT
HF PPM	NA	1.000
TA PPM	NA	1.000
W PPM	NA	3.000
PB PPM	DCP	2.000
BI PPM	DCP	0.500
TH PPM	NA	0.500
U PPM	NA	0.500

X-RAY ASSAY LABORATORIES LIMITED

DATE 13-MAR-85

CERTIFIED BY ....

X-RAY ASSAY LABORATORIES 13-MAR-85 REPORT 23785 REF.FILE 19391-S5 PAGE 1 OF

SAMPLE	AU PPB	NA PPM	SC PPM	CR PPM	MN PPM
3001-21.4	<20	18000	33.0	~~370~~ 200	1100
ALN-1	<20	19000	27.0	~~92~~ 40	1200
BRL-1	<20	28000	11.0	~~250~~ <10	810
CQ-10	20	23000	29.0	40	1300
ES-19	<20	17000	32.0	130	960
D-122	<20	16000	35.0	~~240~~ 190	2500
D-168	<20	17000	35.0	~~83~~ <10	1500
D-170	<20	16000	37.0	9	1600
D-172	<20	20000	44.0	150	4900
D-176	<20	16000	41.0	~~210~~ 170	6000
DC-121B	<20	21000	34.0	120	1300
DG-8	<20	28000	4.2	52	580
DG-32	<20	14000	36.0	~~310~~ 150	1600
DG-34	<20	19000	8.7	210	820
DG-48	<20	20000	17.0	140	1200
DG-60	<20	25000	4.2	~~280~~ 90	380
EM-1	<20	28000	7.0	~~260~~ 10	600
F-290	<20	16000	33.0	~~230~~ 140	1100
FBR-1	<20	23000	27.0	350	1200
FGR-1	<20	26000	8.3	9	640
GBL-5	<20	18000	36.0	210	1200
GKC-14	<20	22000	29.0	10	1100
GP-20A	<20	17000	31.0	97	880
H-6	<20	32000	18.0	20	890
LM-7	<20	28000	6.7	<2	780
LM-9	<20	29000	13.0	~~130~~ 20	760
M-7358	<20	23000	13.0	~~430~~ 200	850
M-7392	<20	23000	26.0	190	1300
TH-62	<20	18000	6.5	20	630
TH-63	<20	25000	39.0	~~180~~ 40	1400

do not use / use Whole Rock XRF data

corr. values 18 July

SAMPLE	FE %	CO PPM	NI PPM	CU PPM	ZN PPM
3001-21.4	8.90	60	200	110.	150.
ALN-1	11.2	48	76	340.	190.
BRL-1	5.18	7	8	39.0	160.
CQ-10	11.6	58	100	290.	190.
ES-19	8.22	46	80	57.0	92.0
D-122	9.47	68	180	280.	290.
D-168	11.2	30	22	290.	230.
D-170	11.6	31	19	290.	220.
D-172	6.80	31	92	380.	220.
D-176	11.3	60	150	400.	360.
DC-121B	12.1	58	140	580.	180.
DG-8	6.36	49	150	42.0	70.0
DG-32	13.0	57	120	330.	210.
DG-34	8.37	69	310	130.	93.0
DG-48	10.3	69	240	140.	160.
DG-60	3.01	17	69	97.0	48.0
EM-1	3.44	5	10	26.0	130.
F-290	8.10	52	220	110.	98.0
FBR-1	9.20	63	270	86.0	200.
FGR-1	2.06	6	8	26.0	84.0
GBL-5	9.70	64	190	150.	120.
GKC-14	9.20	26	10	55.0	170.
GP-20A	8.30	48	70	120.	98.0
H-6	8.20	30	41	200.	150.
LM-7	3.94	<5	5	28.0	200.
LM-9	7.91	34	44	240.	160.
M-7358	10.0	66	180	250.	110.
M-7392	11.4	67	210	280.	180.
TH-62	5.59	55	230	36.0	66.0
TH-63	10.3	34	20	190.	170.

do not use
use whole rock
XRF
data

SAMPLE	AS PPM	SE PPM	BR PPM	RB PPM	SR PPM
3001-21.4	<2	<3	1	20	<500
ALN-1	5	<3	1	<20	<500
BRL-1	3	<3	1	180	<500
CC-10	3	<3	3	50	600
ES-19	<2	<3	<1	40	<500
D-122	<2	<3	2	20	<500
D-168	10	<3	2	90	<500
D-170	45	<3	1	100	<500
D-172	<2	<3	3	<20	<500
D-176	370	<3	2	20	<500
DC-121B	<2	<3	<1	<20	<500
DG-8	<2	<3	<1	<20	<500
DG-32	<2	<3	<1	20	<500
DG-34	<2	<3	2	<20	<500
DG-48	2	<3	2	20	<500
DG-60	<2	<3	<1	<20	<500
EM-1	2	<3	1	150	<500
F-290	<2	<3	<1	<20	<500
FBR-1	2	<3	2	70	1500
FGR-1	<2	<3	2	210	<500
GBL-5	<2	<3	<1	20	<500
GKC-14	8	<3	<1	120	<500
GP-20A	<2	<3	<1	20	<500
H-6	3	<3	2	110	600
LM-7	2	<3	<1	220	<500
LM-9	<2	<3	1	60	1500
M-7358	<2	<3	<1	<20	<500
M-7392	2	<3	1	50	<500
TH-62	<2	<3	1	<20	<500
TH-63	<2	<3	<1	40	<500

WHOLE ROCK ANALYSIS - ppm TRACES - XRF - PW 1600 - REFERENCE STANDARDS

	MRG-1	SY-2	SY-3	G-2	Mica Fe	Mica Mg	GS-N	NIM-G	NIM-L	NIM-S	
Rb	<10 (8)	210 (220)	200 (208)	170 (170)	2240 (2200)	1250 (1300?)	180 (190?)	310 (320)	190 (190)	490 (530)	Rb
Sr	220 (260)	260 (275)	300 (306)	510 (480)	<10 (5)	20 (25?)	640 (570?)	<10 (10)	4500 (4600)	60 (62)	Sr
Y	10 (16?)	140 (130)	730 (740)	20 (11)	40 (25?)	10 (-)	10 (-)	160 (145)	40 (25?)	<10 (3?)	Y
Zr	100 (105)	280 (280)	340 (320)	320 (300)	900 (800?)	10 (20?)	230 (240?)	280 (300)	11400 (11200)	10 (33?)	Zr
Nb	30 (20?)	10 (23?)	120 (130)	10 (13?)	300 (270?)	130 (120?)	10 (-)	60 (53?)	1000 (960)	<10 (3.5?)	Nb
Ba	100 (50?)	420 (460)	390 (430)	1900 (1900)	190 (145)	3800 (4000?)	1350 (1400?)	100 (120?)	500 (450)	2350 (2400)	Ba

NOTE: ( ) are usable values as per Sydney Abbey, 1979 - (-) indicates no values available
This represents only part of the group of 50 reference materials used for calibrating the simultaneous spectrometer. Others are available on request.

INSTRUMENT STABILITY

(10 replicate analyses)

	Mean (ppm)	SD (ppm)	Mean (ppm)	SD (ppm)
Rb	210	10	200	10
Sr	260	10	4400	40
Y	130	10	50	10
Zr	280	10	11500	40
Nb	10	10	980	20
Ba	420	20	520	20

SAMPLE PREPARATION REPRODUCIBILITY

(42 replicate analyses)

Mean (ppm)	SD (ppm)	Mean (ppm)	SD (ppm)	
30	10	220	20	Rb
<10	10	340	10	Sr
20	10	590	20	Y
60	10	280	10	Zr
20	10	870	20	Nb
660	10	1200	40	Ba

NOTE: Mean is the arithmetic mean
SD is standard deviation

SAMPLE	MO PPM	AG PPM	CD PPM	SB PPM	CS PPM
3001-21.4	<5	<0.5	<0.2	<0.2	<0.5
ALN-1	<5	0.5	<0.2	0.2	0.9
BRL-1	<5	<0.5	<0.2	0.2	3.5
CQ-10	<5	<0.5	<0.2	0.4	3.0
ES-19	<5	<0.5	<0.2	<0.2	1.7
D-122	<5	<0.5	<0.2	<0.2	2.7
D-168	<5	0.5	<0.2	2.0	3.0
D-170	7	0.5	<0.2	0.9	2.4
D-172	<5	1.0	<0.2	0.3	2.6
D-176	<5	0.5	<0.2	0.3	2.3
DC-121B	<5	<0.5	<0.2	<0.2	<0.5
DG-8	8	<0.5	<0.2	<0.2	0.7
DG-32	5	0.5	<0.2	<0.2	1.2
DG-34	<5	<0.5	<0.2	<0.2	<0.5
DG-48	<5	<0.5	<0.2	<0.2	2.0
DG-60	<5	<0.5	<0.2	<0.2	0.5
EM-1	<5	<0.5	<0.2	0.3	3.5
F-290	<5	<0.5	<0.2	<0.2	<0.5
FBR-1	<5	0.5	<0.2	<0.2	1.5
FGR-1	<5	<0.5	<0.2	<0.2	6.7
GBL-5	<5	<0.5	<0.2	<0.2	2.3
GKC-14	<5	<0.5	<0.2	0.5	2.8
GP-20A	<5	<0.5	<0.2	<0.2	1.5
H-6	<5	<0.5	<0.2	<0.2	5.8
LM-7	<5	<0.5	<0.2	0.4	2.5
LM-9	<5	<0.5	<0.2	0.2	6.0
M-7358	<5	<0.5	<0.2	<0.2	1.0
M-7392	<5	<0.5	<0.2	0.3	2.5
TH-62	<5	<0.5	<0.2	<0.2	0.5
TH-63	<5	<0.5	<0.2	0.2	2.8

SAMPLE	BA PPM	LA PPM	CE PPM	ND PPM	SM PPM
3001-21.4	200	12.1	30	10	3.7
ALN-1	200	39.2	90	40	9.5
BRL-1	1100	89.7	183	90	16.5
CQ-10	400	46.4	103	50	11.5
ES-19	300	24.1	47	20	4.3
D-122	200	15.9	37	20	5.0
D-168	700	67.4	151	80	17.6
D-170	600	72.2	164	80	18.5
D-172	300	24.4	62	30	7.8
D-176	300	26.8	59	30	7.3
DC-121B	400	32.2	72	40	8.5
DG-8	200	0.6	<3	<10	<0.1
DG-32	400	31.9	71	40	8.5
DG-34	<150	3.5	7	<10	0.7
DG-48	200	17.6	38	20	4.3
DG-60	<150	6.9	15	10	1.5
EM-1	1000	77.2	150	60	12.2
F-29C	<150	10.2	25	10	3.1
FBR-1	1200	95.3	160	70	12.4
FGR-1	900	46.1	86	30	5.4
GBL-5	<150	12.8	32	10	4.1
GKC-14	800	50.3	110	50	10.8
GP-20A	400	25.7	50	20	4.6
H-6	900	43.2	91	40	9.5
LM-7	1100	129.	266	120	23.3
LM-9	500	59.2	122	50	10.8
M-7358	200	8.0	18	10	1.8
M-7392	300	28.0	61	30	7.1
TH-62	<150	3.6	7	<10	0.8
TH-63	300	31.0	73	30	9.0

SAMPLE	EU PPM	YB PPM	LU PPM	HF PPM	TA PPM
3001-21.4	1.4	3	0.33	3	<1
ALN-1	2.9	4	0.61	8	1
BRL-1	2.8	9	1.30	18	2
CQ-10	3.5	3	0.50	9	<1
ES-19	1.3	2	0.34	3	<1
D-122	1.8	3	0.45	4	<1
D-168	4.0	10	1.48	16	2
D-170	4.2	11	1.59	17	2
D-172	2.6	5	0.69	7	<1
D-176	2.3	4	0.69	6	<1
DC-121B	2.3	5	0.68	6	1
DG-8	<0.2	<1	<0.05	<1	<1
DG-32	2.7	5	0.76	8	1
DG-34	0.6	<1	0.08	1	<1
DG-48	1.4	2	0.35	3	<1
DG-60	1.4	1	0.13	1	<1
EM-1	1.9	6	0.88	13	2
F-29C	1.3	2	0.32	2	<1
FBR-1	3.4	2	0.32	6	5
FGR-1	1.0	2	0.44	5	<1
GBL-5	1.5	3	0.39	3	<1
GKC-14	2.7	6	0.84	10	<1
GP-20A	1.5	2	0.28	4	1
H-6	2.8	4	0.57	9	1
LM-7	3.7	12	1.78	27	5
LM-9	3.5	3	0.32	9	2
M-7358	1.2	1	0.18	1	<1
M-7392	2.3	4	0.58	5	<1
TH-62	0.6	<1	0.08	1	<1
TH-63	2.2	6	0.86	8	<1

SAMPLE	W PPM	PB PPM	BI PPM	TH PPM	U PPM
3001-21.4	<3	28	<0.5	1.1	<0.5
ALN-1	<3	26	<0.5	5.1	1.7
BRL-1	<3	30	<0.5	14.0	3.9
CQ-10	<3	30	<0.5	4.8	1.8
ES-19	<3	20	<0.5	3.1	1.0
D-122	<3	96	<0.5	1.6	0.6
D-168	3	34	<0.5	9.6	3.0
D-170	<3	32	<0.5	9.8	2.9
D-172	<3	48	<0.5	2.6	0.9
D-176	<3	32	<0.5	2.1	0.9
DC-121B	<3	30	<0.5	1.1	0.9
DG-8	<3	18	<0.5	<0.5	<0.5
DG-32	<3	30	<0.5	2.4	0.8
DG-34	<3	20	0.5	<0.5	<0.5
DG-48	<3	24	<0.5	2.3	0.7
DG-60	<3	22	<0.5	0.7	<0.5
EM-1	<3	24	<0.5	13.0	4.1
F-290	<3	24	<0.5	0.8	<0.5
FBR-1	4	30	<0.5	11.0	3.0
FGR-1	<3	30	<0.5	18.0	4.9
GBL-5	<3	20	<0.5	1.0	<0.5
GKC-14	<3	22	<0.5	8.4	2.5
GP-20A	<3	18	<0.5	3.3	1.1
H-6	<3	24	<0.5	5.7	1.7
LM-7	<3	34	<0.5	20.0	6.8
LM-9	<3	26	<0.5	5.9	1.5
M-7358	<3	20	<0.5	0.8	<0.5
M-7392	<3	28	<0.5	3.5	1.0
TH-62	<3	22	<0.5	0.5	<0.5
TH-63	<3	24	<0.5	4.4	1.7

```
X       X        RRRRR            A          LL
XX     XX        RR   RR         AAA         LL
 XX XX           RR     RR      AA AA        LL
  XXX            RR   RR       AA     AA     LL
  XXX            RRRRR         AAAAAAA       LL
 XX XX           RR   RR       AA     AA     LL
XX     XX        RR     RR     AA     AA     LLLLLLL
X       X        RR      R     AA     AA     LLLLLLL
```

XRF – WHOLE ROCK ANALYSIS

UNIVERSITY OF MINNESOTA
Attn: J.C. GREEN
GEOLOGY DEPT-LITHOCHEMISTRY
DULUTH, MINNESOTA 55812
USA

CUSTOMER No. 1088

DATE SUBMITTED
11-APR-85

REPORT 24255   REF. FILE 19752   DATE REPORTED 16-MAY-85

XRF W. R. A. SUMS INCLUDE ALL ELEMENTS DETERMINED.
FOR SUMMATION ELEMENTS ARE CALCULATED AS OXIDES.

SAMPLE	SIO2	AL2O3	CAO	MGO	NA2O	K2O	FE2O3	TIO2	P2O5	CR2O3	LOI	SUM
C-9	74.1	11.4	0.15	0.52	0.92	7.65	4.02	0.36	0.04	---	0.85	100.3
C-10	48.8	15.9	10.0	6.71	2.52	0.50	11.8	1.43	0.17	0.02	2.39	100.3
C-12	51.4	12.9	7.62	3.71	2.63	1.50	15.6	2.29	0.26	---	2.08	100.1
C-13	50.0	15.3	10.4	5.37	2.48	0.76	13.2	1.64	0.30	0.02	0.62	100.2
D-42	69.0	12.9	1.09	0.95	3.32	5.39	5.20	0.80	0.11	---	1.16	100.1
D-138	63.7	12.5	3.41	0.73	3.61	3.91	9.96	1.08	0.25	---	0.47	100.0
DT-9	70.0	12.7	0.26	1.16	3.44	5.30	5.45	0.53	0.08	---	1.23	100.4
DT-24	69.1	12.3	0.25	0.24	2.44	6.41	6.65	0.55	0.08	---	1.47	99.7
F-35	66.2	12.3	2.57	1.69	3.37	3.95	5.58	1.17	0.26	---	1.93	99.2
F-46	57.6	11.4	5.57	1.13	3.22	2.34	14.7	1.81	0.45	<0.01	1.93	100.3
F-180	52.6	12.5	6.52	3.89	2.40	1.43	15.1	2.57	0.48	---	2.39	100.0
F-248	54.6	13.4	5.06	4.18	3.58	1.89	11.8	1.74	0.20	<0.01	2.85	99.4
F-256	50.2	16.0	9.70	4.94	2.62	0.71	12.6	1.81	0.27	---	1.31	100.3
F-278	72.8	11.3	0.86	0.58	2.16	4.95	4.50	0.39	0.06	---	2.39	100.2
F-289	54.3	13.0	5.45	4.21	2.85	1.34	12.7	2.04	0.31	<0.01	3.77	100.1
GM-52	70.7	12.7	0.90	0.21	3.80	4.53	5.31	0.54	0.08	---	1.31	100.4
MI-28	80.0	7.13	0.64	0.92	2.36	1.83	5.16	0.77	0.10	---	1.23	100.3
MI-40	71.2	12.6	0.23	0.46	4.54	3.71	4.85	0.48	0.04	---	1.31	99.7
ML-1	73.0	11.8	0.23	0.71	2.52	5.57	4.65	0.38	0.05	---	1.16	100.4
ML-12	70.8	12.7	0.21	0.21	2.74	6.32	5.39	0.54	0.09	---	1.08	100.3
ML-32	SMPMISS	SMPMISS	SMPMISS	SMPMISS	SMPMISS	SMPMISS	SMPMISS	SMPMISS	SMPMISS	---	SMPMISS	---
ML-34	56.6	13.1	4.53	2.59	3.80	2.80	12.5	2.34	0.38	<0.01	1.31	100.1
ML-37	50.0	16.1	6.52	7.23	3.90	1.44	10.3	1.01	0.11	0.04	3.31	100.1
NL-3	53.0	19.7	8.16	2.20	3.94	1.18	8.90	1.96	0.27	---	0.93	100.4
PM-1	56.7	12.0	4.17	1.88	3.48	2.64	14.5	2.04	0.58	<0.01	1.70	99.9
PM-2	71.5	12.4	0.31	0.63	3.26	5.48	4.32	0.48	0.08	0.01	1.16	99.9
SB-28	47.4	12.8	8.11	3.96	2.40	0.92	18.2	3.99	0.16	---	1.54	99.6
TL-13	47.3	16.5	11.2	7.61	2.19	0.72	11.3	1.12	0.11	---	2.08	100.2
TL-27A	74.0	12.1	0.21	0.48	2.97	5.43	3.22	0.38	0.05	---	1.08	100.2
WHY-2	73.6	12.5	0.62	0.11	4.08	4.55	3.79	0.35	0.03	---	0.31	100.2

SAMPLE	RB	SR	Y	ZR	NB	BA
C-9	190	10	50	610	30	1280
C-10	10	230	20	140	30	200
C-12	60	160	40	220	40	380
C-13	20	220	30	160	30	260
D-42	220	40	110	580	70	320
D-138	150	160	130	1160	70	1060
DT-9	180	70	70	650	50	1120
DT-24	160	50	120	640	40	1100
F-35	150	160	70	460	30	830
F-46	70	190	70	570	60	610
F-180	50	250	40	300	30	630
F-248	60	200	70	370	20	510
F-256	30	260	30	170	20	360
F-278	140	40	90	580	50	1130
F-289	30	310	20	210	30	630
GM-52	170	200	100	660	50	1050
MI-28	50	50	20	340	40	540
MI-40	100	140	40	810	40	1400
ML-1	120	30	60	600	60	1550
ML-12	190	80	80	650	40	1140
ML-32	SMPMISS	SMPMISS	SMPMISS	SMPMISS	SMPMISS	SMPMISS
ML-34	70	230	40	280	50	730
ML-37	50	350	10	60	10	390
NL-3	50	710	30	150	30	360
PM-1	100	130	60	510	60	850
PM-2	170	90	80	520	40	1170
SB-28	30	160	30	620	40	360
TL-13	20	210	20	60	20	100
TL-27A	130	40	40	600	50	1440
WHY-2	110	80	60	570	40	1350

X-RAY ASSAY LABORATORIES LIMITED

1885 LESLIE STREET, DON MILLS, ONTARIO M3B 3J4

PHONE 416-445-5755 TELEX 06-986947

CERTIFICATE OF ANALYSIS

TO: UNIVERSITY OF MINNESOTA
ATTN: J.C. GREEN
GEOLOGY DEPT-LITHOCHEMISTRY
DULUTH, MINNESOTA 55812
USA

CUSTOMER NO. 1088

DATE SUBMITTED
11-APR-85

REPORT 24255

REF. FILE 19752-E4

9 C.PULPS,20 PULPS P.O. Q-173232 PROJ. LGC

WERE ANALYSED AS FOLLOWS:

	METHOD	DETECTION LIMIT
AU PPB	NA	10.000
LI PPM	AA	10.000
BE PPM	DCP	10.000
B PPM	DCP	10.000
WRMAJ %	WR	0.010
SC PPM	NA	0.100
V PPM	DCP	10.000
CR PPM	NA	2.000
MN PPM	DCP	2.000
CO PPM	NA	1.000
NI PPM	DCP	1.000
CU PPM	DCP	0.500
ZN PPM	DCP	0.500
GE PPM	DCP	10.000
AS PPM	NA	2.000
SE PPM	NA	3.000
BR PPM	NA	1.000
WRMIN PPM	WR	10.000
MO PPM	NA	5.000
AG PPM	DCP	0.500
CD PPM	DCP	0.200
SB PPM	NA	0.200
CS PPM	NA	0.500
LA PPM	NA	0.500
CE PPM	NA	3.000
ND PPM	NA	5.000
SM PPM	NA	0.100
EU PPM	NA	0.200
YB PPM	NA	0.200
LU PPM	NA	0.050

No

	METHOD	DETECTION LIMIT
HF PPM	NA	1.000
TA PPM	NA	1.000
W PPM	NA	3.000
PB PPM	DCP	2.000
BI PPM	DCP	0.500
TH PPM	NA	0.500
U PPM	NA	0.500

X-RAY ASSAY LABORATORIES LIMITED

DATE 16-MAY-85

CERTIFIED BY ....

SAMPLE	AU PPB	LI PPM	BE PPM	B PPM	SC PPM	V PPM
C-9	<10	20	<10	40	3.8	22
C-10	10	20	<10	50	32.0	270
C-12	<10	20	<10	60	39.0	380
C-13	<10	10	<10	40	37.0	270
D-42	<10	10	<10	50	6.5	52
D-138	<10	10	<10	50	18.0	22
DT-9	<10	40	<10	50	7.2	4
DT-24	<10	10	<10	50	9.3	14
F-35	<10	30	<10	40	14.0	62
F-46	20	10	<10	50	26.0	8
F-180	<10	20	<10	60	33.0	360
F-248	<10	20	<10	50	29.0	260
F-256	<10	10	<10	50	31.0	290
F-278	10	20	<10	40	4.7	20
F-289	<10	30	<10	50	29.0	290
GM-52	<10	10	<10	50	7.7	10
MI-28	<10	40	<10	50	11.0	68
MI-40	<10	20	<10	40	3.9	4
ML-1	<10	10	<10	40	4.9	6
ML-12	<10	10	<10	50	7.8	10
ML-32	SMP MISS	SMP MISS	SMP MISS	SMP MISS	SMP MISS	SMP MISS
ML-34	80	10	<10	70	25.0	260
ML-37	<10	20	<10	60	33.0	270
NL-3	<10	20	<10	100	15.0	180
PM-1	<10	20	<10	60	23.0	22
PM-2	<10	20	<10	40	6.1	12
SB-28	<10	10	<10	70	41.0	750
TE-13	<10	10	<10	50	34.0	250
TL-27A	<10	10	<10	40	4.1	6
WHY-2	<10	<10	<10	40	3.7	4

SMP.MISS. - SAMPLE WAS NOT RECEIVED AT XRAL

SAMPLE	CR PPM	MN PPM % MnO	CO PPM	NI PPM	CU PPM	ZN PPM
C-9	2	280	2	5	20.0	170.
C-10	~~280~~ 200	1000	50	150	67.0	110.
C-12	45	930	44	52	85.0	140.
C-13	~~260~~ 130	1100	48	67	100.	120.
D-42	33	540	8	17	100.	190.
D-138	<2	1900	6	10	59.0	290.
DT-9	6	570	5	3	16.0	140.
DT-24	<2	1000	3	4	16.0	140.
F-35	<2	880	9	6	91.0	120.
F-46	~~100~~ <10	1700	18	8	220.	240.
F-180	23	1400	40	38	40.0	190.
F-248	~~110~~ 40	1300	37	53	110.	140.
F-256	100	1000	45	110	120.	130.
F-278	<2	310	2	5	20.0	110.
F-289	~~120~~ 40	1200	31	38	64.0	140.
GM-52	<2	600	3	4	14.0	110.
MI-28	15	530	8	19	430.	78.0
MI-40	3	520	2	3	19.0	160.
ML-1	5	480	2	4	6.5	130.
ML-12	<2	460	2	4	25.0	150.
ML-32	SMP MISS	SMP MISS	SMP MISS	SMP MISS	SMP MISS	SMP MISS
ML-34	~~100~~ 10	1200	33	32	96.0	170.
ML-37	~~380~~ 300	890	40	160	5.0	98.0
NL-3	18	680	25	39	190.	93.0
PM-1	~~80~~ <10	1400	21	9	82.0	210.
PM-2	~~180~~ <10	380	4	10	33.0	96.0
SB-28	24	1600	56	43	140.	220.
TL-13	330	990	48	250	94.0	83.0
TL-27A	4	270	2	4	25.0	110.
WHY-2	<2	400	2	4	20.0	110.

↑ Corr. values 18 July

SMP.MISS. - SAMPLE WAS NOT RECEIVED AT XRAL

SAMPLE	GE PPM	AS PPM	SE PPM	BR PPM	MO PPM	AG PPM
C-9	<10	6	<3	1	<5	<0.5
C-10	<10	<2	<3	<1	<5	<0.5
C-12	<10	<2	<3	<1	<5	<0.5
C-13	<10	<2	<3	<1	<5	<0.5
D-42	<10	7	<3	1	<5	<0.5
D-138	<10	5	3	1	5	<0.5
DT-9	<10	12	<3	<1	<5	<0.5
DT-24	<10	<4	<3	<1	7	<0.5
F-35	<10	4	<3	2	<5	<0.5
F-46	<10	4	<3	<1	<5	<0.5
F-180	10	<2	<3	<1	<5	<0.5
F-248	<10	<2	<3	<1	<5	<0.5
F-256	<10	<2	<3	<1	<5	<0.5
F-278	10	<2	<3	2	<5	<0.5
F-289	<10	<2	<3	<1	<5	<0.5
GM-52	<10	4	<3	1	<5	<0.5
MI-28	<10	<2	<3	1	<5	<0.5
MI-40	<10	<2	<3	<1	<5	<0.5
ML-1	<10	<2	<3	<1	<5	<0.5
ML-12	<10	7	<4	1	<5	<0.5
ML-32	SMP MISS	SMP MISS	SMP MISS	SMP MISS	SMP MISS	SMP MISS
ML-34	<10	3	<3	1	<5	<0.5
ML-37	<10	5	<3	1	<5	<0.5
NL-3	<10	<2	<3	<1	<5	<0.5
PM-1	<10	3	<3	1	<5	<0.5
PM-2	<10	<2	<3	<1	<5	<0.5
SB-28	<10	2	<3	<1	<5	<0.5
TL-13	<10	8	<3	<1	<5	<0.5
TL-27A	<10	<2	<3	<1	<5	<0.5
WHY-2	<10	<2	<3	1	<5	<0.5

SMP.MISS. - SAMPLE WAS NOT RECEIVED AT XRAL

SAMPLE	CD PPM	SB PPM	CS PPM	LA PPM	CE PPM	ND PPM
C-9	<0.2	0.3	3.1	54.8	134	44
C-10	<0.2	<0.2	2.3	19.5	88	19
C-12	<0.2	<0.2	1.6	28.7	69	33
C-13	<0.2	<0.2	2.0	25.5	59	29
D-42	<0.2	1.2	1.9	102.	214	89
D-138	<0.2	1.0	7.7	91.5	199	101
DT-9	<0.2	0.8	2.2	84.9	206	60
DT-24	<0.2	0.7	2.5	111.	256	100
F-35	<0.2	0.5	3.3	76.7	161	74
F-46	<0.2	0.2	3.0	68.1	165	70
F-180	<0.2	<0.2	<0.5	47.6	104	50
F-248	<0.2	<0.2	<0.5	40.4	94	44
F-256	<0.2	<0.2	2.3	28.8	58	28
F-278	<0.2	<0.2	2.0	145.	225	106
F-289	<0.2	<0.2	<0.6	37.9	83	33
GM-52	<0.2	0.6	1.5	87.9	198	70
MI-28	<0.2	0.2	<0.6	35.4	74	38
MI-40	<0.2	<0.2	1.2	92.8	221	67
ML-1	<0.2	0.2	2.7	56.3	138	43
ML-12	<0.2	0.6	1.4	97.6	195	90
ML-32	SMP MISS	SMP MISS	SMP MISS	SMP MISS	SMP MISS	SMP MISS
ML-34	<0.2	0.2	1.7	46.1	100	43
ML-37	<0.2	0.2	4.1	7.7	23	11
NL-3	<0.2	<0.2	2.8	24.2	53	27
PM-1	<0.2	0.2	2.1	67.8	146	69
PM-2	<0.2	0.3	2.0	70.8	152	59
SB-28	<0.2	<0.2	2.4	19.7	45	22
TL-13	<0.2	0.3	<0.7	6.9	18	10
TL-27A	<0.2	<0.2	1.2	38.0	220	30
WHY-2	<0.2	0.2	<1.0	59.7	141	68

SMP.MISS. - SAMPLE WAS NOT RECEIVED AT XRAL

SAMPLE	SM PPM	EU PPM	YB PPM	LU PPM	HF PPM	TA PPM
C-9	8.6	1.1	6.9	1.05	17	1
C-10	4.2	1.5	2.3	0.43	3	<1
C-12	7.5	2.1	4.2	0.68	5	<1
C-13	6.9	1.5	3.8	0.53	5	<1
D-42	20.8	1.3	11.0	1.74	16	2
D-138	22.3	4.7	13.3	2.15	27	3
DT-9	12.3	1.8	8.2	1.24	18	2
DT-24	21.0	3.4	14.0	2.00	24	2
F-35	14.5	2.9	7.4	1.10	13	<1
F-46	17.2	4.2	9.9	1.52	15	3
F-180	10.7	3.3	5.0	0.76	7	1
F-248	10.5	2.3	6.6	1.05	9	2
F-256	6.0	1.9	3.1	0.53	4	<1
F-278	19.0	2.5	8.8	1.26	15	2
F-289	7.3	1.6	3.4	0.54	5	<1
GM-52	15.0	2.2	8.7	1.36	22	2
MI-28	6.8	1.0	3.7	0.60	9	1
MI-40	11.6	1.1	7.8	1.19	17	2
ML-1	8.0	1.4	5.6	0.99	23	2
ML-12	17.5	2.5	8.3	1.23	19	2
ML-32	SMP MISS	SMP MISS	SMP MISS	SMP MISS	SMP MISS	SMP MISS
ML-34	9.0	2.0	3.6	0.61	6	<1
ML-37	2.4	1.5	1.7	0.26	1	<1
NL-3	5.8	2.3	1.9	0.36	4	<1
PM-1	15.6	3.2	7.7	1.13	12	2
PM-2	12.9	2.3	6.7	1.05	13	2
SB-28	5.3	1.9	4.4	0.70	15	<1
TL-13	2.6	0.8	1.6	0.27	2	<1
TL-27A	6.4	0.8	6.7	1.12	20	1
WHY-2	13.8	2.3	5.7	0.85	16	1

SMP.MISS. - SAMPLE WAS NOT RECEIVED AT XRAL

SAMPLE	W PPM	PB PPM	BI PPM	TH PPM	U PPM
C-9	<3	16	<0.5	12.0	2.5
C-10	<3	28	<0.5	1.4	0.5
C-12	<3	32	<0.5	4.2	0.8
C-13	3	28	<0.5	2.8	0.6
D-42	3	36	<0.5	20.0	6.3
D-138	<3	50	<0.5	16.0	4.3
DT-9	<3	12	<0.5	15.0	3.6
DT-24	<12	22	<0.5	17.0	7.8
F-35	<3	24	<0.5	12.0	2.9
F-46	<3	30	<0.5	9.2	2.6
F-180	<3	30	<0.5	4.2	1.0
F-248	<3	26	<0.5	6.3	1.5
F-256	<3	26	<0.5	2.8	<0.5
F-278	<3	26	<0.5	17.0	3.3
F-289	<3	26	<0.5	3.9	0.6
GM-52	<3	26	<0.5	16.0	2.5
MI-28	<3	16	<0.5	9.1	3.5
MI-40	<3	10	<0.5	17.0	3.6
ML-1	<3	12	<0.5	10.0	3.3
ML-12	3	24	<0.5	16.0	3.3
ML-32	SMP MISS	SMP MISS	SMP MISS	SMP MISS	SMP MISS
ML-34	<3	36	<0.5	5.8	1.7
ML-37	<3	26	<0.5	0.5	<0.5
NL-3	<3	28	<0.5	3.0	1.2
PM-1	3	30	<0.5	9.5	2.5
PM-2	<3	14	<0.5	13.0	3.9
SB-28	<3	32	<0.5	3.2	0.9
TL-13	<3	28	<0.5	0.5	<0.5
TL-27A	<3	12	<0.5	17.0	3.0
WHY-2	3	26	<0.5	8.0	2.7

SMP.MISS. - SAMPLE WAS NOT RECEIVED AT XRAL

```
X     X    RRRRR       A       LL
XX   XX    RR  RR     AAA      LL
 XX XX     RR   RR   AA AA     LL
  XXX      RR  RR   AA   AA    LL
  XXX      RRRRR    AAAAAAA    LL
 XX XX     RR  RR   AA   AA    LL
XX   XX    RR   RR  AA   AA    LLLLLLL
X     X    RR    R  AA   AA    LLLLLLL
```

XRF - WHOLE ROCK ANALYSIS

UNIVERSITY OF MINNESOTA
Attn: J.C. GREEN
GEOLOGY DEPT-LITHOCHEMISTRY
DULUTH, MINNESOTA 55812
USA

CUSTOMER No. 1088

DATE SUBMITTED
2-MAY-85

REPORT 24297   REF. FILE 19896   DATE REPORTED 22-MAY-85

XRF W. R. A. SUMS INCLUDE ALL ELEMENTS DETERMINED.
FOR SUMMATION ELEMENTS ARE CALCULATED AS OXIDES.

SAMPLE	SIO2	AL203	CAO	MGO	NA20	K20	FE203	MNO	TIO2	P205	CR203	LOI	SUM
AN-1	58.8	17.3	5.07	1.62	4.33	2.92	6.76	0.09	1.06	0.49	---	1.77	100.5
BAB-9	48.1	14.4	8.66	5.66	2.83	1.21	15.4	0.19	3.29	0.47	---	0.16	100.5
C-4	49.5	18.3	9.81	3.88	2.81	0.99	11.1	0.14	2.22	0.30	0.02	1.16	100.3
C-23	56.4	12.8	6.00	2.74	3.10	1.93	12.9	0.18	1.95	0.34	<0.01	1.16	99.6
CQ-1	51.0	15.1	7.68	2.77	3.36	1.67	13.7	0.14	3.21	0.52	---	1.00	100.3
CQ-2	49.1	14.7	8.87	5.54	2.72	0.81	15.3	0.19	2.21	0.27	---	0.47	100.3
D-25	50.1	17.2	9.66	3.93	2.96	1.10	12.0	0.15	2.40	0.46	---	0.31	100.4
D-62	47.5	12.3	8.71	4.38	2.11	1.21	15.8	0.26	3.97	0.68	---	3.08	100.1
D-128	49.8	12.6	5.05	3.31	2.94	2.53	17.6	0.23	4.19	0.57	---	1.23	100.3
D-130	48.2	15.7	11.2	7.14	2.53	0.42	12.6	0.18	0.91	0.11	---	1.47	100.5
DG-37	43.1	1.87	13.5	13.8	0.29	0.02	22.0	0.31	4.54	0.03	0.06	0.08	99.6
DG-51	26.3	2.55	2.17	16.7	0.17	0.05	35.8	0.39	16.7	0.03	---	-0.77	100.2
F-92	55.2	13.5	5.86	3.99	3.01	1.74	11.1	0.20	2.09	0.31	---	2.93	100.1
F-125A	72.3	11.5	0.64	0.37	1.98	6.60	5.24	0.06	0.42	0.05	0.54	0.70	100.7
F-237	53.5	10.6	6.58	0.44	3.19	1.78	18.7	0.34	1.64	0.27	---	3.08	100.3
F-275	47.7	15.7	7.80	5.21	2.78	0.79	16.3	0.19	2.32	0.21	0.04	1.00	100.1
GP-47	60.5	13.1	4.22	1.23	3.68	3.16	9.92	0.12	1.33	0.27	---	2.23	100.0
H-15	75.0	11.7	0.14	0.21	3.68	4.61	3.20	0.03	0.32	0.03	---	0.70	99.8
KL-1	49.1	23.0	10.2	3.24	3.34	0.66	9.12	0.11	1.15	0.37	---	-0.23	100.1
MCC-13	58.0	12.7	4.11	1.66	3.02	3.95	12.4	0.14	1.69	0.53	---	1.77	100.2
MI-26	73.3	12.1	0.43	0.43	3.16	5.56	3.41	0.09	0.32	0.03	---	1.08	100.2
NL-2	66.2	14.9	1.70	1.10	4.60	2.57	6.81	0.10	0.55	0.09	---	1.23	100.1
PD-1	41.6	0.62	0.53	42.9	0.10	0.01	8.22	0.13	0.02	0.01	---	5.08	99.7
PW-5B	47.1	16.1	9.72	4.60	2.74	0.61	15.7	0.15	3.12	0.19	---	0.00	100.1
SB-105	65.6	12.3	2.63	0.42	4.64	3.30	9.42	0.13	0.80	0.11	---	0.85	100.5
T-65	49.3	16.3	9.72	5.15	2.67	0.62	12.7	0.16	1.71	0.24	---	1.62	100.3
T-86	49.8	13.0	8.05	4.98	2.57	0.98	15.4	0.18	2.62	0.30	<0.01	2.54	100.5
T-96	59.2	12.6	5.02	1.89	3.37	2.01	11.9	0.18	1.96	0.72	---	1.47	100.5
VC-226-7C	48.5	12.3	7.19	3.62	2.75	1.66	17.5	0.18	4.24	0.58	---	0.93	99.6
VC-227-4	66.0	14.9	0.82	2.97	2.73	2.27	6.73	0.06	0.68	0.14	---	2.77	100.2

SAMPLE	CR	RB	SR	Y	ZR	NB	BA
AN-1	20	70	730	20	220	20	1230
BAB-9	130	50	190	20	280	40	350
C-4	140	40	260	20	160	40	260
C-23	30	50	240	30	230	50	570
CQ-1	10	70	430	40	310	40	480
CQ-2	90	30	230	10	150	30	320
D-25	60	40	240	40	290	40	290
D-62	70	40	150	50	390	40	350
D-128	30	70	350	50	380	40	900
D-130	190	20	140	10	50	30	140
DG-37	520	<10	<10	20	40	30	50
DG-51	680	<10	<10	<10	70	50	150
F-92	60	40	260	30	210	20	620
F-125A	≤10	190	70	70	680	50	1380
F-237	10	60	190	80	490	50	620
F-275	300	40	210	30	180	20	240
GP-47	20	110	300	80	570	30	820
H-15	20	160	50	90	600	60	780
KL-1	10	20	350	20	100	30	180
MCC-13	10	120	120	100	720	50	760
MI-26	10	190	70	280	530	70	1090
NL-2	20	90	430	70	660	60	900
PD-1	2990	10	<10	<10	<10	10	130
PW-5B	20	30	300	10	100	20	210
SB-105	10	90	150	110	730	70	1110
T-65	90	10	290	20	150	20	280
T-86	50	30	210	30	250	20	340
T-96	10	60	310	50	350	50	800
VC-226-7C	30	60	320	40	360	50	480
VC-227-4	140	70	250	20	120	20	620

X-RAY ASSAY LABORATORIES LIMITED

1885 LESLIE STREET, DON MILLS, ONTARIO M3B 3J4

PHONE 416-445-5755 TELEX 06-986947

CERTIFICATE OF ANALYSIS

TO: UNIVERSITY OF MINNESOTA
ATTN: J.C. GREEN
GEOLOGY DEPT-LITHOCHEMISTRY
DULUTH, MINNESOTA 55812
USA

CUSTOMER NO. 108

DATE SUBMITTED
23-MAY-85
(2 may)

REPORT 24451

REF. FILE 20020-PH

30 PULPS P.O. Q175870 PROJ. LGC

WERE ANALYSED AS FOLLOWS:

	METHOD	DETECTION LIMIT
AU PPB	NA	10.000
SC PPM	NA	0.100
CO PPM	NA	1.000
NI PPM	DCP	1.000
CU PPM	DCP	0.500
ZN PPM	DCP	0.500
AS PPM	NA	2.000
SE PPM	NA	3.000
BR PPM	NA	1.000
MO PPM	NA	5.000
AG PPM	DCP	0.500
CD PPM	DCP	0.200
SB PPM	NA	0.200
CS PPM	NA	0.500
LA PPM	NA	0.500
CE PPM	NA	3.000
ND PPM	NA	5.000
SM PPM	NA	0.100
EU PPM	NA	0.200
YB PPM	NA	0.200
LU PPM	NA	0.050
HF PPM	NA	1.000
TA PPM	NA	1.000
W PPM	NA	3.000
PB PPM	DCP	2.000
BI PPM	DCP	0.500
TH PPM	NA	0.500
U PPM	NA	0.500

X-RAY ASSAY LABORATORIES LIMITED

DATE 14-JUN-85

CERTIFIED BY ....

SAMPLE	AU PPB	SC PPM	CO PPM	NI PPM	CU PPM
AN-1	10	13.0	16	20	69.0
BAB-9	10	37.0	55	130	310.
C-4	50	27.0	35	79	220.
C-23	<10	32.0	30	30	120.
CQ-1	20	27.0	39	49	390.
CQ-2	<10	39.0	54	110	250.
D-25	<10	29.0	35	73	220.
D-62	<10	42.0	44	83	420.
D-128	10	30.0	48	73	540.
D-130	<10	42.0	51	130	170.
DG-37	20	100.	100	410	2200.
DG-51	30	40.0	170	3	82.0
F-92	<10	32.0	40	39	99.0
F-125A	10	4.6	1	6	6.5
F-237	<10	33.0	8	440	910.
F-275	10	21.0	57	100	200.
GP-47	10	15.0	11	11	120.
H-15	<10	2.3	37	3	7.0
KL-1	<10	6.2	33	76	210.
MCC-13	<10	21.0	15	5	120.
MI-26	<10	2.3	3	4	10.0
NL-2	10	7.1	2	6	16.0
PD-1	<10	9.4	1	2500	8.0
PW-5B	<10	32.0	51	160	51.0
SB-105	10	11.0	3	3	16.0
T-65	<10	31.0	50	120	120.
T-86	10	41.0	48	45	200.
T-96	<10	26.0	21	6	26.0
VC-226-7C	70	32.0	52	85	390.
VC-227-4	10	18.0	21	67	53.0

SAMPLE	ZN PPM	AS PPM	SE PPM	BR PPM	MO PPM
AN-1	110.	<2	<3	1	<5
BAB-9	180.	2	3	2	<5
C-4	140.	3	<3	<1	<5
C-23	170.	11	<3	2	5
CQ-1	220.	3	<3	<1	<5
CQ-2	160.	<2	<3	<1	<5
D-25	150.	2	<3	<1	<5
D-62	200.	2	<3	<1	<5
D-128	240.	3	<3	1	<5
D-130	130.	<2	<3	1	<5
DG-37	150.	<2	3	1	<5
DG-51	280.	<2	<3	<1	<5
F-92	150.	<2	<3	1	<5
F-125A	150.	15	<3	<1	<5
F-237	200.	<2	<3	<1	<5
F-275	160.	<2	<3	<1	<5
GP-47	180.	<2	5	<1	<5
H-15	76.0	2	4	<1	5
KL-1	96.0	<2	<3	<1	<5
MCC-13	140.	<2	<3	1	<5
MI-26	64.0	110	3	1	<5
NL-2	140.	<2	5	1	<5
PD-1	39.0	<2	<3	<1	<5
PW-58	170.	<2	<3	<1	<5
SB-105	170.	<2	<3	2	<5
T-65	130.	<2	<3	<1	<5
T-86	150.	2	<3	<1	<5
T-96	170.	<2	<3	1	<5
VC-226-7C	200.	5	3	3	<5
VC-227-4	110.	4	<3	2	<5

SAMPLE	AG PPM	CD PPM	SB PPM	CS PPM	LA PPM
AN-1	<0.5	<0.2	4.8	1.8	41.5
BAB-9	<0.5	<0.2	0.4	2.8	34.2
C-4	<0.5	<0.2	0.3	6.0	24.8
C-23	<0.5	<0.2	0.4	4.2	37.0
CQ-1	<0.5	<0.2	0.2	3.1	45.0
CQ-2	<0.5	<0.2	<0.2	2.4	19.7
D-25	<0.5	<0.2	0.3	2.4	33.5
D-62	<0.5	<0.2	0.6	<1.1	48.2
D-128	<0.5	<0.2	0.3	3.0	51.3
D-130	<0.5	<0.2	<0.2	<1.0	4.9
DG-37	1.5	<0.2	<0.2	<1.0	2.4
DG-51	0.5	<0.2	0.3	<0.5	1.2
F-92	<0.5	<0.2	<0.2	1.7	36.1
F-125A	<0.5	<0.2	0.8	3.4	74.4
F-237	<0.5	<0.2	<0.2	1.9	75.8
F-275	<0.5	<0.2	<0.2	2.2	20.0
GP-47	<0.5	<0.2	0.3	4.0	76.7
H-15	<0.5	<0.2	0.4	1.9	16.3
KL-1	<0.5	<0.2	<0.2	<0.6	19.1
MCC-13	<0.5	<0.2	0.5	1.4	72.3
MI-26	<0.5	<0.2	1.7	2.8	76.6
NL-2	<0.5	<0.2	0.3	1.8	105.
PD-1	0.5	<0.2	1.7	<0.5	<0.5
PW-5B	0.5	<0.2	0.2	2.5	16.1
SB-105	<0.5	<0.2	<0.2	1.6	90.2
T-65	<0.5	<0.2	<0.2	2.0	25.4
T-86	<0.5	<0.2	<0.2	<1.1	32.9
T-96	<0.5	<0.2	<0.2	1.6	61.4
VC-226-7C	<0.5	<0.2	0.2	4.7	54.8
VC-227-4	<0.5	<0.2	0.9	2.4	32.3

SAMPLE	CE PPM	ND PPM	SM PPM	EU PPM	YB PPM
AN-1	70	27	5.7	1.3	1.8
BAB-9	79	37	9.3	2.5	4.5
C-4	56	27	6.0	2.0	3.2
C-23	80	37	8.2	1.8	3.8
CQ-1	100	52	11.3	3.5	4.2
CQ-2	44	22	5.7	2.1	3.4
D-25	79	41	9.2	2.8	4.8
D-62	111	65	13.3	3.3	6.8
D-128	114	67	12.8	3.5	4.9
D-130	12	9	2.2	0.9	2.2
DG-37	15	11	3.8	0.9	2.8
DG-51	6	<5	0.6	0.3	1.0
F-92	74	33	7.3	2.2	3.6
F-125A	172	70	14.3	2.8	7.4
F-237	166	90	20.6	5.5	10.5
F-275	45	22	5.3	1.6	3.1
GP-47	157	75	16.0	3.0	6.2
H-15	225	14	4.7	0.7	9.3
KL-1	44	23	5.1	1.3	2.4
MCC-13	168	73	19.0	4.2	10.7
MI-26	290	84	23.9	2.9	14.9
NL-2	215	105	19.8	5.1	4.5
PD-1	<3	<5	<0.1	<0.2	<0.2
PW-5B	35	22	4.1	1.6	1.9
SB-105	193	94	20.1	4.8	11.8
T-65	55	24	5.6	1.7	2.9
T-86	75	44	8.6	2.2	5.0
T-96	125	59	11.7	3.3	4.3
VC-226-7C	117	62	13.4	4.3	5.3
VC-227-4	66	25	5.3	0.7	2.3

SAMPLE	LU PPM	HF PPM	TA PPM	W PPM
AN-1	0.29	4	<1	<3
BAB-9	0.73	7	<1	3
C-4	0.49	5	<1	<3
C-23	0.62	6	<1	<3
CQ-1	0.68	8	1	<3
CQ-2	0.50	4	<1	<7
D-25	0.74	6	<1	<3
D-62	1.05	10	1	<3
D-128	0.72	9	2	<3
D-130	0.37	2	<1	<3
DG-37	0.36	2	1	<3
DG-51	0.18	3	2	<3
F-92	0.53	5	<1	<3
F-125A	1.14	19	2	<3
F-237	1.65	13	3	<3
F-275	0.48	5	<1	<3
GP-47	0.99	15	2	<3
H-15	1.53	18	5	210
KL-1	0.38	2	1	<3
MCC-13	1.66	19	3	<3
MI-26	2.21	18	3	42
NL-2	0.65	17	4	<3
PD-1	<0.05	<1	<1	<3
PW-5B	0.27	3	<1	<3
SB-105	1.75	19	2	<3
T-65	0.46	4	<1	<3
T-86	0.78	7	2	<3
T-96	0.69	9	<1	<3
VC-226-7C	0.74	10	2	<3
VC-227-4	0.33	4	<1	<3

SAMPLE	PB PPM	BI PPM	TH PPM	U PPM
AN-1	28	0.5	6.4	2.1
BAB-9	10	0.5	6.5	1.6
C-4	8	<0.5	3.4	1.4
C-23	12	<0.5	7.2	2.0
CQ-1	8	<0.5	6.3	1.6
CQ-2	4	<0.5	2.3	<0.5
D-25	6	<0.5	4.6	1.6
D-62	8	<0.5	6.5	2.5
D-128	6	<0.5	6.9	2.3
D-130	<2	<0.5	0.5	<0.5
DG-37	10	1.0	<0.5	<0.5
DG-51	8	<0.5	<0.5	<0.5
F-92	8	<0.5	3.4	0.9
F-125A	22	<0.5	11.0	3.3
F-237	4	<0.5	6.9	1.8
F-275	6	<0.5	2.8	0.9
GP-47	14	<0.5	12.0	4.2
H-15	14	<0.5	19.0	3.3
KL-1	6	<0.5	1.9	0.5
MCC-13	14	<0.5	12.0	3.5
MI-26	14	0.5	20.0	4.3
NL-2	16	<0.5	16.0	1.6
PD-1	<2	<0.5	<0.5	<0.5
PW-5B	4	<0.5	1.9	<0.5
SB-105	6	<0.5	14.0	3.2
T-65	6	<0.5	2.3	<0.5
T-86	10	<0.5	4.2	0.9
T-96	10	<0.5	5.7	1.4
VC-226-7C	10	<0.5	7.2	2.3
VC-227-4	16	0.5	7.4	2.9

X-RAY ASSAY LABORATORIES LIMITED

1885 LESLIE STREET, DON MILLS, ONTARIO M3B 3J4

PHONE 416-445-5755 TELEX 06-986947

CERTIFICATE OF ANALYSIS

TO: UNIVERSITY OF MINNESOTA
ATTN: J.C. GREEN
GEOLOGY DEPT-LITHOCHEMISTRY
DULUTH, MINNESOTA 55812
USA

CUSTOMER NO. 1088

DATE SUBMITTED
18-JUL-85

REPORT 25030

REF. FILE 20572-D1

69 PULPS P.O. 0179213 PROJ. ONR-LOD

WERE ANALYSED AS FOLLOWS:

	METHOD	DETECTION LIMIT
Y PPM	XRF	3.000
ZR PPM	XRF	3.000
NB PPM	XRF	3.000
SN PPM	EMS	3.000
LA PPM	NA	0.100
CE PPM	NA	1.000
ND PPM	NA	3.000
SM PPM	NA	0.010
EU PPM	NA	0.050
TB PPM	NA	0.100
YB PPM	NA	0.050
LU PPM	NA	0.010
W PPM	NA	1.000
TH PPM	XRF	10.000

X-RAY ASSAY LABORATORIES LIMITED

DATE 13-AUG-85

CERTIFIED BY ....

NOTE: DETECTION LIMITS FOR Y, ZR, NB ARE
ELEVATED DUE TO SMALL SAMPLE SIZE.

SAMPLE	Y PPM	ZR PPM	NB PPM	SN PPM	LA PPM
BA-5	50	180	10	--	--
BAB-1	50	320	20	--	--
C-6	90	450	40	--	--
C-31	--	--	--	5	--
CQ-3	20	300	20	--	43.4
CQ-4	30	280	<10	--	--
CQ-5	40	270	20	--	--
CQ-6	30	310	30	--	--
CQ-8	20	270	30	--	--
D-40	60	400	20	--	--
D-103	60	610	30	--	--
D-108	60	370	20	--	46.0
D-112	40	180	<10	--	16.8
D-118	40	210	10	--	--
D-121	50	230	<10	--	--
D-125	30	150	10	--	--
D-138	--	--	--	5	--
D-152	40	180	<10	--	--
D-162	50	260	<10	--	--
D-170	--	--	--	--	75.2
DG-30	110	680	30	--	--
DG-65	70	390	20	--	--
DG-66	60	690	20	--	--
DT-11	--	--	--	3	--
DT-24	--	--	--	<3	--
ES-21	50	320	20	--	--
ES-22	60	310	10	--	--
ES-23	20	150	<10	--	--
ES-26	40	250	30	--	--
ES-27	40	320	20	--	--
ES-29	30	160	20	--	29.8
F-257	50	240	<10	--	--
F-267	50	260	<10	--	--
FBR-1	40	280	100	--	--
GBL-2	30	130	<10	--	--
GM-21	--	--	--	<3	--
GM-31	--	--	--	3	--
GP-11	20	270	20	--	--
GP-16	20	310	30	--	--
GP-24	10	290	30	--	--
GP-30	60	430	30	--	--
GP-60	40	280	10	--	--
GR-2	<10	310	20	--	--
I-13	--	--	--	3	--
KC-47	--	--	--	3	--
KC-60	--	--	--	3	--
LM-17A	--	--	--	3	--
LW-6	--	--	--	20	--
LW-8	--	--	--	25	--
LW-28	30	190	10	--	--

SAMPLE	Y PPM	ZR PPM	NB PPM	SN PPM	LA PPM
LW-56	40	200	<10	--	18.2
LW-57	20	80	<10	--	--
LW-58	30	170	<10	--	--
M-7129	30	120	<10	--	--
M-7268	30	120	<10	--	--
M-7359	40	230	20	--	--
M-7402	30	190	10	--	--
M-7671	10	50	<10	--	--
MC-1	--	--	--	3	--
MI-11	--	--	--	<3	--
ML-1	--	--	--	<3	--
PP-7	20	200	<10	--	--
PP-15	40	320	20	--	--
PP-34	30	100	<10	--	--
PP-35	40	240	10	--	--
PP-36	20	110	<10	--	--
VC-221-1A	--	--	--	--	52.3
WHY-2	--	--	--	<3	--
20-3-C	30	170	<10	--	--

SAMPLE	CE PPM	ND PPM	SM PPM	EU PPM	TB PPM
BA-5	--	--	--	--	--
BAB-1	--	--	--	--	--
C-6	--	--	--	--	--
C-31	--	--	--	--	--
CQ-3	96	53	11.3	3.26	1.3
CQ-4	--	--	--	--	--
CQ-5	--	--	--	--	--
CQ-6	--	--	--	--	--
CQ-8	--	--	--	--	--
D-40	--	--	--	--	--
D-103	--	--	--	--	--
D-108	106	55	12.9	3.39	2.2
D-112	42	23	5.63	1.80	1.0
D-118	--	--	--	--	--
D-121	--	--	--	--	--
D-125	--	--	--	--	--
D-138	--	--	--	--	--
D-152	--	--	--	--	--
D-162	--	--	--	--	--
D-170	172	85	20.4	4.11	3.2
DG-30	--	--	--	--	--
DG-65	--	--	--	--	--
DG-66	--	--	--	--	--
DT-11	--	--	--	--	--
DT-24	--	--	--	--	--
ES-21	--	--	--	--	--
ES-22	--	--	--	--	--
ES-23	--	--	--	--	--
ES-26	--	--	--	--	--
ES-27	--	--	--	--	--
ES-29	56	30	5.02	1.49	0.8
F-257	--	--	--	--	--
F-267	--	--	--	--	--
FBR-1	--	--	--	--	--
GBL-2	--	--	--	--	--
GM-21	--	--	--	--	--
GM-31	--	--	--	--	--
GP-11	--	--	--	--	--
GP-16	--	--	--	--	--
GP-24	--	--	--	--	--
GP-30	--	--	--	--	--
GP-60	--	--	--	--	--
GR-2	--	--	--	--	--
I-13	--	--	--	--	--
KC-47	--	--	--	--	--
KC-60	--	--	--	--	--
LM-17A	--	--	--	--	--
LW-6	--	--	--	--	--
LW-9	--	--	--	--	--
LW-28	--	--	--	--	--

SAMPLE	CE PPM	ND PPM	SM PPM	EU PPM	TB PPM
LW-56	43	25	5.99	1.96	1.1
LW-57	--	--	--	--	--
LW-58	--	--	--	--	--
M-7129	--	--	--	--	--
M-7268	--	--	--	--	--
M-7359	--	--	--	--	--
M-7402	--	--	--	--	--
M-7671	--	--	--	--	--
MC-1	--	--	--	--	--
MI-11	--	--	--	--	--
ML-1	--	--	--	--	--
PP-7	--	--	--	--	--
PP-15	--	--	--	--	--
PP-34	--	--	--	--	--
PP-35	--	--	--	--	--
PP-36	--	--	--	--	--
VC-221-1A	115	61	13.7	3.58	1.8
WHY-2	--	--	--	--	--
20-3-C	--	--	--	--	--

SAMPLE	YB PPM	LU PPM	W PPM	TH PPM
BA-5	--	--	--	<10
BAB-1	--	--	--	<10
C-6	--	--	--	<10
C-31	--	--	2	--
CQ-3	2.75	0.39	--	<10
CQ-4	--	--	--	<10
CQ-5	--	--	--	<10
CQ-6	--	--	--	<10
CQ-8	--	--	--	10
D-40	--	--	--	10
D-103	--	--	--	10
D-108	6.42	0.98	--	<10
D-112	3.34	0.50	--	<10
D-118	--	--	--	<10
D-121	--	--	--	<10
D-125	--	--	--	<10
D-138	--	--	3	--
D-152	--	--	--	<10
D-162	--	--	--	20
D-170	10.3	1.59	--	--
DG-30	--	--	--	<10
DG-65	--	--	--	<10
DG-66	--	--	--	20
DT-11	--	--	1	--
DT-24	--	--	1	--
ES-21	--	--	--	<10
ES-22	--	--	--	<10
ES-23	--	--	--	<10
ES-26	--	--	--	<10
ES-27	--	--	--	<10
ES-29	2.74	0.44	--	<10
F-257	--	--	--	20
F-267	--	--	--	<10
FBR-1	--	--	--	<10
GBL-2	--	--	--	<10
GM-21	--	--	1	--
GM-31	--	--	1	--
GP-11	--	--	--	<10
GP-16	--	--	--	10
GP-24	--	--	--	<10
GP-30	--	--	--	10
GP-60	--	--	--	<10
GR-2	--	--	--	10
I-13	--	--	1	--
KC-47	--	--	1	--
KC-60	--	--	1	--
LM-17A	--	--	1	--
LW-6	--	--	1	--
LW-8	--	--	1	--
LW-28	--	--	--	<10

SAMPLE	YB PPM	LU PPM	W PPM	TH PPM
LW-56	3.54	0.53	--	<10
LW-57	--	--	--	<10
LW-58	--	--	--	<10
M-7129	--	--	--	<10
M-7268	--	--	--	<10
M-7359	--	--	--	<10
M-7402	--	--	--	<10
M-7671	--	--	--	<10
MC-1	--	--	2	--
MI-11	--	--	1	--
ML-1	--	--	<1	--
PP-7	--	--	--	<10
PP-15	--	--	--	10
PP-34	--	--	--	<10
PP-35	--	--	--	10
PP-36	--	--	--	<10
VC-221-1A	5.06	0.78	--	--
WHY-2	--	--	3	--
20-3-C	--	--	--	<10

X-RAY ASSAY LABORATORIES LIMITED

1885 LESLIE STREET, DON MILLS, ONTARIO M3B 3J4

PHONE 416-445-5755 TELEX 06-986947

CERTIFICATE OF ANALYSIS

TO: UNIVERSITY OF MINNESOTA
ATTN: J.C. GREEN
GEOLOGY DEPT-LITHOCHEMISTRY
DULUTH, MINNESOTA 55812
USA

CUSTOMER NO. 1088

DATE SUBMITTED
25-JUN-85

REPORT 24776

REF. FILE 20307-S1

28 PULPS

WERE ANALYSED AS FOLLOWS:

	METHOD	DETECTION LIMIT
CR PPM	NA	10.000

X-RAY ASSAY LABORATORIES LIMITED

DATE 18-JUL-85

CERTIFIED BY ....

*** UNLESS INSTRUCTED OTHERWISE WE WILL DISCARD PULPS 180 DAYS ***
AND REJECTS 90 DAYS FROM DATE OF THIS REPORT

SAMPLE	CR PPM
ALN-1	40
BRL-1	<10
C-4	140
C-10	200
C-13	130
C-23	30
D-122	190
D-163	<10
D-176	170
DG-32	150
DG-37	520
DG-60	90
EM-1	10
F-46	<10
F-125A	<10
F-248	40
F-275	300
F-289	40
F-290	140
LM-9	20
M-7358	200
ML-34	10
ML-37	300
PM-1	<10
PM-2	<10
T-86	50
TH-63	40
3001-21.4	200

```
X      X     RRRRR          A          LL
XX    XX     RR   RR       AAA         LL
 XX  XX      RR    RR     AA AA        LL
  XXX        RR   RR     AA   AA       LL
  XXX        RRRRR       AAAAAAA       LL
 XX  XX      RR   RR     AA    AA      LL
XX    XX     RR    RR    AA    AA      LLLLLLL
X      X     RR     R    AA    AA      LLLLLLL
```

XRF - WHOLE ROCK ANALYSIS

UNIVERSITY OF MINNESOTA
Attn: J.C. GREEN
GEOLOGY DEPT-LITHOCHEMISTRY
DULUTH, MINNESOTA 55812
USA

CUSTOMER No. 1088

DATE SUBMITTED
18-JUL-85

REPORT 25134 REF. FILE 20585 DATE REPORTED 21-AUG-85

XRF W. R. A. SUMS INCLUDE ALL ELEMENTS DETERMINED.
FOR SUMMATION ELEMENTS ARE CALCULATED AS OXIDES.

SAMPLE	SIO2	AL2O3	CAO	MGO	NA2O	K2O	FE2O3	MNO	TIO2	P2O5	LOI	SUM
CD-6	47.2	11.9	7.63	4.13	3.10	1.24	16.9	0.20	5.13	0.40	0.85	98.8
D-126	53.9	12.2	4.96	2.24	3.35	3.32	15.3	0.18	2.45	0.90	0.62	99.6
KL-4	51.7	14.3	7.96	5.01	2.67	1.38	13.8	0.17	2.59	0.38	0.23	100.3
ML-32	77.2	10.5	0.48	0.30	2.74	4.80	3.04	---	0.29	0.03	0.62	100.4
ML-36	51.5	13.8	7.30	5.14	2.99	1.28	13.4	0.19	2.07	0.42	1.85	100.1
PW-1A	51.2	12.7	7.04	3.45	3.33	1.81	14.9	0.19	3.10	0.95	0.39	99.2
PW-6	70.8	12.7	1.09	0.44	3.92	5.10	4.82	---	0.42	0.04	0.47	100.1
TL-18	51.8	12.6	7.72	3.99	2.73	1.26	15.6	0.20	2.87	0.56	0.47	99.9
TL-114	48.5	15.7	9.31	6.34	2.91	0.94	11.9	0.16	1.62	0.18	2.08	99.7
TM-12	73.7	12.1	0.89	0.79	3.15	5.16	3.05	---	0.34	0.04	0.77	100.2
VC-230-3	50.6	12.9	3.70	4.34	2.30	1.67	15.2	0.24	3.43	0.58	4.23	99.3

SAMPLE	RB	SR	Y	ZR	NB	BA
CD-6	60	350	20	240	50	340
D-126	100	340	60	490	60	710
KL-4	<10	230	30	230	30	370
ML-32	130	30	60	620	40	2250
ML-36	20	310	40	190	30	430
PW-1A	70	260	60	430	60	510
PW-6	240	60	120	950	90	1070
TL-18	40	240	30	260	30	570
TL-114	20	250	20	130	30	200
TM-12	170	180	70	460	40	910
VC-230-3	60	160	50	320	20	590

X-RAY ASSAY LABORATORIES LIMITED

1885 LESLIE STREET, DON MILLS, ONTARIO M3B 3J4

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CERTIFICATE OF ANALYSIS

TO: UNIVERSITY OF MINNESOTA
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GEOLOGY DEPT-LITHOCHEMISTRY
DULUTH, MINNESOTA 55812
USA

CUSTOMER NO. 1088

DATE SUBMITTED
18-JUL-85

REPORT 25134

REF. FILE 20585-H4

11 PULPS P.O. Q179213 PROJ. DNR-LGC

WERE ANALYSED AS FOLLOWS:

	METHOD	DETECTION LIMIT
AU PPB	NA	10.000
LI PPM	AA	10.000
BE PPM	DCP	10.000
B PPM	DCP	10.000
WRMAJ %	WR	0.010
SC PPM	NA	0.100
V PPM	DCP	10.000
CR PPM	NA	2.000
MN PPM	DCP	2.000
CO PPM	NA	1.000
NI PPM	DCP	1.000
CU PPM	DCP	0.500
ZN PPM	DCP	0.500
GE PPM	DCP	10.000
AS PPM	NA	2.000
SE PPM	NA	3.000
BR PPM	NA	1.000
WRMIN PPM	WR	10.000
MO PPM	NA	5.000
AG PPM	DCP	0.500
CD PPM	DCP	0.200
SB PPM	NA	0.200
CS PPM	NA	0.500
LA PPM	NA	0.500
CE PPM	NA	3.000
ND PPM	NA	5.000
SM PPM	NA	0.100
EU PPM	NA	0.200
YB PPM	NA	0.200
LU PPM	NA	0.050

	METHOD	DETECTION LIMIT
HF PPM	NA	1.000
TA PPM	NA	1.000
W PPM	NA	3.000
PB PPM	DCP	2.000
BI PPM	DCP	0.500
TH PPM	NA	0.500
U PPM	NA	0.500

X-RAY ASSAY LABORATORIES LIMITED

DATE 21-AUG-85

CERTIFIED BY ....

NOTE: DETECTION LIMITS ARE VARIABLE
DUE TO THE NATURE OF SAMPLES.

SAMPLE	AU PPB	LI PPM	BE PPM	B PPM	SC PPM	V PPM
CD-6	<10	30	<10	30	41.0	500
D-126	<10	20	<10	40	26.0	130
KL-4	<10	30	<10	40	29.0	310
ML-32	<10	10	<10	10	1.8	<10
ML-36	<10	20	<10	50	34.0	330
PW-1A	<10	20	<10	30	31.0	220
PW-6	<10	10	<10	20	4.3	<10
TL-18	<10	20	<10	30	33.0	350
TL-114	<10	20	<10	40	36.0	300
TM-12	<10	20	<10	20	5.0	20
VC-230-3	<10	20	<10	40	47.0	310

SAMPLE	CR PPM	MN PPM	CO PPM	NI PPM	CU PPM	ZN PPM
CD-6	4	--	45	46	140.	260.
D-126	<2	--	28	15	170.	190.
KL-4	100	--	45	120	230.	160.
ML-32	6	300	<1	230	17.0	56.0
ML-36	96	--	45	85	48.0	170.
PW-1A	17	--	34	38	200.	190.
PW-6	<2	440	1	5	24.0	140.
TL-18	32	--	43	54	88.0	170.
TL-114	210	--	45	140	160.	130.
TM-12	11	310	3	16	24.0	90.0
VC-230-3	11	--	46	16	340.	59.0

SAMPLE	GE PPM	AS PPM	SE PPM	BR PPM	MO PPM	AG PPM
CD-6	<10	<2	<5	3	<5	<0.5
D-126	<10	<2	<4	2	<5	<0.5
KL-4	<10	<2	<3	<1	<5	<0.5
ML-32	<10	<2	<3	1	<5	<0.5
ML-36	<10	<2	<3	<1	<5	<0.5
PW-1A	<10	3	<3	2	<5	<0.5
PW-6	<10	<2	<8	1	<5	<0.5
TL-18	<10	<2	<3	<1	<5	<0.5
TL-114	<10	2	<3	1	<5	<0.5
TM-12	<10	<2	<8	1	<5	<0.5
VC-230-3	<10	4	3	<1	<5	<0.5

SAMPLE	CD PPM	SB PPM	CS PPM	LA PPM	CE PPM	ND PPM
CD-6	<0.2	0.7	2.3	33.4	76	39
D-126	<0.2	0.3	2.2	74.5	157	88
KL-4	<0.2	0.2	2.5	30.9	63	34
ML-32	<0.2	<0.2	1.2	86.8	169	69
ML-36	<0.2	<0.2	1.9	30.1	63	30
PW-1A	<0.2	0.3	3.8	67.2	145	87
PW-6	<0.2	0.2	1.8	120.	237	134
TL-18	<0.2	<0.2	<0.5	41.6	87	37
TL-114	<0.2	0.3	<0.5	14.1	35	18
TM-12	<0.2	0.4	2.1	87.6	174	67
VC-230-3	<0.2	2.3	2.7	43.6	91	58

SAMPLE	SM PPM	EU PPM	YB PPM	LU PPM	HF PPM	TA PPM
CD-6	9.0	2.2	3.4	0.47	6	1
D-126	17.7	3.0	6.4	0.90	12	2
KL-4	7.3	1.7	3.7	0.56	6	1
ML-32	14.1	2.3	7.5	1.00	16	<1
ML-36	7.0	1.3	2.8	0.44	4	<1
PW-1A	14.7	3.1	5.9	0.87	10	2
PW-6	21.5	2.9	10.0	1.38	23	3
TL-18	8.4	2.3	3.3	0.52	5	1
TL-114	4.4	1.1	2.9	0.35	3	<1
TM-12	13.7	1.3	5.9	0.86	13	2
VC-230-3	10.3	2.0	4.5	0.63	8	1

SAMPLE	W PPM	PB PPM	BI PPM	TH PPM	U PPM
CD-6	<3	14	0.5	3.6	1.5
D-126	<3	14	<0.5	9.5	3.9
KL-4	<3	14	<0.5	4.0	1.1
ML-32	<3	12	<0.5	9.6	2.5
ML-36	<3	12	<0.5	1.9	0.6
PW-1A	<3	16	<0.5	9.2	2.6
PW-6	3	24	<0.5	19.0	4.9
TL-18	<3	14	<0.5	3.6	0.5
TL-114	<3	10	<0.5	1.3	0.5
TM-12	3	18	<0.5	15.0	4.1
VC-230-3	<3	14	<0.5	6.2	2.5