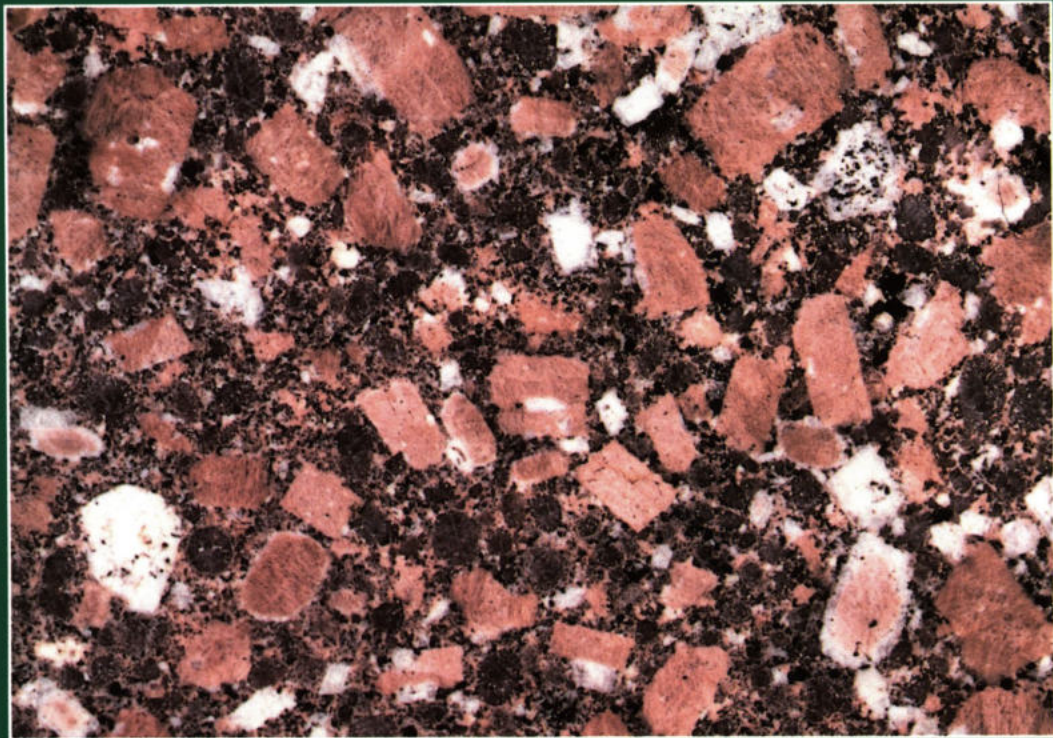




GEOLOGICAL SURVEY OF CANADA  
BULLETIN 436

**GEOLOGY, PETROGRAPHY, AND  
GEOCHEMISTRY OF APPALACHIAN  
GRANITES IN NEW BRUNSWICK AND  
GASPÉSIE, QUEBEC**

Joseph B. Whalen



1993



Energy, Mines and  
Resources Canada

Énergie, Mines et  
Ressources Canada

Canada

The map area which is bounded between 47°00' and 47°30' latitude and 66°15' and 67°00' longitude is divided into 15-minute grid squares...

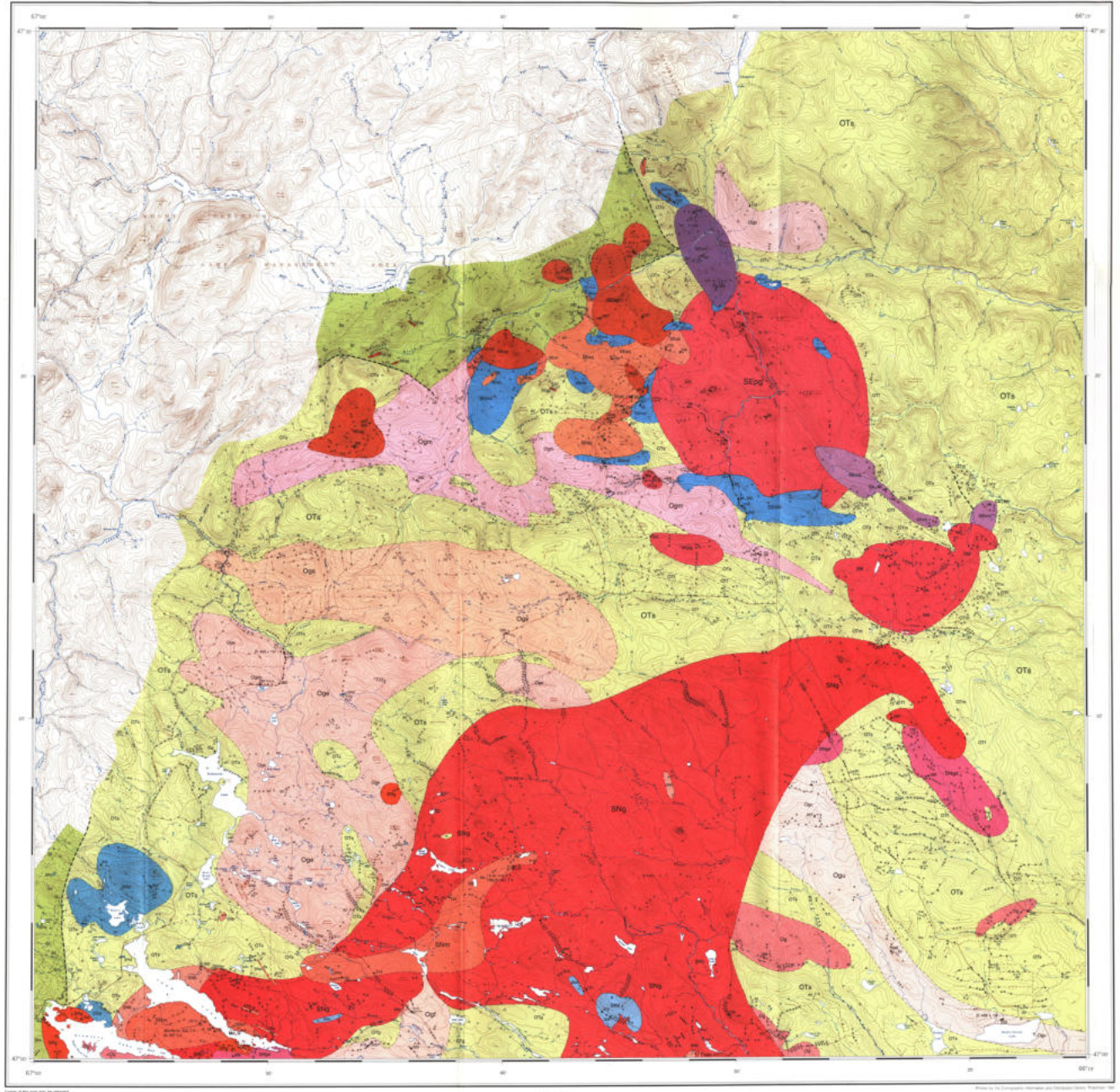
One of the largest intrusion bodies in the Central Plutonic Belt, the North Pole intrusion is a medium to coarse grained, oligoclase to biotite perthite...

Two north-trending bodies in the map area have been the subject of past and present work by the Geological Survey of Canada...

The Mount Elizabeth intrusive complex (SEB) is a large, irregularly shaped, medium to coarse grained, oligoclase to biotite perthite...

REFERENCES

1961. Lithologic and structural maps of the Mount Elizabeth intrusive complex, New Brunswick. Geological Survey of Canada, Paper 61-1.



LEGEND: PALEOZOIC SILLUITS TO EARLY DEVONIAN (less than 300 Ma or less of same age). NORTH POLE STRIKE SLIP GRANITE SUITE (NSP-S). MOUNT ELIZABETH INTRUSIVE COMPLEX (SEB-SEB).

MAP 1751A GEOLOGY OF A NORTHERN PORTION OF THE CENTRAL PLUTONIC BELT, NEW BRUNSWICK. Scale 1:100 000 - Échelle 1:100 000.

Geological Survey of Canada. Any enquiries or additional geological information from this map would be welcomed by the Geological Survey of Canada.



Contribution to Canada-New Brunswick Mineral Development Agreement 1984-1989, a subsidiary agreement under the Economic and Regional Development Agreement. Project funded by the Geological Survey of Canada

Contribution à l'Entente auxiliaire Canada/Nouveau-Brunswick sur l'Exploitation minière 1984-1989 faisant partie de l'Entente de développement économique et régional. Ce projet a été financé par la Commission géologique du Canada



Natural Resources and Energy  
New Brunswick

Ressources naturelles et Énergie  
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COOPERATION

COOPERATION  
AGREEMENT ON  
MINERAL DEVELOPMENT

ENTENTE DE  
COOPERATION SUR  
L'EXPLOITATION MINÉRALE

Contribution to Canada-New Brunswick Cooperation Agreement on Mineral Development 1990-1995, a subsidiary agreement under the Economic and Regional Development Agreement. Project funded by the Geological Survey of Canada.

Contribution à l'Entente de coopération Canada-Nouveau Brunswick sur l'exploitation minière 1990-1995 dans le cadre de l'Entente de développement économique et régional. Ce projet a été financé par la Commission géologique du Canada.

Canada

New Brunswick  
Nouveau Brunswick

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# GEOLOGY, PETROGRAPHY, AND GEOCHEMISTRY OF APPALACHIAN GRANITES IN NEW BRUNSWICK AND GASPÉSIE, QUEBEC

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## Abstract

All major Appalachian tectonostratigraphic zones in Gaspésie, Quebec and New Brunswick (i.e. Humber, Dunnage, Gander, and Avalon) are intruded by Paleozoic granites. Granite petrological and geochemical data assist in evaluating the economic potential of the plutons and provide insight into the crustal and tectonic evolution of the orogen.

Based on  $\text{Na}_2\text{O}$  and Al index values (generally  $>3.2$  wt.% and  $<1.1$  respectively) and high-field strength element contents, most of the granites are I-types; some have "A-type affinities". Granite chemical and isotopic characteristics distinguish three contrasting groups of granites: Humber-Dunnage, Gander, and Avalon. Positive  $\epsilon_{\text{Nd}}$  values for Humber, Dunnage, and Avalon granites indicate melting of predominately juvenile sources. Negative  $\epsilon_{\text{Nd}}$  and elevated  $^{207}\text{Pb}/^{204}\text{Pb}$  and  $\delta^{18}\text{O}$  values for Gander granites are consistent with reworking of older (1.1-1.8 Ga) crust containing a significant supracrustal component. Neodymium isotopic data effectively rules out Grenville basement as a source for Humber-Dunnage granites. Gander zone is apparently the autochthonous surface expression of a distinct lower crustal block. Contrasting  $\epsilon_{\text{Nd}}$  signatures from Avalon and Gander granites indicates that Gander and Avalon zones are underlain by different crustal blocks, i.e. Precambrian Avalon basement is not a suitable protolith for Gander granites.

## Résumé

Toutes les zones tectonostratigraphiques d'importance des Appalaches en Gaspésie (Québec) et au Nouveau-Brunswick (soit celles de Humber, de Dunnage, de Gander et d'Avalon) sont recoupées par des intrusions de granite paléozoïque. Les données pétrologiques et géochimiques sur les granites aident à évaluer le potentiel économique des plutons et renseignent sur l'évolution crustale et tectonique de l'orogène.

En se basant sur les valeurs des indices de  $\text{Na}_2\text{O}$  et d'Al (moyenne respective de  $>3,2$  et de  $<1,1$  % en poids) et les teneurs en éléments à forte intensité de champ, la plupart des granites sont de type I; certains ont des «affinités de type A». Les caractéristiques chimiques et isotopiques des granites permettent de les diviser en trois groupes distincts : Humber-Dunnage, Gander et Avalon. Les valeurs positives de  $\epsilon_{\text{Nd}}$  obtenues dans les granites de Humber, de Dunnage et d'Avalon indiquent que les roches originelles étaient principalement juvéniles. Les valeurs négatives de  $\epsilon_{\text{Nd}}$  ainsi que les rapports  $^{207}\text{Pb}/^{204}\text{Pb}$  et les valeurs de  $\delta^{18}\text{O}$  élevés caractérisant les granites de Gander correspondent à un remaniement de croûte plus ancienne (1,1 à 1,8 Ga) contenant une importante composante supracrustale. Les données sur la composition isotopique du néodyme montrent clairement que le socle de Grenville ne peut pas être la source des granites de Humber-Dunnage. La zone de Gander semble être l'expression à la surface d'un bloc autochtone distinct de croûte inférieure. Les signatures  $\epsilon_{\text{Nd}}$  contrastantes des granites d'Avalon et de Gander indiquent que les zones correspondantes reposent sur des blocs crustaux différents, c'est-à-dire que le socle précambrien d'Avalon ne peut pas être la roche originelle des granites de Gander.

## SUMMARY

Between 1983 and 1990, detailed geological, petrographic, geochemical, isotopic, and geochronological work was carried out by the author and co-workers on all Paleozoic granites in New Brunswick and Gaspésie, Quebec and their economic potential was evaluated. This report provides an overview or compilation of all work carried out on these granites and an interpretation of their implications for the evolution of the Appalachian orogen.

Prior to the past decade, Appalachian granitoid rocks received little attention, either in regional mapping studies or in models for the evolution of the orogen. However, in New Brunswick and Gaspésie, Quebec these igneous rocks intrude all four major tectonostratigraphic zones and form a major component of this orogenic belt. From northwest to southeast, these zones consist of: (1) Humber Zone, the western margin of Iapetus, deposited on the edge of the Grenville craton; (2) Dunnage Zone, allochthonous remnants of Iapetus ocean floor, arc and back-arc sequences; (3) Gander Zone, the eastern continental margin of Iapetus; and (4) Avalon Zone, a stable platform during the early Paleozoic. Because they exhibit distinctive, zone specific petrological characteristics, granites have been subdivided or grouped according to which of these zones they intrude.

Recent deep seismic transects across the Canadian Appalachian orogen have outlined three major lower crustal blocks (LCBs): Grenville, Central, and Avalon. The Grenville lower crustal block, interpreted as the tectonically overridden edge of the Grenville craton, underlies Humber Zone and western Dunnage Zone. Central lower crustal block, believed to be continental in composition, underlies eastern Dunnage Zone and Gander Zone, implying that Dunnage Zone oceanic sequences are allochthonous. It remains unresolved whether Gander Zone rocks are allochthonous or autochthonous with respect to Central lower crustal block. Avalon lower crustal block abuts Central lower crustal block along a steep vertical strike-slip fault corresponding to the surface trace of the Gander-Avalon Zone boundary. Avalon lower crustal block is considered to be autochthonous with respect to its cover rocks and basement to Avalon Zone. Of these three seismically defined lower crustal blocks, only Grenville can be studied directly. Basement to other zones has not been recognized. Granites as "probes" of their deep crustal sources are particularly valuable in "mapping" segments of orogenic belts (i.e. zones or terranes) with similar lower crustal signatures and in putting constraints on the nature and age of such seismically defined lower crustal blocks.

## SOMMAIRE

Entre 1983 et 1990, l'auteur et ses coéquipiers ont étudié en détail (géologie, pétrographie, géochimie, isotopes et géochronologie) tous les granites paléozoïques du Nouveau-Brunswick et de la Gaspésie (Québec), en plus d'en évaluer le potentiel économique. Le présent rapport donne une vue d'ensemble ou constitue une compilation de tous les travaux qui ont été réalisés sur ces granites; il explique aussi comment ces intrusions s'inscrivent dans l'évolution de l'orogène appalachien.

Avant la dernière décennie, les granitoïdes appalachiens avaient peu retenu l'attention, que l'on se réfère aux travaux de cartographie régionale ou aux modèles de l'évolution de l'orogène. Cependant, au Nouveau-Brunswick et en Gaspésie (Québec), ces roches ignées s'observent en intrusion dans les quatre principales zones tectonostratigraphiques et constituent une importante composante de cette ceinture orogénique. Du nord-ouest au sud-est, les zones sont les suivantes : 1) la zone de Humber, marge occidentale de l'océan Iapetus formée sur le bord du craton de Grenville; 2) la zone de Dunnage, restes allochtones des séquences d'arc et d'arrière-arc du plancher océanique de l'Iapetus; 3) la zone de Gander, marge continentale orientale de l'Iapetus; et 4) la zone d'Avalon, plate-forme stable associée au Paléozoïque précoce. Comme ils présentent des caractéristiques pétrologiques distinctes propres à chaque zone, les granites ont été subdivisés ou regroupés en tenant compte de la zone où ils ont fait intrusion.

Des transects récents de sismique profonde traversant l'orogène appalachien au Canada ont permis de délimiter trois grands blocs de croûte inférieure (LCBs), soit les blocs de Grenville, du Centre et d'Avalon. Le bloc de croûte inférieure de Grenville, interprété comme étant la bordure tectoniquement chevauché du craton de Grenville, repose sous la zone de Humber et sous la partie occidentale de la zone de Dunnage. Le bloc de croûte inférieure du Centre, de composition présumée continentale, se trouve sous la partie orientale de la zone de Dunnage et sous la zone de Gander, indiquant que les séquences océaniques de la zone de Dunnage sont allochtones. Il n'a pas encore déterminé si les roches de la zone de Gander sont allochtones ou autochtones par rapport au bloc de croûte inférieure du Centre. Le dernier bloc, celui d'Avalon, jouxte le bloc du Centre le long d'une faille de décrochement à pendage fort correspondant à la trace en surface de la limite des zones de Gander et d'Avalon. Le bloc de croûte inférieure d'Avalon est considéré comme étant autochtone par rapport aux roches qui le recouvrent et comme constituant le socle de la zone d'Avalon. De ces trois blocs définis par des méthodes sismiques, seul celui de Grenville peut être étudié directement. Il est aussi à noter que le socle des autres zones n'a pas été déterminé. L'utilisation des granites afin de «retracer» leurs sources crustales profondes est particulièrement valable pour «cartographier» les segments des ceintures orogéniques (zones ou terranes) où la croûte inférieure produit des signatures semblables, ainsi que pour délimiter la nature et l'âge de ces blocs de croûte inférieure définis à l'aide des méthodes sismiques.

## Nature of granite protoliths

Granites may be partial melts from mantle or juvenile (mantle-derived) material added to the lower crust by underplating or, at the other extreme, they may be derived wholly from older continental crust. A spectrum of variable degrees of interaction or mixing between juvenile (mantle) and crustal protoliths lies between these extremes. The close relationship which exists between mafic and felsic rocks in many Appalachian granites suites suggests that chemical variations reflect regional differences both in crustal lithologies involved in partial melting and in the degree of interaction between mantle and crustal melts. The most significant spatially-related geochemical and isotopic variations across the orogen occur in "jumps" corresponding to the Dunnage-Gander and Gander-Avalon boundaries. These jumps or steps can be interpreted as representing major crustal breaks where lower crustal blocks with different evolutionary histories have been tectonically juxtaposed. Each block or granite group will be discussed separately below.

1. Humber-Dunnage group: This group of Siluro-Devonian, metaluminous, amphibole-bearing intrusive rocks spans a compositional spectrum from gabbro to granite and forms a mafic magmatic association. According to genetic granite classifications, these granites were clearly derived from igneous or reworked mantle-derived (infra-crustal) protoliths. This conclusion is supported by their  $\delta^{18}\text{O}$ ,  $\epsilon_{\text{Nd}}$ , and  $^{207}\text{Pb}/^{204}\text{Pb}$  values which overlap those of mantle-derived magmas indicating supra-crustal rocks were not a significant source component.

Seismic data indicates that Humber granites are underlain by the Grenville lower crustal block and that there is a junction between Grenville and Central lower crustal blocks beneath the Dunnage Zone. Neodymium isotopic evidence effectively rules out Grenville basement as a significant source component and dictates an isotopically mantle-like igneous protolith of early Paleozoic age for Humber and Dunnage granites. It is possible that the Grenville lower crustal block is not all "Grenville-like", i.e. it is composite. An underplate, probably formed during the Iapetus Wilson cycle, would be a plausible source for Humber-Dunnage granites. Alternately, juvenile Humber-Dunnage granites might be melts of underthrust modified Paleozoic "oceanic" crust, on which the allochthonous Dunnage supracrustals were originally deposited, or its underlying metasomatized early Paleozoic mantle. Clearly, the granite data indicates that the crust beneath these zones is more complex than was suggested by the seismic interpretation. Future seismic interpretations, which take into account this granite study, may substantiate the existence of lower crustal layering or inhomogeneities beneath this area.

## Nature : roches originelles des granites

Les granites peuvent être constitués à l'origine des matériaux partiellement fondus provenant du manteau ou des matériaux juvéniles (dérivés du manteau) ajoutés à la croûte inférieure par subduction ou, à l'autre extrême, être entièrement issus d'une ancienne croûte continentale. Entre ces deux extrêmes, il existe des degrés variables d'interaction ou de mélange de roches originelles juvéniles (manteau) et crustales. Le lien étroit qui existe entre les roches mafiques et felsiques dans de nombreuses suites granitiques des Appalaches indique que les variations chimiques reflètent des différences régionales à la fois dans les lithologies crustales participant à la fusion partielle et dans le degré d'interaction entre les magmas du manteau et de la croûte. Les variations géochimiques et isotopiques les plus importantes qui caractérisent l'ensemble de l'orogène et qui présentent un lien spatial sont déterminées par des «sauts» correspondant aux limites entre les zones de Dunnage et de Gander de même qu'entre celles de Gander et d'Avalon. Ces sauts peuvent être interprétés comme la représentation de ruptures crustales importantes, où des blocs de croûte inférieure ayant évolué différemment ont été juxtaposés par des processus tectoniques. Chaque bloc ou groupe de granite sera traité séparément ci-dessous.

1. Groupe de Humber-Dunnage : Ce groupe de roches intrusives métalumineuses à amphibole datant du Siluro-Dévonien présente un spectre de composition variant du gabbro au granite; il forme une association magmatique mafique. Selon les classifications génétiques, ces granites sont nettement dérivés de roches originelles qui sont soit ignées, soit mantelliques remaniées (infracrustales). Cette conclusion est appuyée par les valeurs de  $\delta^{18}\text{O}$  et de  $\epsilon_{\text{Nd}}$  ainsi que par les rapports  $^{207}\text{Pb}/^{204}\text{Pb}$  caractérisant ces granites, lesquelles chevauchent celles qui sont associées aux magmas dérivés du manteau; ainsi, les roches supracrustales n'ont pas été une importante composante originelle.

Les données sismiques indiquent que les granites de Humber reposent sur le bloc de croûte inférieure de Grenville et qu'il existe une jonction entre les blocs de Grenville et du Centre au-dessous de la zone de Dunnage. Les données sur la composition isotopique du néodyme montrent clairement que le socle de Grenville ne peut pas être une des principales composantes originelles et que les granites de Humber et de Dunnage dériveraient de roches ignées du Paléozoïque précoce, isotopiquement semblables au manteau. Il est possible que le bloc de croûte inférieure de Grenville ne soit pas entièrement de type Grenville mais qu'il soit composite. Une plaque en subduction, formée probablement durant le cycle de Wilson de l'Iapetus, pourrait être une source possible des granites de Humber-Dunnage. Les granites juvéniles de Humber-Dunnage pourraient alternativement être le résultat de la fusion de la croûte «océanique» modifiée et sous-charriée du Paléozoïque, sur laquelle les roches supracrustales allochtones de Dunnage ont d'abord été déposées, ou provenir du manteau metasomatisé sous-jacent du Paléozoïque précoce. Les données sur les granites indiquent clairement que la croûte reposant sous ces zones est plus complexe que ne l'a révélé l'interprétation des données sismiques. Les interprétations sismiques qui tiendront compte de la présente étude sur les granites pourraient corroborer l'existence d'une stratification de la croûte inférieure ou l'absence d'homogénéité au-dessous de la région.

2. Gander group: This is a group of Ordovician and Siluro-Devonian, metaluminous to moderately per-aluminous, mainly felsic, biotite granites, which includes minor gabbroic and amphibole-bearing granodioritic rocks. It belongs to an alumino-cafemic magmatic association, derived from a mixture of supracrustal and mantle-derived source components. Elevated concentrations of high field strength elements in many Gander granites indicate affinities to A-type granites. Elevated  $\delta^{18}\text{O}$  values ( $8.7 \pm 1.0$ ) of Gander granites suggests that this alumino-cafemic suite does contain a significant supracrustal source component. Negative  $\epsilon_{\text{Nd}}$  and high  $^{207}\text{Pb}/^{204}\text{Pb}$  values as well as Proterozoic xenocrystic zircon data for Gander granites are consistent with reworking of old crust ( $T_{\text{DM}} = 1.1$  to 1.8 Ga).

$\epsilon_{\text{Nd}}$  values of Gander granites overlap the upper portion of the range reported from the Grenville province and some of their inherited zircons are of Grenville age. However, the distinctly lower  $^{207}\text{Pb}/^{204}\text{Pb}$  signature of North American Grenville basement versus Gander granites suggests that such basement is not a suitable protolith. Basement of Grenville age characterized by Pb isotopic characteristics differing from North American Grenville could be a possible source.

Although Precambrian Avalonian rocks and Gander granites have similar  $^{207}\text{Pb}/^{204}\text{Pb}$  signatures,  $\epsilon_{\text{Nd}}$  values in the Precambrian samples (+2 to -5) overlap only in their negative values the range in Gander granites. Whole rock geochemical data, like the Nd isotopic data, suggests that Gander granite sources had a restricted compositional range, were relatively homogeneous over a large area, and were essentially identical during Ordovician and Siluro-Devonian melting events.

As there is a complete overlap between Nd  $T_{\text{DM}}$  ages and U-Pb zircon inheritance ages (1.1 to 1.8 Ga) from Gander granites, the Nd model ages could be interpreted as true crustal residence or crust formation ages. However, the correlation between elevated  $\delta^{18}\text{O}$  values, per-aluminous character, and high  $^{207}\text{Pb}/^{204}\text{Pb}$  and  $\epsilon_{\text{Nd}}$  values in these granites may mean that they contain a significant supracrustal (possibly sedimentary) component. In this case,  $T_{\text{DM}}$  ages may only represent the average age of detrital components, not the age of the granite source.

2. Groupe de Gander : Ce groupe de granites à biotite principalement felsiques de l'Ordovicien et du Siluro-Dévonien est métalumineux à modérément hyperalumineux; il comprend un peu de roches gabbroïques et granodioritiques à amphibole et fait partie d'une association magmatique alumino-cafémiq, dérivée d'un mélange de composantes originelles supracrustales et mantelliques. Les concentrations élevées en éléments à forte intensité de champ obtenues dans de nombreux granites de Gander indiquent des affinités avec les granites de type A. Les valeurs élevées de  $\delta^{18}\text{O}$  ( $8,7 \pm 1,0$ ) associées à ces granites suggèrent que cette suite alumino-cafémiq contient en fait une importante composante originelle supracrustale. Les valeurs négatives de  $\epsilon_{\text{Nd}}$  et les rapports  $^{207}\text{Pb}/^{204}\text{Pb}$  élevés de même que les données sur les xénocristaux de zircon du Protérozoïque caractérisant les granites de Gander abondent dans le sens d'un remaniement de l'ancienne croûte ( $T_{\text{DM}} = 1,1$  à 1,8 Ga).

Les valeurs de  $\epsilon_{\text{Nd}}$  des granites de Gander chevauchent la partie supérieure de l'intervalle connu dans le cas de la province de Grenville et certains de leurs zircons hérités sont d'âge grenvillien. Toutefois, les signatures  $^{207}\text{Pb}/^{204}\text{Pb}$  nettement inférieures du socle de Grenville nord-américain par rapport aux granites de Gander laissent supposer que ce socle ne constitue pas une roche originelle appropriée. Le socle d'âge grenvillien, caractérisé par des valeurs de Pb isotopique différant de celles du Grenville nord-américain, pourrait être la roche originelle.

Même si les roches avaloniennes précambriennes et les granites de Gander donnent des signatures  $^{207}\text{Pb}/^{204}\text{Pb}$  semblables, les valeurs de  $\epsilon_{\text{Nd}}$  dans les échantillons précambriens (+2 à -5) ne chevauchent l'intervalle de signatures correspondant aux granites de Gander que dans les valeurs négatives. Les données géochimiques sur la roche entière, dont notamment celles sur la composition isotopique du Nd, indiquent que les roches originelles des granites de Gander avaient un intervalle limité de composition, étaient relativement homogènes sur une grande étendue et étaient essentiellement identiques tout au long des événements de fusion de l'Ordovicien et du Siluro-Dévonien.

Comme dans les granites de Gander, il y a chevauchement complet entre les âges  $T_{\text{DM}}$  du Nd et les âges U-Pb sur zircon hérité (entre 1,1 et 1,8 Ga), les âges modèles obtenus à partir du Nd pourraient être interprétés comme ceux correspondant vraiment au séjour dans la croûte ou à la formation de la croûte. Cependant, le caractère hyperalumineux de ces granites, leurs rapports  $^{207}\text{Pb}/^{204}\text{Pb}$  élevés et les grandes valeurs de  $\delta^{18}\text{O}$  et de  $\epsilon_{\text{Nd}}$  pourraient indiquer qu'ils contiennent une importante composante supracrustale (probablement sédimentaire). Dans ce cas, les âges  $T_{\text{DM}}$  ne peuvent que représenter l'âge moyen des composantes détritiques et non pas celui de la roche originelle du granite.

Available data suggests that anatexis of some uniform Proterozoic basement block is a more plausible method for generating Gander granites than any process which involves blending of Paleozoic supracrustal and mantle-derived melts. Derivation of these voluminous Ordovician to Devonian granites from similar, compositionally restricted sources suggests that there has been no major basement-cover displacements in Gander Zone since at least Middle Ordovician time. Based on this, Gander Zone is the surface expression of the Central lower crustal block and Gander granites represent the only available samples of this material. This Central lower crustal block remains enigmatic for it differs from Grenville or Avalonian basement.

3. Avalon group: This group of Siluro-Devonian, metaluminous, mainly felsic biotite±amphibole granites forms a calcic granite association derived from I-type (infracrustal) or mantle-derived sources. Some granites are peralkaline A-type granites and most others have some A-type affinities. However, their  $\delta^{18}\text{O}$  values (7.7-9.1), which are only slightly lower than those of Gander granites, may reflect the presence of a supracrustal component. Positive  $\epsilon_{\text{Nd}}(0.4 \text{ Ga})$  values indicate derivation from relatively young, juvenile sources, whereas elevated  $^{207}\text{Pb}/^{204}\text{Pb}$  signatures and xenocrystic zircon data indicate an ancient crustal component.

The juvenile Nd signature exhibited by both Siluro-Devonian and Precambrian Avalonian granites in New Brunswick is the same as that of Avalonian granites in Nova Scotia and Newfoundland. The Al index,  $^{207}\text{Pb}/^{204}\text{Pb}$ ,  $\epsilon_{\text{Nd}}$ , and  $\delta^{18}\text{O}$  characteristics of Avalon granites lie between those exhibited by the Humber-Dunnage and Gander groups. The Nd data show that the bulk of the protolith of Avalonian granites was juvenile or young, whereas O and Pb data may reflect incorporation into these granites of a minor supracrustal component, either at the source, or during magma ascent from the site of partial melting. These features, as well as inherited zircons, suggest the presence of a volumetrically minor Proterozoic supracrustal (sedimentary?) component in these granites.

Both Nd and Pb signatures of Avalonian granites are distinct from those of North American Grenville, effectively ruling out such basement as a significant source component. Neodymium data also rule out derivation of Gander and Avalonian granites from similar protoliths. In agreement with the seismic data, each zone can be inferred to be underlain by different types of basement. Siluro-Devonian Avalonian granites overlap Precambrian Avalonian basement only at the upper end of the range in  $\epsilon_{\text{Nd}}(0.4 \text{ Ga})$  values exhibited by basement. Either the granites were derived by melting of juvenile components of that basement, or they represent mixtures between Siluro-Devonian mantle-derived magmas and partial melts of less juvenile Avalonian basement. A petrogenetic model of basalt-driven partial melting is compatible with the latter scenario.

Selon les données recueillies, l'anatexis d'un bloc quelconque de socle protérozoïque uniforme serait un phénomène plus plausible pour expliquer la formation des granites de Gander que tout autre procédé par lequel sont mélangés des magmas supracrustaux et mantelliques du Paléozoïque. Le fait que ces granites volumineux de l'Ordovicien au Dévonien dérivent de sources semblables dont l'intervalle de composition est limité indique que dans la zone de Gander, il n'y a pas eu d'importants déplacements entre le socle et la couverture depuis au moins l'Ordovicien moyen. Il ressort de ce qui précède que la zone de Gander est l'expression à la surface du bloc de croûte inférieure du Centre et que les granites de Gander représentent les seuls échantillons disponibles de ce matériau. Le bloc du Centre demeure une énigme du fait qu'il est différent du socle grenvillien ou avalonien.

3. Groupe d'Avalon : Ce groupe siluro-dévonien de granites à biotite±amphibole principalement felsiques et métalumineux forme une association de granite calcique dérivée de roches originelles de type I (infracrustales) ou mantelliques. Certains granites sont des granites de types A hyperalkalins et les autres ont pour la plupart des affinités de type A. Cependant, leurs valeurs de  $\delta^{18}\text{O}$  (7,7 à 9,1), qui ne sont que légèrement inférieures à celles des granites de Gander, peuvent refléter la présence d'une composante supracrustale. Les valeurs positives de  $\epsilon_{\text{Nd}}(0,4 \text{ Ga})$  indiquent que les granites sont dérivés de roches juvéniles relativement récentes, tandis que les signatures  $^{207}\text{Pb}/^{204}\text{Pb}$  élevées et les données sur les xénoctaux de zircon révèlent une composante crustale ancienne.

La signature du Nd juvénile produite par les granites avaloniens tant siluro-dévonien que précambrien du Nouveau-Brunswick est la même que celle des granites avaloniens de la Nouvelle-Écosse et de Terre-Neuve. Dans les granites d'Avalon, les indices d'Al, les rapports  $^{207}\text{Pb}/^{204}\text{Pb}$  ainsi que les valeurs de  $\epsilon_{\text{Nd}}$  et de  $\delta^{18}\text{O}$  se situent entre celles obtenues dans les cas des granites des groupes de Humber-Dunnage et de Gander. Les données sur le Nd indiquent que l'ensemble de la roche originelle des granites avaloniens était juvénile ou récente, tandis que les données sur l'O et le Pb semblent indiquer l'incorporation d'une petite composante supracrustale dans ces granites, soit à la source ou durant l'ascension du magma à partir du site de fusion partielle. Ces éléments ainsi que les zircons hérités révèlent la présence d'une composante supracrustale (sédimentaire ?) protérozoïque de volume peu important dans ces granites.

Les signatures du Nd et du Pb dans les granites avaloniens se distinguent de celles des granites grenvilliens nord-américains, il devient clair que ce socle ne peut constituer une importante composante originelle. Les données sur le néodyme éliminent aussi la possibilité que les granites de Gander et d'Avalon proviennent des mêmes roches. En accord avec les données sismiques, il est possible d'inférer que chaque zone repose sur différents types de socle. Les granites d'Avalon du Siluro-Dévonien ne recouvrent le socle précambrien d'Avalon qu'à l'extrémité supérieure des valeurs de  $\epsilon_{\text{Nd}}(0,4 \text{ Ga})$  associées au socle. Les granites résultent soit de la fusion de composantes juvéniles de ce socle, soit d'un mélange de magmas mantelliques siluro-dévonien avec des roches du socle d'Avalon partiellement fondues et moins juvéniles. Un modèle pétrogénétique de fusion partielle où le basalte domine correspond au deuxième scénario.

The granite data suggests that the Avalon lower crustal block consists mainly of Late Proterozoic or younger crust with a minor pre-Middle Proterozoic crustal component. This basement block may have formed mainly during a late Proterozoic arc-type crust formation event.

### Tectonic models

The geology of the Canadian Appalachians is generally interpreted in terms of opening and closing of the Late Precambrian–Early Paleozoic Iapetus ocean. Because most granite plutonism in the orogen occurred during this Middle Ordovician to Early Devonian period, these rocks are particularly relevant to understanding the latter stages of Iapetus closure. Tectonic models which account for the granite magmatism can be split into two parts: Early to Middle Ordovician, and the Siluro-Devonian.

#### Early to Middle Ordovician

The Tetagouche Group and adjacent Fournier Group, a dismembered oceanic back-arc fragment, formed in different segments of the same Middle Ordovician back-arc basin. Ensialic arc volcanic rocks of the Meductic-Woodstock area, which are intruded by the probably consanguineous, late Arenigian Benton and Gibson stocks, are interpreted as remnants of the Early Ordovician part of the Taconic arc. As Iapetus closed by southeast-directed subduction, a back-arc basin opened behind the Taconic arc. Back-arc formation within a continental block was accompanied by crustal attenuation and partial melting, generating voluminous felsic magmatism. Within-plate signatures of both consanguineous Ordovician extrusive and plutonic rocks in Gander zone is compatible with this model. Granite isotopic signatures suggest that this rifted continental basement was neither of "Avalonian" or "Grenvillian" affinity, i.e. its provenance is enigmatic. Iapetus closure by southeast-directed subduction resulted in collision between the Taconic arc and Laurentia in the Caradocian.

#### Siluro-Devonian

Notable features of Silurian magmatic activity are its widespread distribution in the Canadian Appalachians, the diversity of magmatic types generated, and differences in metamorphic and tectonic overprinting, even in contiguous areas. This activity can not be adequately explained by models which consider all basin closure and major plate movements, other than transcurrent faulting, to be complete by Middle Ordovician time. According to a recent tectonic model, Iapetus closure and collision of the Taconic arc and Laurentia was followed by Late Ordovician to Early Silurian closure by northwest-directed subduction of an ensialic back-arc basin located behind the Taconic arc.

Les données sur les granites indiquent que le bloc de croûte inférieure d'Avalon est principalement constitué de matériel crustal du Protérozoïque tardif ou plus récent comportant une faible composante qui serait antérieure au Protérozoïque moyen. Il est possible que ce bloc de socle se soit formé principalement durant un épisode de formation de croûte de type arc au Protérozoïque tardif.

### Modèles tectoniques

La géologie des Appalaches canadiennes est généralement interprétée en fonction de l'ouverture et de la fermeture de l'océan Iapetus au Précambrien tardif-Paléozoïque. Étant donné que la majeure partie du plutonisme granitique de l'orogène a eu lieu durant la période de l'Ordovicien moyen au Dévonien précoce, ces roches sont particulièrement appropriées pour comprendre les dernières étapes de la fermeture de l'Iapetus. Les modèles tectoniques qui rendent compte du magmatisme granitique décrivent soit l'Ordovicien précoce à moyen, soit le Siluro-Dévonien.

#### Ordovicien précoce à moyen

Le Groupe de Tetagouche et le Groupe de Fournier adjacent, constituant un fragment d'arrière-arc océanique démembré, se sont formés dans différents segments du même bassin d'arrière-arc de l'Ordovicien moyen. Les roches volcaniques d'arc ensialique de la région de Meductic-Woodstock, recoupées par les stocks de Benton et de Gibson de l'Arenigien tardif qui sont peut-être comagmatiques, sont interprétées comme des restes de la partie de l'arc taconique associée à l'Ordovicien précoce. Pendant la fermeture de l'océan Iapetus par une subduction de direction sud-est, un bassin d'arrière-arc s'est ouvert derrière l'arc taconique. La formation de cet arrière-arc au sein d'un bloc continental a été accompagnée d'un amincissement de la croûte et d'une fusion partielle, ce qui s'est traduit par un magmatisme felsique impliquant d'importants volumes de matériel. Dans la zone de Gander, les signatures au sein de la plaque des roches comagmatiques tant extrusives que plutoniques de l'Ordovicien sont compatibles avec ce modèle. Les signatures isotopiques du granite indiquent que ce socle continental de divergence n'avait aucune affinité «avalonienne» ou «grenvillienne»; sa provenance demeure donc une énigme. La fermeture de l'Iapetus par une subduction vers le sud-est a causé une collision entre l'arc taconique et la Laurentie au Caradocien.

#### Siluro-Dévonien

Les caractéristiques importantes de l'activité magmatique silurienne sont les suivantes : grande étendue dans les Appalaches canadiennes, diversité des types magmatiques et différences au niveau de la surimpression tant métamorphique que tectonique, même dans les régions contiguës. Cette activité ne peut pas être bien expliquée par les modèles dans lesquels la fermeture du bassin et les déplacements majeurs de plaques autres que la formation de failles de coulissage sont considérés terminés à l'Ordovicien moyen. Selon un modèle tectonique récent, la fermeture de l'Iapetus et la collision de l'arc taconique et de la Laurentie ont été suivis par la fermeture d'un bassin d'arrière-arc ensialique situé derrière l'arc taconique, par un processus de subduction vers le nord-ouest qui a eu lieu de l'Ordovicien tardif au Silurien précoce.

Lithospheric delamination accompanying closure of Iapetus as well as its back-arc basin(s) would have brought hot asthenosphere against the base of the crust. Subsequent upward conductive heat loss and rapid cooling of the mantle asthenosphere would have produced regional high-temperature metamorphism, crustal melting and extensive, widespread synkinematic granites. Localized and temporal variations in tectonic regime (e.g. extensional, compressive, pre-existing major boundary faults) may, in part, account for emplacement of different petrological types of granites in different portions of the orogen. In addition, this study has clearly demonstrated that many granite characteristics reflect the tectonostratigraphic zone they intrude, i.e. they appear to be source-related rather than process-related.

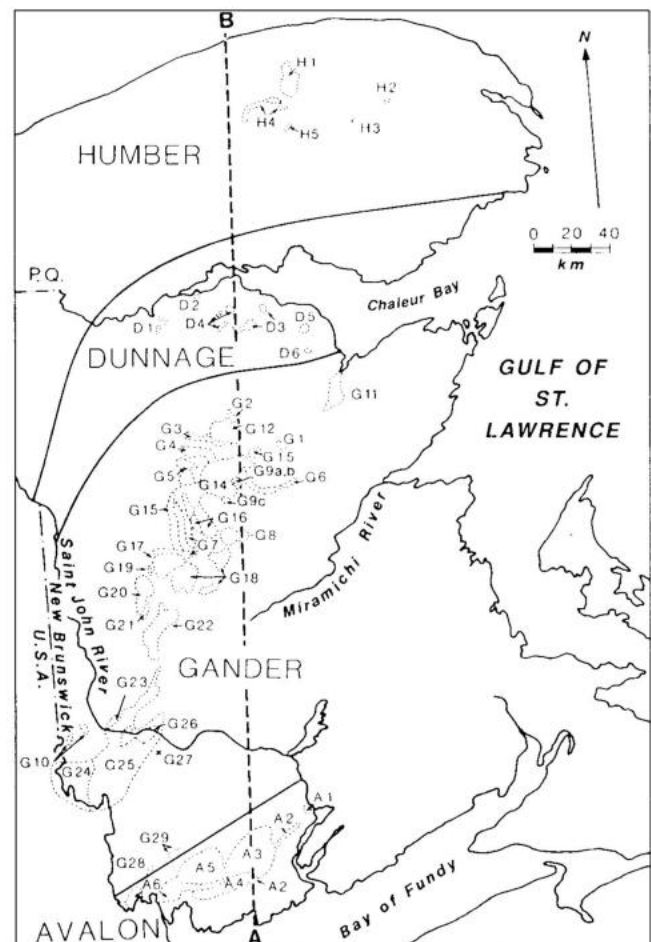
Un décollement lithosphérique pendant la fermeture de l'Iapetus et de ses bassins d'arrière-arc aurait poussé l'asthénosphère chaude contre la base de la croûte. Par la suite, la perte de chaleur par conduction vers le haut et le refroidissement rapide de l'asthénosphère du manteau auraient été à l'origine d'un métamorphisme régional de haute température, d'une fusion de la croûte et de la mise en place de vastes granites syncinématiques. Des variations locales et temporelles du régime tectonique (par ex. grandes failles limites de distension, de compression et préexistantes) peuvent, en partie, expliquer la mise en place de divers types pétrologiques de granite dans différentes parties de l'orogène. De plus, la présente étude a clairement démontré que de nombreuses caractéristiques des granites reflètent la zone tectonostratigraphique dans laquelle ils ont fait intrusion; il semble donc qu'ils soient liés à leurs roches originelles plutôt qu'au processus dont ils résultent.

## INTRODUCTION

Granitoid rocks constitute a major component of the Appalachian orogenic belt (see compilations by Williams (1978) and Currie (in press)). Prior to the past decade, granites received little attention, either in regional mapping studies or in models for the evolution of the orogen. However, new insights into granite petrogenesis coupled with recent improvements in geochemical, isotopic dating, and isotopic tracer techniques have made granite studies a very topical area of research. It is now generally recognized that granites represent samples of large volumes of material in the lower crust and/or mantle. A major theme of recent studies is that granites compositionally reflect or image their source materials and that various granite types can be correlated with tectonic setting. As granites can be readily and precisely dated, they provide a record of the lower crust and the tectonic environment at their time of formation. Isotopic tracer studies (Pb, Nd-Sm, Sr, and O) have proved to be particularly valuable in "mapping" zones or terranes of orogenic belts with similar lower crustal signatures and in putting constraints on the nature and age of granite protoliths. Also, granitic rocks have a well known potential as a source of various metals and as building material.

Between 1983 and 1990, detailed geological, petrographic, geochemical, isotopic, and geochronological work was carried out by the author and co-workers on all Paleozoic Appalachian granites in New Brunswick and Gaspésie, Quebec. This report provides both an overview or compilation of all work carried out on these granites, and an in-depth interpretation of their implications for the evolution of the Appalachian orogen. The text, plus appendices which tabulate all data collected during this study, should make this a lasting reference on New Brunswick and Gaspésie granites. Detailed petrologic and petrochemical interpretations of certain aspects or portions of data contained in this report will be published elsewhere.

New Brunswick and Gaspésie, Quebec can be subdivided from northwest to southeast into four major Appalachian zones (after Williams, 1978, 1979; Fig. 1): (1) Humber Zone, the western margin of Iapetus, deposited on the edge of the



**Figure 1.** Location map of New Brunswick and Gaspésie, Quebec granite intrusions studied, numbered as listed in Appendix 1. Tectonostratigraphic zone boundaries are after Williams and Hatcher (1983). Also shown is the location of a south-north cross-section (A-B) across the area.

Grenville craton; (2) Dunnage Zone, allochthonous remnants of Iapetus ocean floor, arc and back-arc sequences; (3) Gander Zone, the eastern continental margin of Iapetus; and (4) Avalon Zone, a stable platform during the early Paleozoic. In this report, Appalachian granites have been subdivided or grouped according to which of these zones they intrude.

A summary, in table form, of major geological, petrological, geochemical, and isotopic characteristics of the various plutons or suites is given in Appendix 1. In Descriptions of granites and related mineral deposits the geological setting of each zone, descriptions of individual plutons or suites, and associated mineral deposits are presented. To help reduce repetition in the main text, sample locations and descriptions, and modal and mineralogical information for the different plutons are tabulated in Appendices 2 and 3. Subsequent sections contain discussions on petrology and petrochemistry, with an emphasis on comparing and contrasting granites in the different zones. Intrusive rock type names used in this report are based on modal data (Appendix 3) and Streckeisen's (1973) granite classification (Fig. 2). More space is devoted to granites in a northern portion of the central plutonic belt in New Brunswick (Map 1751A, in pocket) in which geological mapping was carried out. Only selected representative analyses from the McGerrigle complex are presented in this

report. Detailed studies carried out on this particular pluton have been presented separately (Whalen, 1985, 1987a; Whalen and Garipey, 1986).

Petrographic, modal, geochemical, and isotopic data collected in this study are tabulated in Appendices 2 to 5. The data in Appendices 2-5 are also available in digital form in Open File 2570.

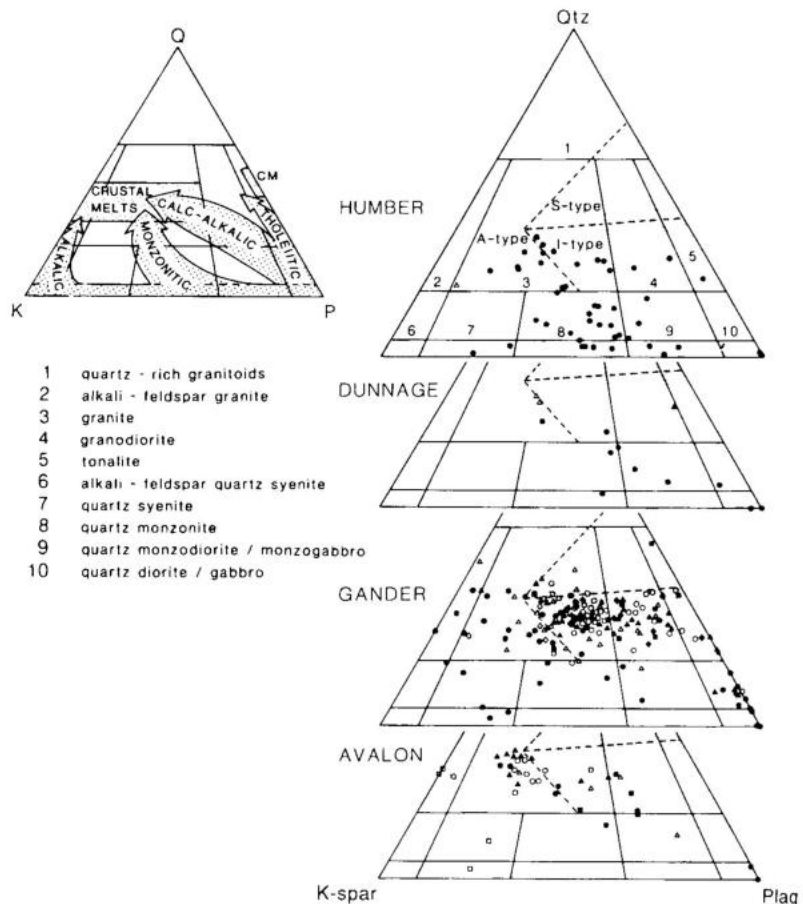
### Acknowledgments

This report summarizes the results of more than seven years' work, over which time the author received help from numerous people. K.L. Currie provided advice and encouragement during all stages of this work, including acting as critical reviewer of this report. Portions of data in this report represent collaborative work with G. Jenner, E. Hegner, C. Garipey, and F. Longstaffe, all of whom provided some advice on data interpretation. New Brunswick Department of Natural Resources and Energy staff, in particular Les Fyffe, are thanked for their assistance and support. The author also benefitted from discussions with C. van Staal, M.L. Bevier, R. Theriault, and S. Barr.

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**Figure 2.**

Quartz-K-feldspar-plagioclase (QKP) modal plots for New Brunswick and Gaspésie granites grouped by tectonostratigraphic zone (see Fig. 1). A key to the symbols used for the different intrusions in this and subsequent plots is given in Table 1 (see page 36). Modal classification fields labelled in the Humber zone QKP plot are after Streckeisen (1973). In the QKP diagrams, fields for Lachlan Fold Belt I-, S-, and A-type granites from Bowden et al. (1984) are also shown. The shaded region between I and S fields is a region of overlap. The insert QKP diagram summarizes trends or fields for various plutonic associations adapted from Lameyre (1987). Modal data from point counts of 1000 points on 16 by 12 cm stained rock slabs are tabulated in Appendix 3.



## DESCRIPTIONS OF GRANITES AND RELATED MINERAL DEPOSITS

### Humber Zone

#### Introduction

The Humber-Dunnage Zone boundary, the Baie Verte-Brompton Line (BBL), has been interpreted as the structural junction between deformed Iapetus continental margin rocks overlying Grenvillian basement to the west and Iapetus oceanic crust and volcanic arc sequences overlying an ophiolitic basement to the east (Williams and St. Julian, 1978). Within the Canadian Appalachians, almost all the widespread Silurian-Devonian granitic magmatism occurred to the east of the Baie Verte-Brompton Line, the notable exceptions being Humber Zone granites in Gaspésie, Quebec and Newfoundland. The Humber Zone in this area has been subdivided, both geologically and tectonically, into two parallel, roughly northeast-trending belts, the St. Lawrence and Piedmont terranes (Williams and Hatcher, 1983).

In Gaspésie, the northern St. Lawrence terrane, extends east-west from the St. Lawrence River to 1.5 km south of the Mont McGerrigle Plutonic complex, where it is separated from the Piedmont terrane by the Chic-Choc fault. The St. Lawrence terrane contains three principle allochthonous Cambro-Ordovician units: the Quebec Group shelf-type sedimentary rocks, Shickshock Group basic volcanic and volcanoclastic rocks, and the Mont Albert ophiolitic sequence. These allochthons are thought to have been all collectively welded to their present position by mid-Ordovician time. Multiple phases of deformation in these rocks are truncated by the Early Devonian Mont McGerrigle plutonic complex. The Piedmont terrane, located south of the Chic-Choc fault, was defined by Williams and Hatcher (1983) as a belt of polydeformed and regionally metamorphosed Cambro-Ordovician sedimentary and tectonic mélange assemblages. This terrane, which is well exposed in the southern Appalachians, is poorly defined in Gaspésie.

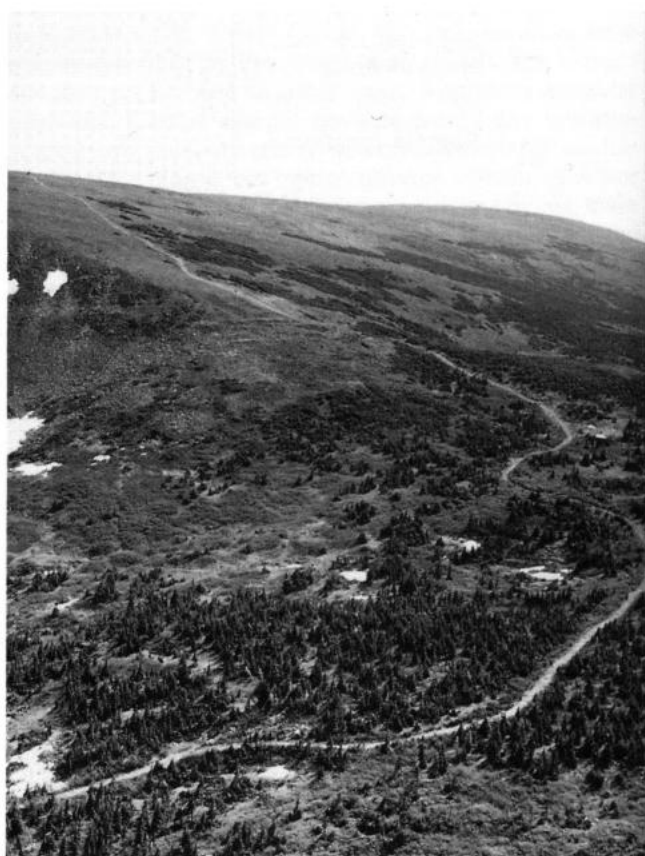
Unconformably overlying Ordovician rocks of the Piedmont terrane are gently folded Siluro-Devonian rocks of the Connecticut Valley-Gaspé Synclinorium. Sedimentary components consist of marine sandstones and limestones grading upwards to terrestrial clastic sediments. Interbedded with these are pyroclastics and flows of acid to intermediate composition. Studies on these volcanic rocks (Laurent and Belanger, 1984; Bedard, 1986) indicate that they are chemically variable (tholeiitic to alkaline, basaltic to rhyolitic) and include some calc-alkaline sequences. A compressional volcanic regime controlled by strike-slip faults has been suggested by Laurent and Belanger (1984), whereas Bedard (1986) has suggested that the volcanism was related to locally tensional zones in an orogenic foreland. Siluro-Devonian rocks of the Gaspé Synclinorium are intruded by four intrusions or groups of intrusions: Mont Chauve-Mont Hog's Back, Mont Vallières-de-St. Real, Mont Brown, and Mines Gaspé (Fig. 1).

### Granite descriptions

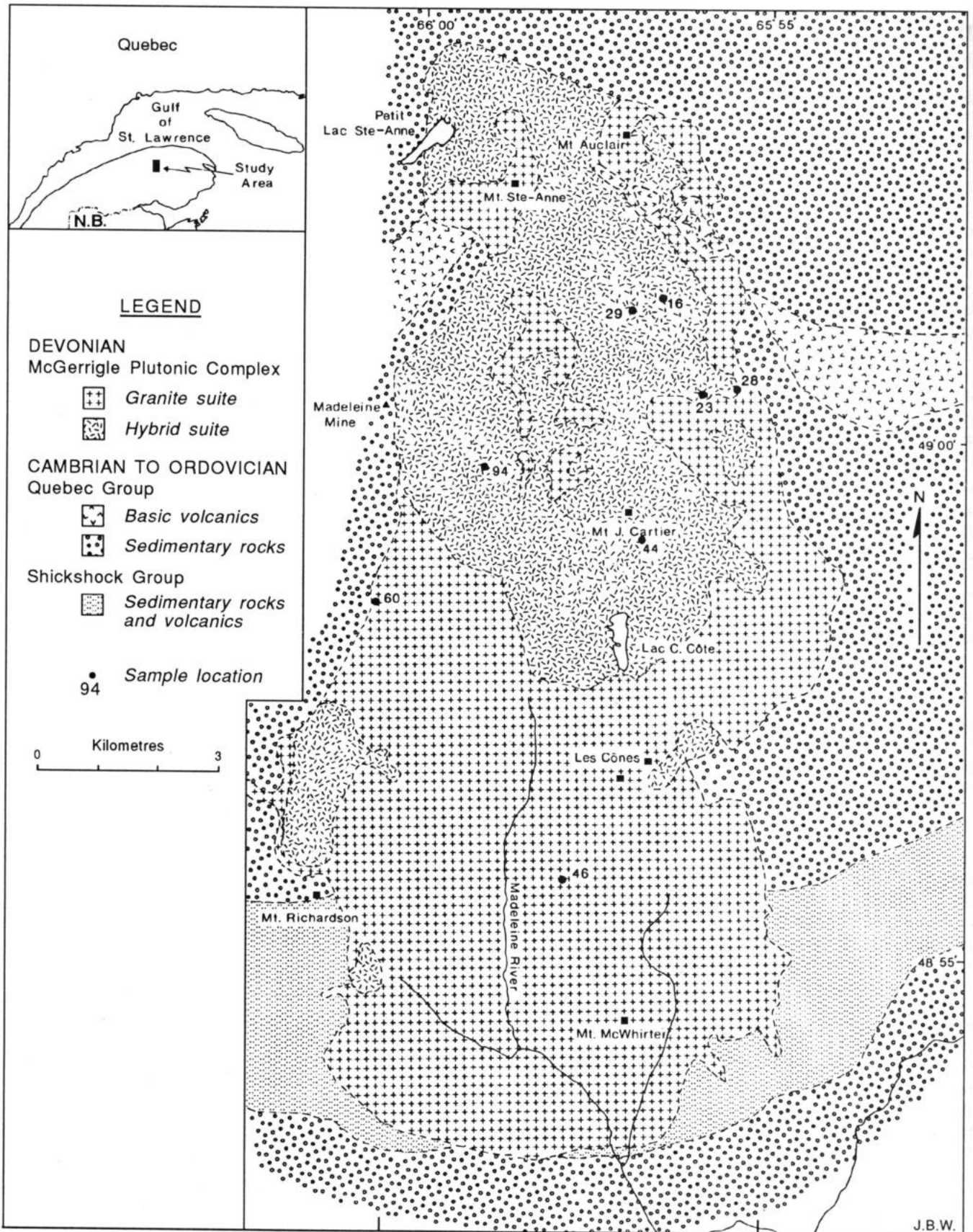
#### H1 – McGerrigle Mountains plutonic complex

The McGerrigle plutonic complex, which covers a rugged area of about 100 km<sup>2</sup> in central Gaspésie (Fig. 3), has been studied in considerable detail (Whalen, 1985, 1987a; Whalen and Gariépy, 1986; Whalen et al., 1991). Only a brief summary of work carried out on this pluton is presented in this report. The complex can be roughly subdivided into granite and hybrid suites (Fig. 4). Whereas the granite suite is mainly restricted to the southern portion of the pluton, the hybrid suite outcrops out in the northern half of the pluton and also to the north and southeast of Mount Richardson and to the east of Les Cones. The hybrid suite includes a component lithologically similar to granite suite rocks which differs in containing common mafic inclusions. There are both gradational and sharp intrusive relationships between younger granite and hybrid suite rocks. Based on their outcrop area, granitic rocks form about 75% of the complex, basaltic rocks about 5%, and hybrid rocks (diioritic to syenitic composition) about 20%.

The relatively compositionally homogeneous granite suite has been subdivided into different intrusive phases on the basis of grain size, feldspar mineralogy, and equigranular



**Figure 3.** McGerrigle Mountains plutonic complex – view to the south from a hill north of Mt. Jacques Cartier; in the foreground is the Mt. Jacques Cartier trail and on the horizon to the right is the peak of Mt. Jacques Cartier. GSC 204123Q



**Figure 4.** Generalized geological map of the McGerrigle Mountains plutonic complex, Gaspésie, Quebec after Whalen (1987a). Sites of geochemical samples discussed in the text and tabulated in Appendices 2 to 5 are given (WXMG prefix omitted).

or porphyritic character. Contacts between these phases appear to be mainly gradational. The granitic rocks vary from scarlet red to white and their main mafic mineral is biotite with local hornblende±pyroxene. Magnetite, apatite, zircon, titanite, and allanite are minor accessory minerals.

The hybrid suite is compositionally diverse and includes most intrusive rocks types between gabbro and granite (Plate 1, fig. a-c). The most striking feature of the bulk of this suite is its heterogeneity on both map and outcrop scale. Variations in texture and composition commonly occur over such a short distance that it is often difficult to decide whether such variants represent large inclusions or contemporaneous or younger intrusions. In the case of mafic-felsic mixtures, contact relationships described by Whalen (1985) such as chilled margins on mafic inclusions, pillow-like structures of chilled basaltic rock in granite (Fig. 5) and broken-up mafic dykes cutting granite, indicate the coexistence of mafic and felsic magmas. On an outcrop scale, there is evidence for intermediate or hybrid rocks produced by mixing, but the field relationships are complex and indicate multiple injection and hybridization.

The mafic hybrid suite phases form small bodies scattered over the northern half of the pluton. In some areas mafic rocks form abundant inclusions in more felsic hybrid suite rocks. The mineralogy is titanite, plagioclase (labradorite), kaersutitic amphibole, biotite, apatite, ilmenite, magnetite, and sulphides. Felsic portions of the hybrid suite often contain patchy mafic mineral aggregates derived from partially digested mafic xenoliths. These aggregates vary from grey to reddish, are fine- to medium-grained and range in texture from hypidiomorphic granular to porphyritic. Mafic mineral content ranges to as high as 30%, the main phase being hornblende, commonly with salitic clinopyroxene cores, and less abundant biotite. Opaques, zircon, titanite, apatite, and allanite are common accessory minerals.

At its northern end, the pluton contains a number of pod-shaped bodies of miaskite (Plate 1, fig. d) which have irregular, probably gradational contacts with hybrid suite rocks. They are porphyritic with perthitic alkali feldspar, biotite and aegerine-augite phenocrysts in a trachytic textured matrix of similar mineralogy plus nepheline, apatite, titanite, zircon, and oxides. Field relationships suggest that this undersaturated magma was contemporaneous with the magmas that produced the hybrid suite. Also, cutting hybrid suite rocks in the northern part of the pluton, are rare, thin (up to 3 m wide) peralkaline nepheline syenite dykes or sills which contain trachytic textured alkali feldspar, nepheline, sodalite, aegirine, arfvedsonite, aenigmatite, and accessory minerals. These undersaturated components of the complex are described in detail by Wallace et al. (1990).

Although a range of K-Ar (de Romer, 1974; Whalen and Roddick, 1987) and Rb-Sr (La Rocque, 1986) ages have been obtained from this complex, new U-Pb zircon and titanite ages indicate that all components were intruded at  $391.3 \pm 3.4$  Ma (Whalen et al., 1991). These U-Pb ages support the field-work-based conclusion that the various components of the complex are contemporaneous (Whalen, 1985, 1987a). Differences in K-Ar ages between the hybrid

and granite suites are interpreted as reflecting different cooling histories for different portions of the complex. The granite suite cooled rapidly (<2 Ma) from 600 to <530°C but more slowly (~10 Ma) from 530 to <300°C. In contrast, temperatures between 600 and 500°C were maintained over an extended period (5-15 Ma) within the hybrid suite, after which it chilled to <300°C at the same time (~370 Ma) as the granite suite.

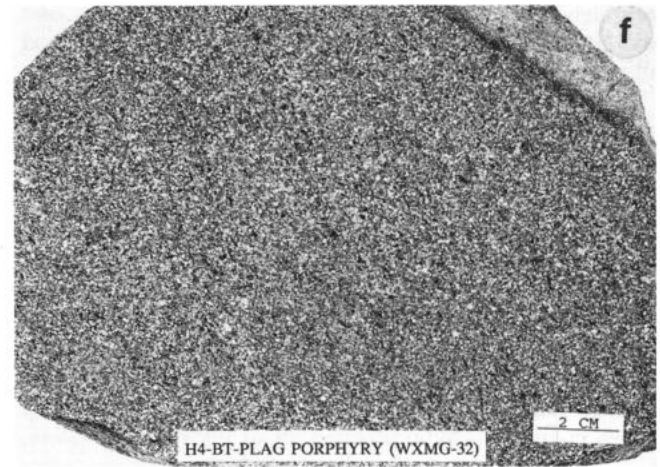
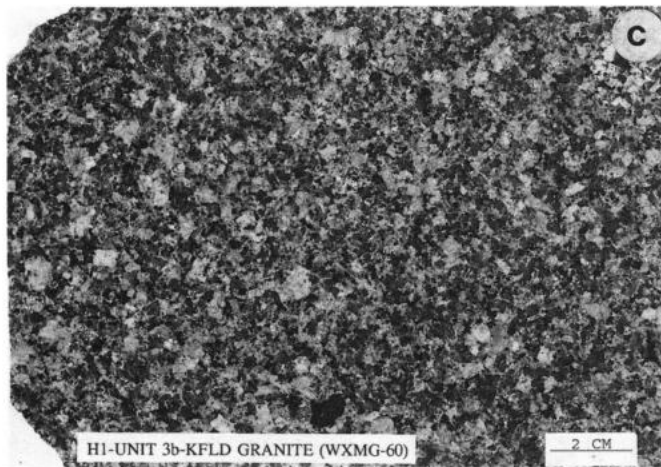
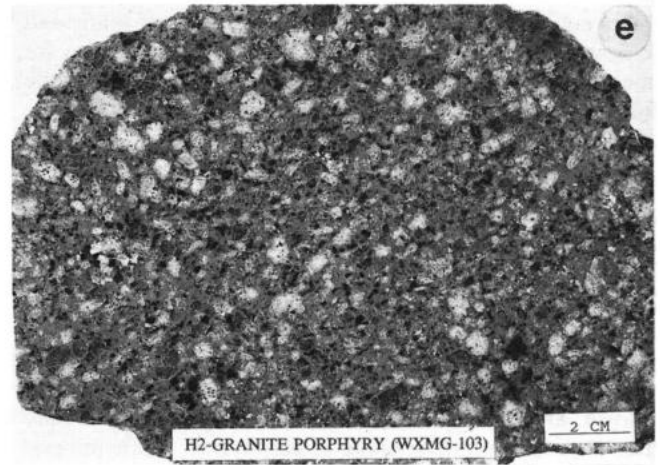
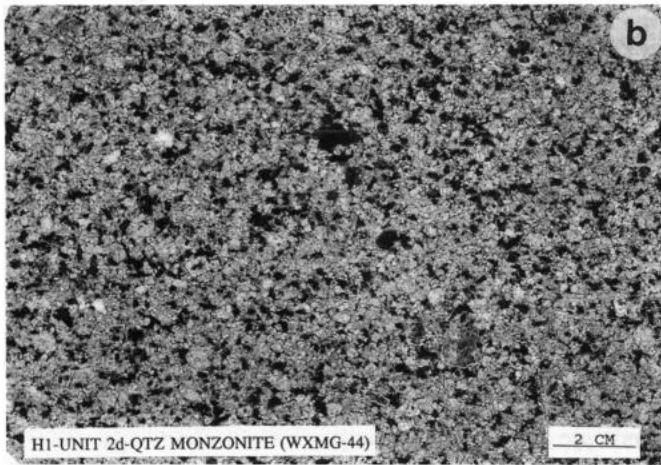
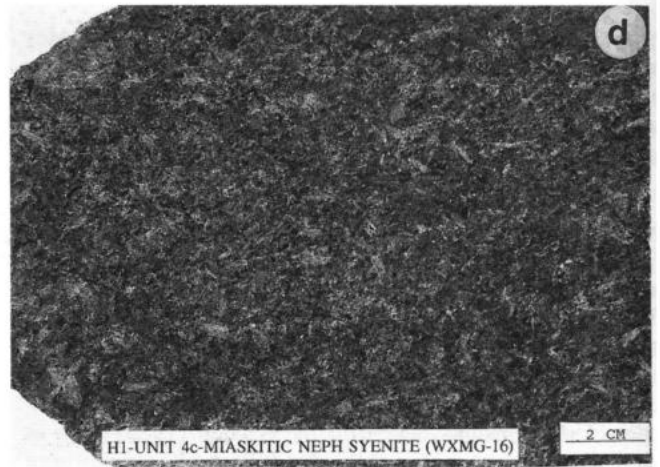
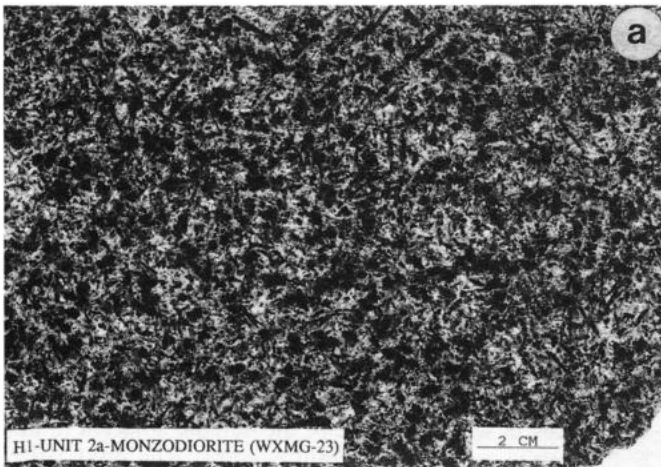
A study of the metamorphic aureole surrounding the McGerrigle pluton by Van Bosse and Williams-Jones (1988) indicated that the complex was emplaced at a pressure between 1.2 and 2.0 kbars, suggesting a depth of intrusion of 4 to 6 km. Van Bosse and Williams-Jones (1988) did not note differences in width or grade of the aureole adjacent to the hybrid suite versus the granite suite. Regional illite crystallinity studies in Gaspésie (Islam et al., 1982; R. Hesse, unpub. data, 1985) outlined a 16-20 km wide epimetamorphic (<300°C) halo at the northern end of the complex which decreases in width southward to only about 1 km at the south end of the pluton. This has been interpreted as indicating that the complex plunges northeasterly at a relatively shallow depth for a distance of eight to more than ten kilometres.

## H2 – Mines Gaspé, Murdochville

Intrusive rocks spatially and genetically associated with Cu-Mo deposits at Mines Gaspé, Murdochville have been recently described by Procyshyn et al. (1989). The Copper Mountain pit exposes an ovoid stock with many irregular apophyses. Chilled internal contacts within this intrusion indicate multiple injections of compositionally similar magma. This plug is cut by quartz veins containing minor pyrite, chalcopyrite, and molybdenite veins and by two main dyke systems, the Ore Dyke (east-northeast-trending) and the North Dyke (north-trending). The Needle East Dyke (north-trending) and associated offshoots transect the Needle Mountain ore body. Similar intrusions, such as the York Lake



**Figure 5.** McGerrigle Mountains plutonic complex – contact between medium grained diabase intrusion and red, fine- to medium-grained granite; note the chilled, very irregular cusped margin on the mafic intrusion; Mt. Jacques Cartier trail. GSC 204134X



**Plate 1**

Humber Zone granite samples

- a. Amphibole-biotite-clinopyroxene monzodiorite (WXMG-23); hybrid suite (pluton H1). GSC 205441-S
- b. Amphibole-biotite quartz monzonite (WXMG-44); hybrid suite (pluton H1). GSC 205441-B
- c. Biotite-amphibole, alkali-feldspar granite (WXMG-60); hybrid suite (pluton H1). GSC 205441-I
- d. Miaskitic nepheline syenite (WXMG-16); dyke rocks; Mont McGerrigle plutonic complex (pluton H1). GSC 205441-M
- e. Plagioclase-quartz-biotite-amphibole porphyry (WXMG-103); Murdockville intrusions (pluton H2). GSC 205441-G
- f. Plagioclase-biotite porphyry (WXMG-32); Mont Hogs Back pluton (pluton H4). GSC 205441-D

Sill, are exposed near Murdochville outside the zone of mineralization. These various intrusions were sampled in the Copper Mountain pit, underground in the Needle Mountain ore body and at exposures near Murdochville.

These intrusions consist of loosely to relatively densely phenocryst packed, quartz-feldspar porphyries (Plate 1, fig. e) which also contain biotite and rare amphibole phenocrysts, and accessory apatite and zircon. Alteration within these intrusions is variable but is generally more pervasive in close proximity to mineralization. Samples collected underground from the Needle Mountain ore body are characterized by extensive carbonate alteration whereas those from the Copper Mountain ore body have chlorite alteration of mafics and variable sericitic alteration of feldspars. Samples from Copper Mountain have yielded a Rb-Sr age of 375 Ma (Larocque, 1986) and K-Ar ages of 360 to 375 Ma (Procysyn et al., 1989).

### *H3 – Mont Brown*

A small intrusion of brown, fine grained, plagioclase porphyritic dacite occurs southwest of Murdochville on Mont Brown. Mafic minerals in this intrusion are completely altered to chlorite and feldspars are replaced by sericite.

### *H4 – Mont Hog's Back and Mont Chauve*

A number of high level intrusions of lithologically and texturally monotonous, plagioclase-quartz-biotite (2-5 mm in size) porphyry (Plate 1, fig. f) occur south and southwest of the McGerrigle intrusion. Biotite in these intrusions is often altered to chlorite + epidote and there is sericite + carbonate alteration of feldspars + matrix. These sill-like intrusions into Siluro-Devonian rocks are surrounded by narrow, poorly-defined calc-silicate hornfels alteration zones (de Romer, 1974). A whole rock K-Ar age of  $342 \pm 11$  Ma (recalculated to the decay constants of Steiger and Jager (1977)) obtained by de Romer (1974) from the Mont Hog's Back intrusion is probably unreliable due to pervasive alteration in this intrusion.

### *H5 – Mont Vallieres-de-St-Real*

The Mont Vallieres-de-St-Real sill or semi-concordant intrusion, located about 4 km southeast of Mont Hog's Back, has developed a calc-silicate hornfels aureole in its Devonian age sedimentary host rocks (de Romer, 1974). In contrast to the Mont Hog's Back intrusion, this intrusion exhibits considerable textural and some compositional variation. It contains K-feldspar porphyritic monzonite, equigranular, medium grained, quartz monzonite and granite (Plate 2, fig. a) and crosscutting feldspar porphyritic dykes (WXMG-78). Some samples contain, in addition to biotite, amphibole and traces of clinopyroxene. All samples contain some chlorite plus carbonate alteration. The coarser grained phases (WXMG-100, 101) resemble portions of the McGerrigle complex hybrid suite. A whole rock K-Ar age of  $371 \pm 11$  Ma (recalculated to the decay constants of Steiger

and Jager (1977)) obtained by de Romer (1974) from this intrusion is probably unreliable due to pervasive alteration in this intrusion.

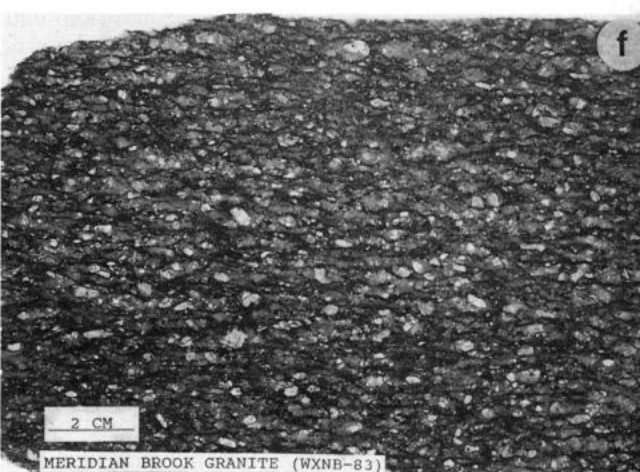
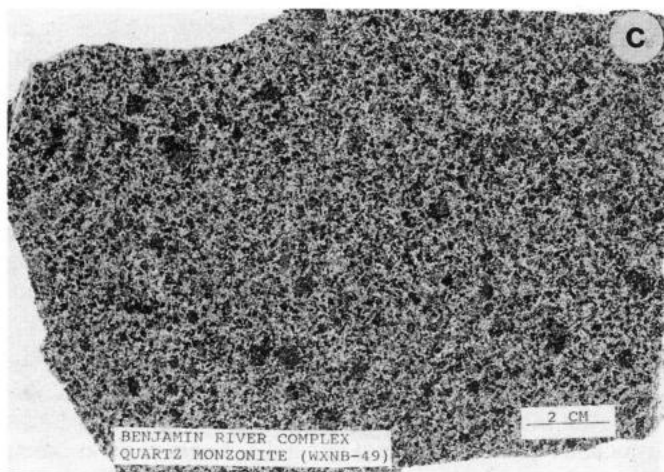
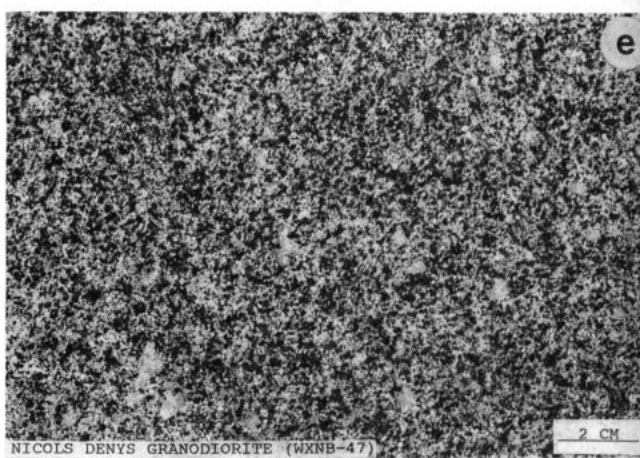
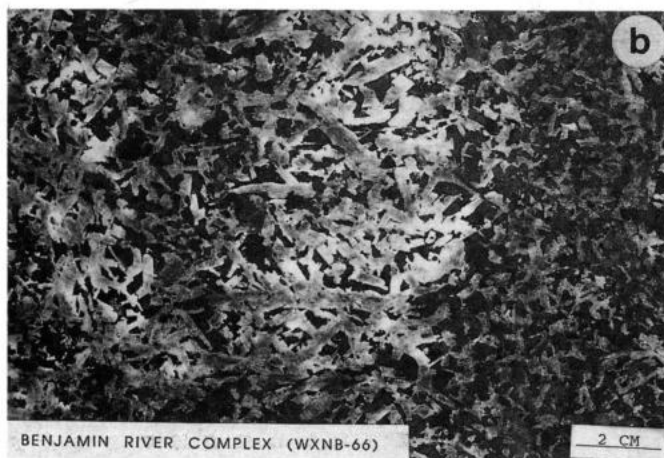
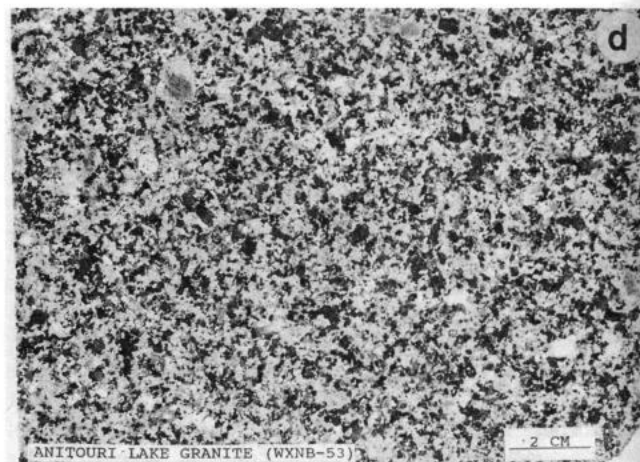
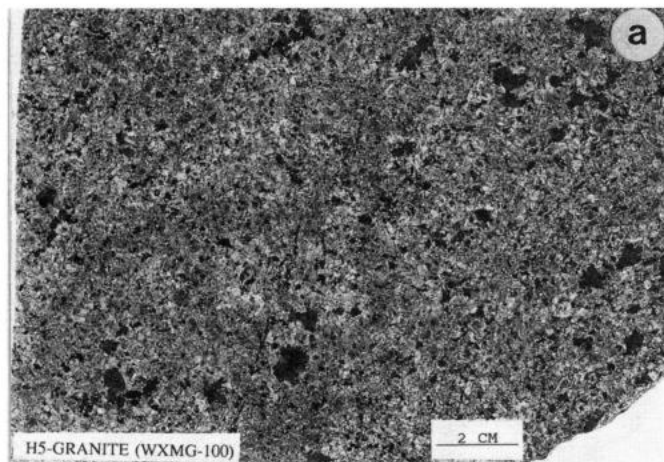
## **Economic geology**

There has been considerable base metal exploration activity for granite-related deposits in Gaspésie. Granitic intrusions have been emplaced into calcareous host rocks – an unusual situation in the Canadian Appalachians – which creates great potential for granite-related vein and skarn type mineralization. Two important granite-related mineral deposits (Madeleine Mine and Gaspé Copper), as well as numerous showings, have been found.

The Needle Mountain Cu skarn and Copper Mountain Cu-Mo deposits are associated with granitic intrusions around Murdochville (see Procysyn et al., 1989). Based on their steep heavy rare-earth element (REE) depleted patterns and lower high field strength element contents (see Humber Zone section, below), Murdochville high-level porphyries are geochemically distinct from other granites in Gaspésie.

Based on previous exploration work and his mapping, de Romer (1977) concluded that, except for a few specks of molybdenite in the vicinity of Mount Jacques Cartier, the interior of the McGerrigle pluton is completely barren. To help re-evaluate its economic potential, whole-rock lithogeochemical analyses for a wide range of trace elements, including Th, U, Zr, Nb, REE, Ta, Hf, Cu, Pb, Zn, Mo, W, and Sn were carried out. These granites are characterized by high Zr (250-2000 ppm), Nb (40-400 ppm) and REE (Ce = 80-250 ppm), as would be expected of A-type granites. A-type granites can be associated with Sn, Mo, and W mineralization. However, values for these elements in the suite are generally low, averaging <1, 3, and <1 ppm, respectively. Higher Sn values (6-15 ppm) were obtained from the metasomatized gabbro (unit 2b), the miaskitic nepheline syenite (unit 4c) and the aplitic granite (part of unit 3b) at the southern margin of the pluton. These aplitic rocks bear a resemblance to the host rocks of Mo and Sn mineralization at the southern margin of the Ackley batholith, Newfoundland (Whalen, 1980, 1983). Further study of the southern end of the complex is merited to evaluate its Sn and Mo potential.

A number of mineral deposits and showings occur within the wall rocks of the McGerrigle pluton. Studies of vein mineral and thermal zoning (Stevens, 1986, 1988, 1989) have documented three different mineralized vein zones radiating from the north end of the McGerrigle pluton, within which occur the Mine Madeleine (Cu) and Candego (Pb-Zn-Ag) deposits. These studies concluded that the vein-depositing fluids, driven by heat from the McGerrigle pluton, leached metals from wall rocks. Metamorphic aureole formation and vein deposition were commonly completely contemporaneous. Fluid-inclusion studies on the Madeleine copper deposit (Williams-Jones et al., 1989) indicate it formed prior to the peak of contact metamorphism at temperatures of 400 to 600°C.



**Plate 2**

Humber, Dunnage, and Gander zone granite samples

- a. Amphibole-biotite alkali-feldspar granite (WXMG-100); Mont Vallieres de St. Real intrusion (pluton H5). GSC 205441-P
- b. Pyroxene gabbronorite (WXNB-66); Benjamin River complex (pluton D3). GSC 204780-C
- c. Clinopyroxene-amphibole quartz monzodiorite (WXNB-49); Benjamin River complex (pluton D3). GSC 204779-H
- d. Biotite-amphibole granite (WXNB-53); Anitouiri Lake granite (pluton D5). GSC 204779-L
- e. Biotite granodiorite (WXNB-47); Nicols Denys pluton (pluton D6). GSC 204779
- f. Strongly foliated, biotite-muscovite granite (WXNB-83); Meridian Brook granite (pluton G3). GSC 204780-I

## **Dunnage Zone**

### **Introduction**

In this report, the Dunnage Zone has been taken to include exposures of Ordovician rocks south of the Baie Verte-Brompton Line in Gaspésie, the Ordovician Elmtree inlier in northern New Brunswick, and a large area in New Brunswick where presumed equivalent Ordovician rocks are covered by Late Ordovician to Siluro-Devonian sedimentary and volcanic sequences (Fig. 1). These Ordovician rocks are thought to include fore-arc and foredeep deposits as well as oceanic and volcanic arc remnants of Iapetus (van Staal et al., 1990). Granitic rocks, a volumetrically insignificant rock type in this area, are Siluro-Devonian in age and postdate the cover sequences. Bimodal volcanic suites in the Siluro-Devonian cover sequences of the Torbique volcanic belt have been interpreted as continental-rift related suites formed in a sinistral shear regime produced by the docking of the Avalon Zone (Dostal et al., 1989). In this report, the Rocky Brook-Millstream fault has been taken as the dividing line between the Dunnage and Gander zones. Recent work by van Staal and Fyffe (1991) in northern New Brunswick has demonstrated that Gander and Dunnage rocks are juxtaposed in complex thrust sequences, i.e. there is no simple surface trace of the Gander-Dunnage contact. This redefinition does not greatly affect subdivision of the granites in this report. It can, however, help explain the features of two granites, Anitouri Lake (D5) and Pabineau Falls (G11), which exhibit isotopic characteristics incompatible with the zone in which they are located (see Isotopic characteristics of the granites, below).

### **Granite descriptions**

#### *D1 – Mount Squaw Cap stocks*

There are a number of high-level porphyry plugs and dykes which, in this study, are called the Mount Squaw Cap stocks, near Robinsonville, in northwest New Brunswick. The size of these intrusions has been considerably exaggerated on the geological map of Greiner (1973) and the compilation map of Davies (1979). The intrusion on Mount Squaw Cap is a grey, feldspar-biotite (phenocryst size = 1-3 mm) porphyry with a strongly developed slaty cleavage (WXNB-71). The intrusion on Slate Mountain includes a phase like that on Mount Squaw Cap and also a very fine grained, rare plagioclase (1-3 mm) porphyritic rhyolite (WXNB-72). A dark reddish brown plagioclase-amphibole (2-4 mm) rhyolite dyke (WXNB-69) and a similarly coloured miarolitic aplite dyke (WXNB-70) were sampled south and east of Robinsonville, respectively. Though they were not sampled for this study, similar dykes are of fairly widespread occurrence south of Robinsonville where they have been the object of exploration interest for skarn-type copper mineralization. Greiner (1973) considered these intrusions, which cut Ordovician to Silurian age sedimentary rocks, to be Devonian in age.

#### *D2 – Mount Sugar Loaf stock*

The high-level intrusion or plug, which forms the prominent hill, Mount Sugar Loaf, within the town of Campbellton, is interpreted by Ferguson and Fyffe (1985) as a volcanic neck. It consists of greenish, plagioclase-pyroxene-amphibole (3-6 mm) porphyry, the aphanitic matrix of which is characterized by chlorite + carbonate alteration. This plug, which intrudes Lower Devonian volcanic rocks of the Dalhousie Group, is considered by Greiner (1973) to be of Devonian age.

#### *D3 – Benjamin River complex*

The Benjamin River complex (Irrinki, 1973c; Stewart, 1979) consists of a probably consanguineous suite of gabbroic, dioritic, quartz monzonitic, and granitic intrusive rocks exposed in and adjacent to the Benjamin River. The gabbroic rocks, which vary from medium- to coarse-grained, are pyroxene-amphibole leuco-gabbroites (Plate 2, fig. b). More felsic phases are equigranular, medium grained rocks (Plate 2, fig. c) which frequently contain miarolitic cavities. Both plagioclase and K-feldspar in these felsic phases are scarlet red due to hematitic + sericitic alteration. Minor chlorite + epidote alteration of mafic minerals is ubiquitous in rocks of the complex. Contact relationships suggest the coexistence and interaction of mafic and felsic magmas during formation of the complex. Stewart (1979) obtained a Rb-Sr whole rock isochron age of  $370 \pm 30$  Ma from this complex which intrudes Silurian age mafic volcanic rocks of the Chaleur Group.

#### *D4 – Charlo stocks*

The Charlo stocks, a group of dykes and small plugs west of the Benjamin River complex, can be subdivided into high-level, grey to reddish, plagioclase-amphibole (2-6 mm) dacite porphyries and medium grained, equigranular, quartz monzonitic intrusions. The latter are similar to, and probably comagmatic with, quartz monzonites in the Benjamin River complex. Carbonate alteration of feldspars and matrix occur in the dacite porphyries. These stocks, which intrude Silurian age sedimentary rocks of the Chaleur Group, were considered by Irrinki (1973a, b) to be of Devonian age.

#### *D5 – Anitouri Lake granite*

The pink, medium grained, equigranular, biotite-amphibole Anitouri Lake granite (Fyffe, 1974)(Plate 2, fig. d) forms an ovoid body south of Belledune and intrudes Ordovician sedimentary rocks of the Elmtree Group. Exposure is poor, except in a former building stone quarry on the northeast side of Anitouri Lake. At this location, the presence of an internal contact in this granite is indicated by red aplite fringed by granophyric pegmatite (Fig. 6). A U-Pb zircon age of  $372 \pm 4$  Ma (Walker et al., 1991) has been obtained from the Anitouri Lake granite.



**Figure 6.** Anitouri Lake granite (pluton D5) – banded aplite and pegmatite define an internal contact in pink, medium grained biotite-amphibole granite. GSC 204394G

#### *D6 – Nicholas Denys*

The Nicholas Denys intrusion (Fyffe, 1975), is a grey, medium grained, equigranular, biotite granodiorite (Plate 2, fig. e), which surrounds the village of the same name. This intrusion, which was emplaced into Silurian sedimentary rocks of the Chaleur Group, has given a U-Pb zircon age of  $381 \pm 4$  Ma (Walker et al., 1991).

#### **Economic geology**

As in Gaspésie, Quebec, potential exists in the Dunnage Zone of New Brunswick for skarn, vein, and porphyry type base metal deposits. A number of showings have been located. The Popelogan showing, which is associated with one of the Charlo feldspar-amphibole porphyry stocks, is a quartz-diopside skarn deposit containing 3.1 million tonnes of 0.3% copper and 200-400 ppb gold (Quartermain, 1981). The Benjamin River showing is a porphyry copper type occurrence within and adjacent to the southern portion of the Benjamin River complex (Stewart, 1979). Associated with feldspar porphyry in the northern part of this complex is an apatite rare-earth element showing (Sinclair and Kingston, 1990). The apatite occurs with pyroxene, magnetite, and minor epidote in small pegmatitic bodies and in veins and stockworks in adjacent rocks. Other porphyry and skarn type showings include those at Quisibis Mountain, Patapedia, Burnt Land Brook, Beresford, and Nicholas Denys (Ruitenbergh and Fyffe, 1982). The Au potential of this area has received considerable recent attention (e.g. Philpott, 1988; Walker et al., 1988). Gold bearing zones are apparently genetically related to small mafic and felsic intrusions.

### **Gander Zone**

#### **Introduction**

The Gander Zone in New Brunswick, which has also been termed the Miramichi terrane (Fyffe and Fricker, 1987), is considered to consist of remnants of the eastern continental

margin of the Early Paleozoic Iapetus ocean. Recent work (van Staal et al., 1990; van Staal and Fyffe, 1991) has shown that the Gander-Dunnage boundary is a complex thrust contact. As this new interpretation of the boundary does not affect the correct grouping by zone of the granite intrusions, the Rocky Brook-Millstream Fault, as suggested by Williams (1979), is used as the Gander-Dunnage boundary in Figure 1. To the southeast, an area, termed St. Croix and Mascarene terranes by Fyffe and Fricker (1987), has been included in this report as part of the Gander Zone. Available data from small intrusions in this area isotopically and geochemically resemble data from Gander rather than Avalon Zone granites. Various faults that bound the northwestern edge of the Saint George Batholith have been taken in this report as delineating the Gander-Avalon boundary. Further work is planned on plutonic and volcanic rocks in this area to better substantiate the position of this zone boundary.

The oldest rocks exposed in Gander Zone are part of the lower Tetagouche Group, a thick sequence of shale, greywacke, and quartzite, which is overlain by bimodal volcanic rocks. An Arenig shallow water, shelly fauna (Fyffe, 1976) and conodonts (Nowlan, 1981) from metasediments just below the felsic volcanics of the Bathurst Camp indicate a pre-Middle Ordovician age for the lower Tetagouche Group. Recent U-Pb zircon ages (van Staal and Fyffe, 1991) place the top of the lower Tetagouche Group at no younger than 466 Ma (Middle Ordovician). Evidence for a consanguineous relationship between Ordovician granites and upper Tetagouche Group bimodal volcanic rocks is: (1) deformed granites rarely or never cut upper portions of the Tetagouche Group; (2) felsic intrusive and volcanic rocks closely resemble one another in petrography and deformational style (C. van Staal, pers. comm., 1990) and; (3) gradations to high-level porphyries and the presence of granophyric and aplitic textures in some deformed intrusives indicate a high-level of emplacement. Major regional metamorphism (up to lower amphibolite facies) and deformation postdates the Ordovician igneous activity. The Ordovician granitic plutons have a striking outcrop pattern of elongate bodies deformed into broad open folds, due to Late Ordovician to Silurian deformation. Subsequent to regional metamorphism and deformation, the area was intruded by a number of Silurian and rare Devonian granitic plutons (Bevier and Whalen, 1990a, b), and was the site of Silurian to Devonian volcanic activity.

Granites belonging to the Ordovician magmatic event (plutons G1 to G10) are described first, followed by Siluro-Devonian intrusions (G12 to G29). Granites in a northern portion of Gander Zone were mapped by the author (Map 1751A, in pocket). Map units (e.g. Ogm) cited in the following descriptions refer to those on this map; granite geochemical samples collected within this area are plotted.

#### **Granite descriptions**

##### *G1 – Heath Steele granite*

Southwest of the Heath Steele deposit, adjacent to South Little River Lake, a small elongate body of foliated, medium grained, pink, equigranular, mafic-poor, biotite-muscovite

granite, intrudes Ordovician volcanic rocks of the Tetagouche Group. Based on its deformed character, it was considered by Irrinki (1972b) to be Ordovician in age.

#### *G2 – Popple Depot granite (map unit Ogp)*

This granite (Whalen, 1987b), which forms talus on the slopes north and northeast of Popple Depot, is a massive, reddish pink to beige, fine grained, mafic-poor, biotite granite. Its fine grained nature and the presence of abundant granophytic textures and pegmatitic clots suggest that it is a high level intrusion. Helmstaedt (1971) considered this granite, which intrudes Ordovician sedimentary rocks of the Tetagouche Group, to be Ordovician in age.

#### *G3 – Meridian Brook granite (map unit Ogm)*

The Meridian Brook granite (Whalen, 1987b), an orange to beige, medium- to coarse-grained, equigranular biotite-muscovite granite (Plate 2, fig. f), forms a 33 km long east-west orientated body immediately south of the Mount Elizabeth complex. Muscovite occurs along foliation planes and is probably not primary, at least in its present textural relationship. South of Tilley Ridge and east of Mount Mitchell, it includes a reddish-brown to grey, fine grained, in places amphibole-bearing phase and also some exposures of deformed inclusion-rich tonalite. Deformation is heterogeneously distributed throughout the pluton. Weakly foliated portions, generally not near contacts, occur beside strongly mylonitized parts. The age of the Meridian Brook granite, as determined by multi-grain zircon fractions is  $464 \pm 43/-10$  Ma with an upper intercept of ca. 1.5 Ga (Whalen and Bevier, 1987). Additional conventional single crystal analyses and corroborating ion microprobe analyses constrain the crystallization age of the Meridian Brook granite to  $470 \pm 1$  Ma (Roddick and Bevier, 1988).

#### *G4 – Sweat Hill granite (map unit Ogs)*

The Sweat Hill granite (Crouse, 1979; Irrinki, 1977a) is a beige, quartz and feldspar-porphyrific, biotite-muscovite granite (Plate 3, fig. a) which forms an east-west elongated body immediately south of the Meridian Brook granite. Throughout the pluton muscovite is a texturally late phase. At its west end, primary textural variations, ranging from a coarse grained, nearly equigranular granite to a high-level porphyry, have been mapped out. In contrast, a gradational change from a nearly massive, coarse grained granite to a chloritic feldspar-augen schist occurs along a 5 km, north-south road which transects the eastern end of the body. Based on U-Pb zircon data,  $476 \pm 6/-4$  Ma is the best estimate of the crystallization age of the Sweat Hill granite (M. Bevier, pers. comm., 1990).

#### *G5 – Serpentine River granite (map unit Oge and Ogeb)*

The Serpentine River granite (Irrinki, 1977b; Whalen, 1987b) is a fine- to coarse-grained, dark pink to beige, biotite-muscovite granite (Plate 3, fig. b) which forms a 20 km long, irregularly shaped body east of Serpentine Lake. Along a

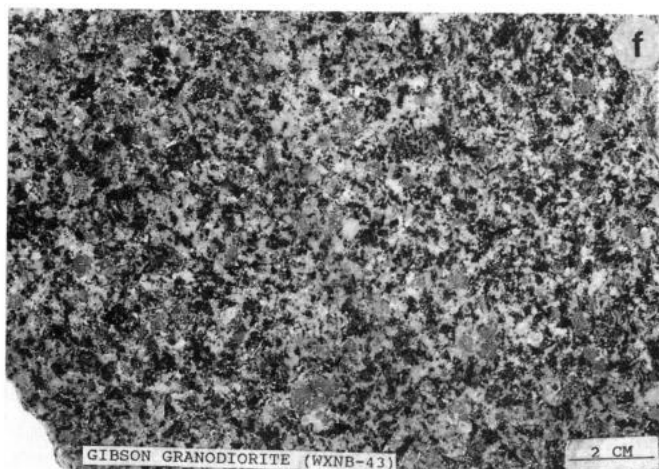
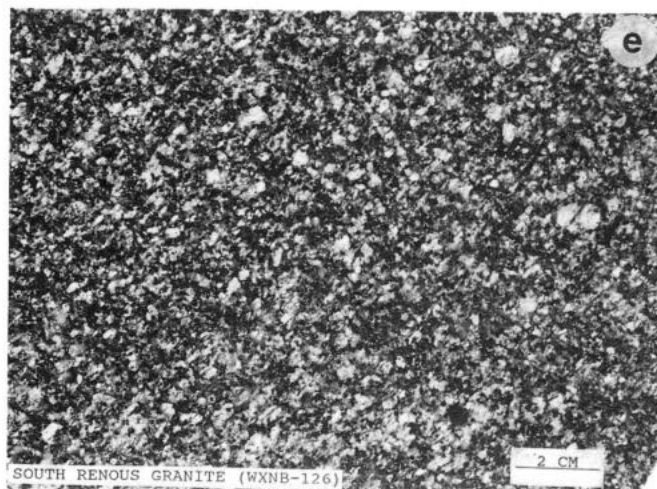
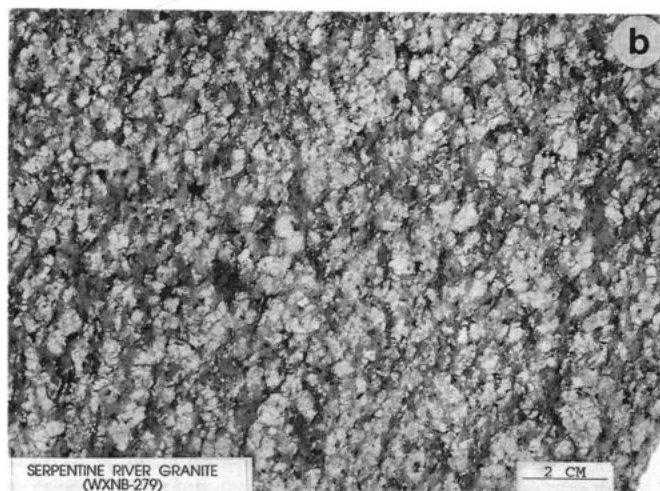
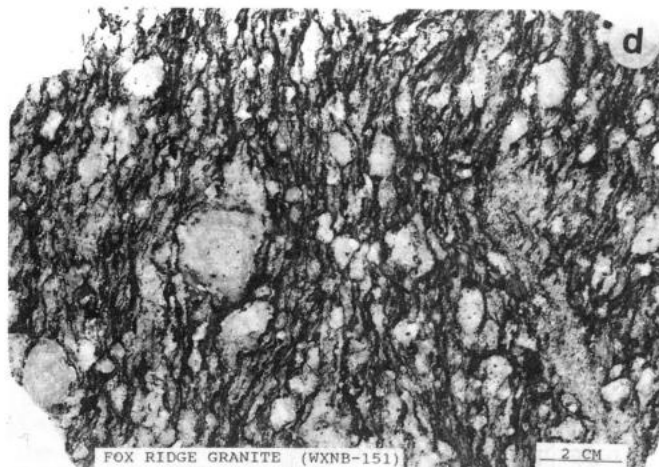
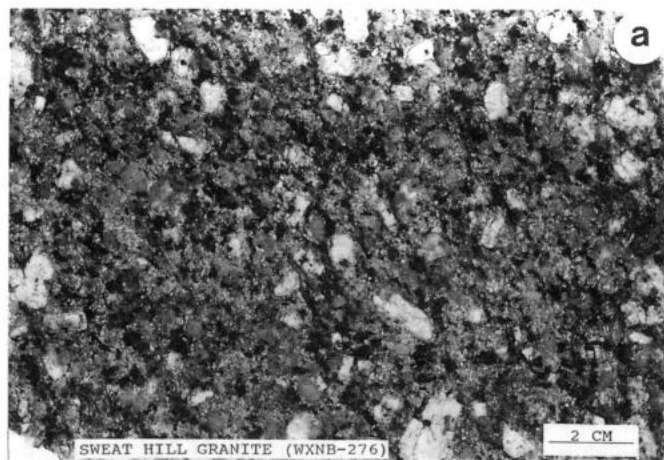
main logging road, which transects the west end of the body, this granite grades from weakly to strongly foliated, increases in grain size, and grades from equigranular into a feldspar-porphyroblastic phase (subunit Ogeb). The southern portion of this granite varies from medium- to fine-grained (aplitic). Based on U-Pb zircon analyses, the best estimate for the crystallization age of the Serpentine River granite is  $455 \pm 10/-8$  Ma (M. Bevier, pers. comm., 1990)

#### *G6 – Mullin Stream Lake granite (map unit Ogu)*

The Mullin Stream Lake granite (Irrinki, 1972a), which extends northwest and northeast of Mullin Stream Lake parallel to the regional structure, is a pink to orange, medium- to coarse-grained, weakly to strongly foliated, biotite-muscovite granite (Plate 3, fig. c). The southeast portion of the body, which is outside the area of Map 1751A, varies from granitic to quartz monzonitic in composition, has finer grained portions and is consistently strongly foliated. Based on its distribution along foliation planes, muscovite in this granite is probably metamorphic. However, the presence of garnet in some samples suggests a primary peraluminous character for this granite. Adjacent to the North Pole Stream granite (map unit SNg), the rock is cut by quartz veins and displays fracture-related alteration. A sample from a small body of identical granite about 4 km north of Mullin Stream Lake (grouped into unit Og in Map 1751A) is grouped in this report with samples from map unit Ogu. Other unnamed Ordovician granites are described below (unit G9a, b, c). There is a close lithologic resemblance between the Mullin Stream Lake granite and the Meridian Brook granite (map unit Ogm, described above), which is compatible with their being comagmatic. A composite Rb-Sr whole rock isochron from the Mullin Stream Lake and several nearby smaller bodies yielded  $479 \pm 14$  Ma (Fyffe et al., 1977). Based on U-Pb zircon analyses, the best estimate of the crystallization age of the Mullin Stream Lake granite is  $458 \pm 9/-13$  Ma with an upper intercept age of  $1.4 \pm 0.8$  Ga (M. Bevier, pers. comm., 1990).

#### *G7 – Fox Ridge granite (map unit Ogf)*

The Fox Ridge granite (Crouse, 1977; Irrinki, 1978; Fyffe and Pronk, 1985), a medium- to coarse-grained, dark pink to orange, K-feldspar augen-bearing, biotite-muscovite granite (Plate 3, fig. d; Fig. 7), is strongly foliated throughout, parallel to its contacts. Feldspar augen range up to 5 cm in diameter and commonly exhibit rapakivi mantling. Exposures of this granite in the south-central portion of Map 1751A are identical to those in the type area southeast of Trousers Lake described by Fyffe and Pronk (1985). This granite, most of which lies outside Map 1751A, forms a narrow, elongate body which extends for over 30 km from east of Long Lake to south of Route 108. Exposures of this granite near Route 108 are schistose or mylonitic and lack the characteristic feldspar augen (Irrinki, 1978). An east-trending feldspar augen granite located adjacent to the Catamaran fault (Crouse, 1981a; St. Peter, 1981; see Fig. 1), is considered in this report to be part of the Fox Ridge granite. Granite samples



**Plate 3**

Ordovician Gander Zone granite samples

- a.** Slightly foliated, biotite-muscovite granite (WXNB-276); Sweet Hill granite (pluton G4). GSC 204780-N
- b.** Slightly foliated, biotite-muscovite granite (WXNB-279); Serpentine River granite (pluton G5). GSC 204780-L
- c.** Moderately foliated, biotite-muscovite granite (WXNB-233); Mullin Stream Lake granite (pluton G6). GSC 204780-D
- d.** Strongly foliated, biotite-muscovite, K-feldspar augen granite (WXNB-151); Fox Ridge granite (pluton G7). GSC 204779-G
- e.** Slightly foliated, biotite granodiorite (WXNB-126); South Renous granite (pluton G8). GSC 204780
- f.** Biotite granodiorite (WXNB-43); Gibson granodiorite (pluton G10). GSC 204779-S



**Figure 7.** Fox Ridge granite (pluton G7) – strongly foliated, feldspar-augen, biotite granite. GSC 204394-H

collected in the area of Fox Ridge yielded a whole rock Rb-Sr isochron age of  $474 \pm 55$  Ma (Fyffe and Pronk, 1985) and a U-Pb zircon age of  $451 +15/-1$  Ma (Fyffe et al., 1988).

#### *G8 – South Renous River granite*

The South Renous River granite (Irrinki, 1980) is a light pink to beige, medium- to coarse-grained, moderately foliated, biotite-muscovite granodiorite (Plate 3, fig. e) which is, in part, feldspar-porphyritic. This granite, which contains distinctive ovoid, blue quartz "eyes", forms an ovoid body 13 km in diameter, abutting Route 108 east of Louis Lake (see Fig. 1). A couple of small, lithologically identical bodies of granite, which outcrop east of Holmes Lake, are considered to be comagmatic with this granite. Based on U-Pb zircon analyses, the best estimate of the age of crystallization of the South Renous granite is  $441 +15/-21$  Ma (M. Bevier, pers. comm., 1990).

#### *G9a, b, c – Unnamed Ordovician granites*

Just northeast of Long Lake, in the southeast portion of Map 1751A, is a small body of equigranular, bluish green, biotite granite (map unit Og; intrusion G9a). The interior of this body is only slightly foliated and exhibits apparently primary layering whereas its margins consists of feldspar-augen chloritic schist.

A body of fine grained, foliated, biotite granodiorite outcrops adjacent to the North Pole Stream granite southeast of Long Lake (map unit Og; intrusion G9b). This body, which contains small (2-4 mm) plagioclase phenocrysts, is thought to be a subvolcanic intrusion.

A moderately foliated pink biotite-muscovite granite is exposed adjacent to the North Pole Stream road, just before it crosses the Little Southwest Miramichi River (intrusion G9c). This body is located just south of latitude  $67^{\circ}30'$ , outside Map 1751A.

#### *G10 – Gibson granodiorite and Benton granite*

These two ovoid stocks, which outcrop south of Woodstock, have been mapped and described by Venugopal (1978, 1981). The main phase is a pervasively altered and epidotized, medium grained, equigranular biotite-hornblende(?) granodiorite to granite (Plate 3, fig. f), but there are also finer grained, granophyric, porphyritic phases. Most phases contain distinctive blue quartz "eyes" and the mafic minerals are pseudomorphed by chlorite + secondary biotite and sphene. Epidote as fracture fillings and veins is also common. Because of their lack of any penetrative fabric, these stocks had been assumed to be of Devonian age. However, as their altered nature seemed to contradict this assumption, the author obtained a U-Pb zircon age from the Gibson granodiorite. An Ordovician crystallization age ( $479 \pm 7$  Ma; M. Bevier, pers. comm., 1990) was indicated for these two intrusions.

#### *G11 – Pabineau Falls granite*

The Pabineau Falls granite (Fyffe et al., 1981), which forms an 20 km long ovoid body within and south of Bathurst, is a dark pink, coarse grained, K-feldspar porphyritic (1-3 cm), biotite granite (Plate 4, fig. a; see Fig. 1). At the type area of Pabineau Falls, it is cut by common pink aplite and pegmatitic dykes which are absent in the building stone quarries where the geochemical samples were collected. Roddick and Bevier (1988) obtained a U-Pb age of  $394 \pm 1$  Ma for this intrusion.

#### *G12 – Mount Elizabeth intrusive complex (map units SEmd to SEah)*

The Mount Elizabeth granite (Fyffe et al., 1981), has been renamed by Whalen (1990) the Mount Elizabeth intrusive complex, for it includes a number of apparently contemporaneous igneous suites. These have been grouped into a mafic suite (units SEmd to SEMp), an eastern peraluminous granite suite (unit SEpg) and a western alkaline (units SEag to SEah) granite suite.

i. Mafic suite (units SEmd-SEmp): The mafic suite includes a diverse group of rocks. One substantial medium- to coarse-grained troctolite body, the Portage Brook troctolite (unit SEMp)(Plate 4, fig. b), contains plagioclase, olivine, two pyroxenes, brown amphibole, opaques, and apatite, and has locally well-developed banding. Contact relationships between this gabbro and other mafic and felsic intrusive phases have not been observed. The Goodwin Lake intrusion (unit SEMg), located on the southeast side of the complex, consists entirely of cumulate rocks ranging from norite and gabbro to peridotite (Paktunc, 1988b). The other mafic intrusive rocks (unit SEmd) include fine- to medium-grained, plagioclase porphyritic and equigranular, ophitic-textured diabase, medium- to coarse-grained amphibole-clinopyroxene-biotite gabbro, and minor areas of diorite to quartz diorite adjacent to granitic intrusions. A small area of medium grained, biotite quartz diorite around Blue Ledge Lake, southeast of Popple Depot, has been included in unit SEmd.

Field relationships between younger granitic rocks (unit SEpg and SEag-SEah) and mafic intrusive rocks suggest that they are contemporaneous. Such features as cusped, irregular contacts with chilled margins of mafic against felsic rocks, pillowed mafic rock in granitic rock, and evidence of interaction between the two different composition melts to produce intermediate or hybrid composition rocks (Fig. 8, 9) are interpreted as reflecting magma-mixing. A few felsic dykes have been noted cutting gabbroic rocks, but no mafic dykes have been observed to cut granitic rocks.

ii. Eastern peraluminous granitic suite (unit SEpg): The eastern portion of the Mount Elizabeth complex consists of a compositionally and texturally homogeneous, pink and white, equigranular, fine- to coarse-grained biotite granite (Plate 4, fig. c) which contains traces of muscovite. A small body of K-feldspar porphyritic, biotite granite occurring to the southeast of Mount Mitchell is compositionally similar. There is a small area adjacent to Mount Elizabeth where this phase is more biotite-rich (granodiorite). A U-Pb monazite age of  $418 \pm 1$  Ma has been obtained from the main granitic phase (Bevier and Whalen, 1990b).

Contacts between the eastern and western granitic suites were not observed, but contacts between both granite suites and mafic intrusive rocks suggest they are contemporaneous. If there is only one age of mafic intrusion, then both the granitic suites are of a similar age, a conclusion which is supported by U-Pb ages.

iii. Western alkaline granitic suite (units SEag-SEah): The western portion of the Mount Elizabeth intrusive complex contains a spectrum of compositions and is characterized by an apparent close genetic relationship between mafic and felsic intrusive rocks. Though some areas are quite homogeneous, it appears, from both restricted outcrop and float, that portions of this suite are remarkably heterogeneous. Contacts between the various phases have not been observed but they are all tentatively considered to be of similar age. The intrusive phases will be discussed in order of increasing silica content.

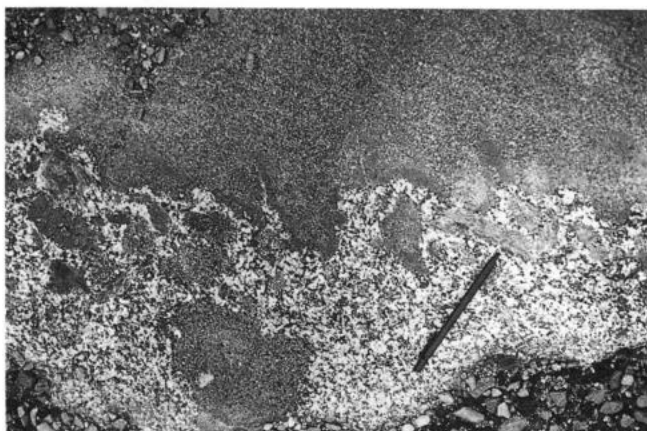
a. Hybrid intrusive rocks (unit SEah): There are areas adjacent to mafic intrusive rocks where probable interaction between coexisting mafic and felsic magmas has produced hybrid or intermediate compositions (Plate 4, fig. d). Most of these are truly mixed rocks in that they are characterized by partially digested mafic igneous inclusions in a dioritic to granitic matrix.

b. Syenite (unit SEas): A dark blue green, equigranular, medium grained, red brown weathering fayalite-hedenbergite syenite (Plate 4, fig. e) forms a small body in the middle of the complex and occurs as a marginal phase of the alkaline granite on Mount La Tour.

c. Quartz monzonite (unit SEaq): A beige-grey to orange, fine- to medium-grained, biotite-amphibole quartz monzonite (Plate 4, fig. f) is a major intrusive phase of the western suite. A notable feature of this rock is euhedral white plagioclase grains which are prominent on weathered surfaces. On the northwest slope of Tilley Ridge, there are a number of zones or dykes of glassy, flow-banded, grey to beige, rhyolitic intrusive rock which appear to be late offshoots of the quartz monzonite.

d. Aplite (unit SEaa): Closely associated with the quartz monzonite, are a number of areas of dark pink to red, very felsic aplite. Some portions have spherulitic textures (Plate 5, fig. a) and contain texturally-late interstitial blue amphibole but no biotite. Other portions consist of equigranular, biotite-bearing aplite which lacks amphibole.

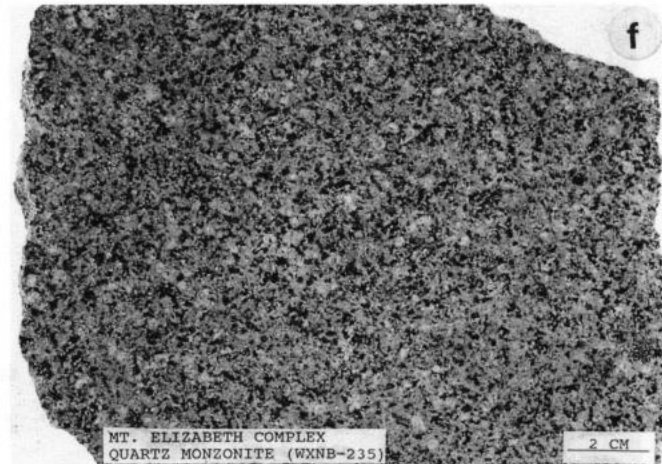
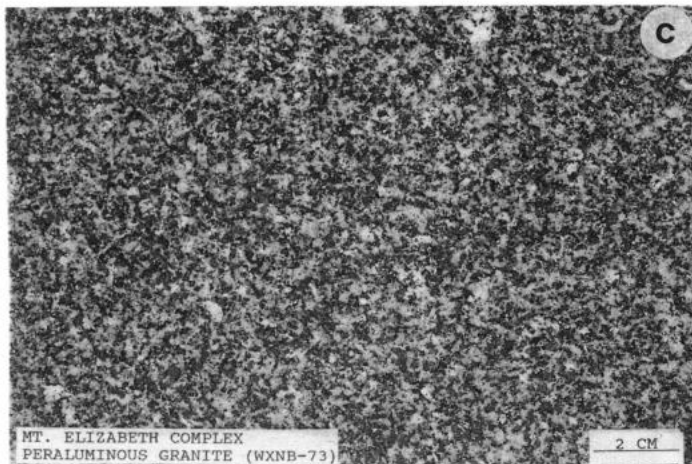
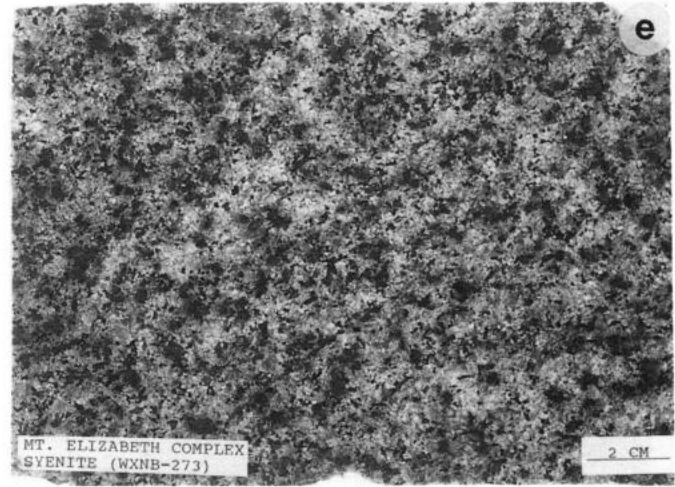
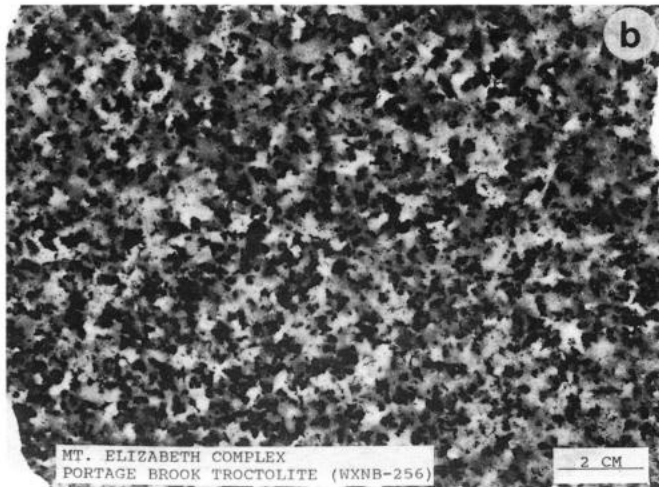
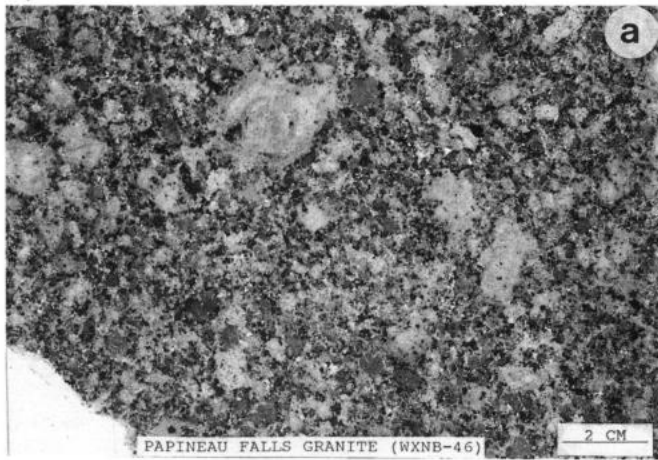
e. Alkaline granite (unit SEag): The most abundant phase of the western suite is a scarlet red, medium- to coarse-grained, equigranular granite (Plate 5, fig. b). Much of this phase contains only one feldspar (i.e. hypersolvus granite) and is amphibole-bearing. Red brown biotite aggregates in some samples are thought to pseudomorph fayalite. East of Mt. Marie, this unit includes cognate rocks that contain two feldspars. On Mount Charnisay this granite grades to high level, subvolcanic porphyry and rhyolite. In this area, there are rhyolites which look like possible volcanic equivalents of



**Figure 8.** Mt. Elizabeth complex (pluton G12) – cusped, irregular contact between diabase and quartz diorite. GSC 204394-E



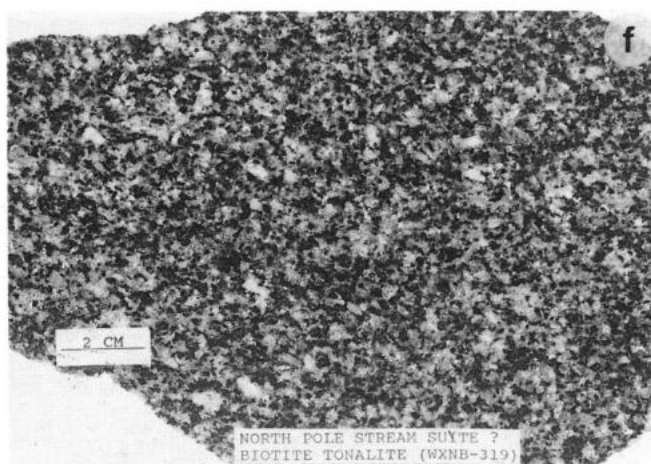
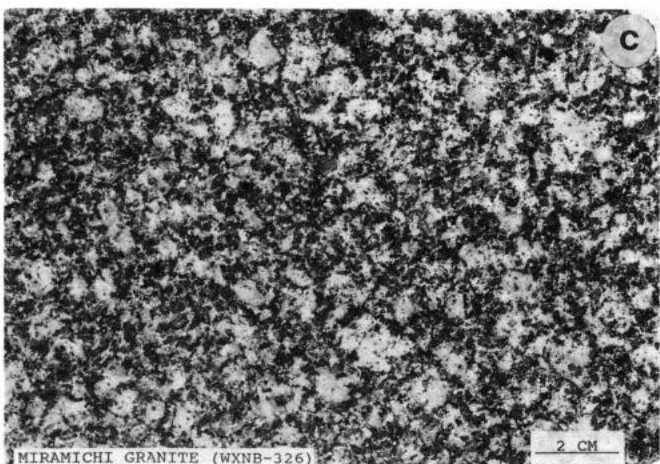
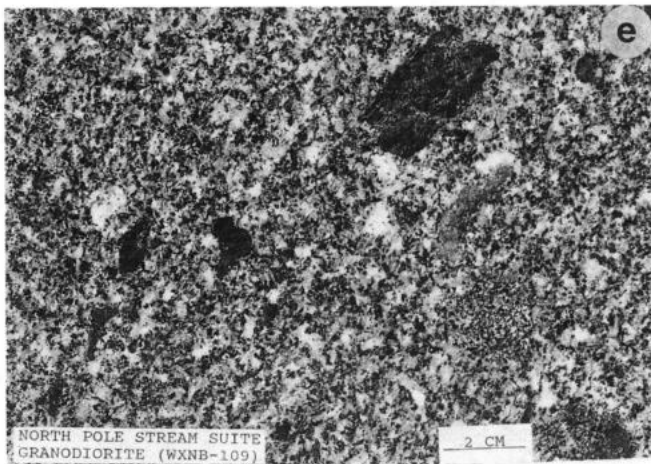
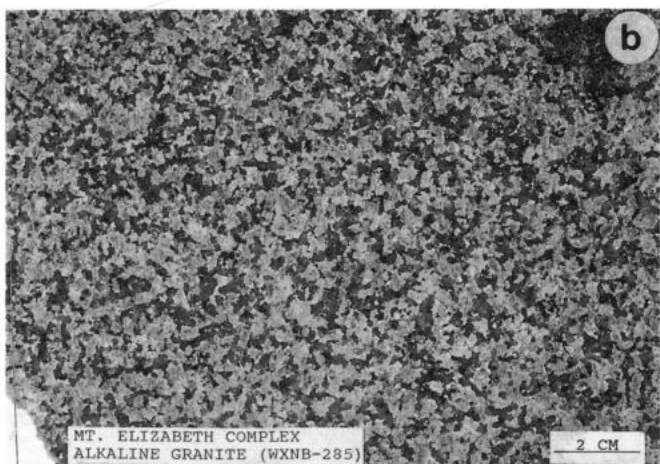
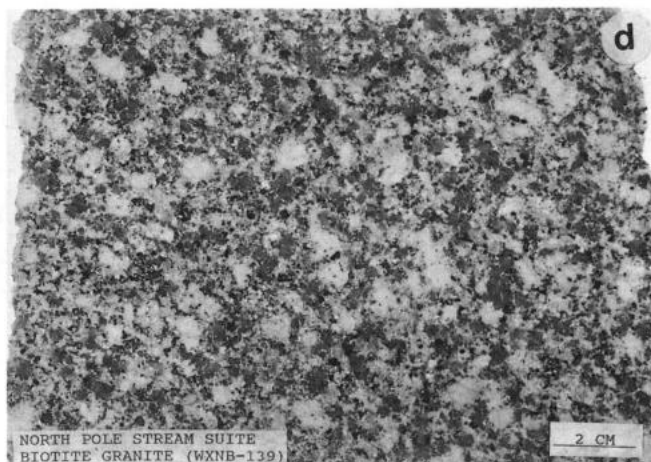
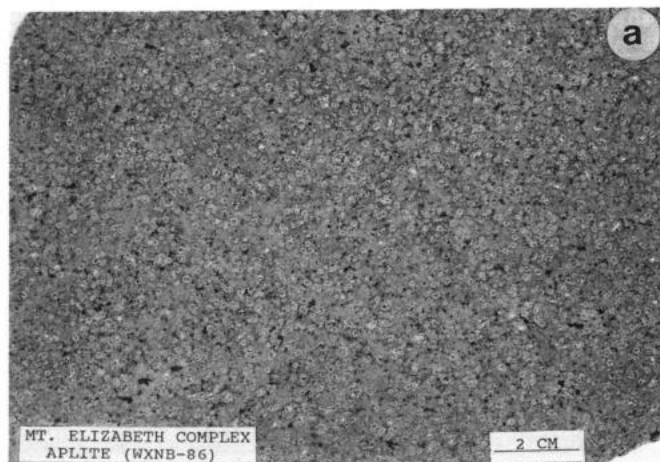
**Figure 9.** Mt. Elizabeth complex (pluton G12) – pillow-like basaltic inclusions in granite, surrounded by a zone of intermediate hybrid granodiorite. GSC 204394-A



#### Plate 4

##### Siluro-Devonian Gander Zone granite samples

- a. K-feldspar porphyritic, biotite granite (WXNB-46); Pabineau Falls granite (pluton G11). GSC 204780-F
- b. Portage Brook troctolite (WXNB-256); Mount Elizabeth complex (map unit SEmp) (pluton G12). GSC 204780-B
- c. Biotite-muscovite granite (WXNB-73); Mount Elizabeth complex (map unit SEpg) (pluton G12). GSC 204780-E
- d. Hybridized contact zone between quartz monzonite and diorite (WX85-56); Mount Elizabeth complex (map unit SEah) (pluton G12). GSC 204779-R
- e. Hedenbergite-fayalite syenite (WXNB-273); Mount Elizabeth complex (map unit SEas) (pluton G12). GSC 204779-U
- f. Amphibole quartz monzonite (WXNB-235); Mount Elizabeth complex (map unit SEaq) (pluton G12). GSC 204779-O



**Plate 5**

Siluro-Devonian Gander Zone granite samples

- a. Sperulitic amphibole aplite (WXNB-86); Mount Elizabeth complex (map unit SEa) (pluton G12). GSC 204780-J
- b. Amphibole-biotite granite (WXNB-285); Mount Elizabeth complex (map unit SEa) (pluton G12). GSC 204780-A
- c. Biotite-muscovite granite (WXNB-326); Miramichi granite (pluton G13). GSC 204779-C
- d. Biotite granite (WXNB-139); North Pole Stream suite (map unit SNg) (pluton G14). GSC 204779-P
- e. Metasedimentary inclusion-rich, biotite granodiorite (WXNB-109); North Pole Stream suite (map unit SNgd) (pluton G14). GSC 204779-I
- f. Biotite tonalite (WXNB-319); North Pole Stream suite (map unit SNgd) (pluton G14). GSC 204779-E

this granite. Some felsic dykes, which cut units SEmP and Ss, are thought to be equivalents of the alkaline granite. A sample of this granite gave a U-Pb zircon age of 414 +11/-1 Ma (Bevier and Whalen, 1990b).

**G13 – Miramichi granite (Map unit SM)**

The Miramichi granite (McNutt, 1961; Crocco, 1975) which is located on the eastern side of Map 1751A, exhibits textural variation from medium grained, equigranular to seriate and K-feldspar porphyritic (Plate 5, fig. c). Portions of this grey biotite granite bear a close resemblance to adjacent granite units SNg and SEpg. All these compositionally similar granites are thought to be comagmatic intrusions of the same age.



**Figure 10.** Exposure of North Pole Stream granite (pluton G14-map phase SNg) in roadcut two kilometres west of Big Bald Mountain; an extreme degree of surficial weathering has converted this granite to "granite gravel" or sand. GSC 204394-D



**Figure 11.** Clear-cut logged area located southwest of Big Bald Mountain in the northeast portion of the North Pole Stream granite (pluton G14-map phase SNg); although relief is moderate, bedrock exposure within this area is extremely poor. The light colour of the logging road reflects its being paved by "granite gravel", as in Figure 10. GSC 204394-F

**G14 – North Pole Stream granite suite (Map units SNp to SNgd)**

One of the largest intrusive bodies in the Central Plutonic Belt, the North Pole Stream granite (Crouse, 1979), has been renamed an intrusive suite by Whalen (1987b). The main intrusive phase is a medium- to coarse-grained, equigranular to K-feldspar porphyritic, white and pink biotite granite (unit SNg) (Plate 5, fig. d). In the region of Big Bald Mountain, this phase is very deeply weathered (Fig. 10, 11). To the south of Big Bald Mountain, there is a body of grey and black, biotite granodiorite (unit SNgd) which contains abundant, highly digested, metasedimentary inclusions (Plate 5, fig. e; Fig. 12). It is cut by white felsic dykes which may be offshoots of the biotite granite (SNg). Exposures of



**Figure 12.** Compositionally-banded metasedimentary and homogeneous biotite-rich inclusions in exposure of North Pole Stream granodiorite (pluton G14-map phase SNgd) on logging road, 8 km southeast of Big Bald Mountain. GSC 204394-I



**Figure 13.** North Pole Stream suite (pluton G14) – contact or hybridization zone between diabase and diorite (map phase SNd) and granite (SNg); the exposure indicates that multiple injection and hybridization has occurred between co-existing mafic and felsic magmas. GSC 204394-B

similar granodiorite and tonalite (Plate 5, fig. f) south of Long Lake in Map 1751A, which were included by Fyffe and Pronk (1985) in an intrusion they named the Squaw Lake granodiorite, have been included in unit SNgd. Contact relationships, like those described above from the Mount Elizabeth suite unit SEM, between amphibole-bearing diorite (Plate 6, fig. a) and diabase (unit SNd) and granite (SNg) (Fig. 13) suggest they are contemporaneous. Cutting the biotite granite (SNg) are bodies of fine- to medium-grained, white, muscovite-biotite granite (unit SNm) (Plate 6, fig. b), reddish biotite granite (unit SNb), and dark red brown quartz-feldspar porphyry (unit SNp) (Plate 6, fig. c). Some samples of unit SNm contain muscovite pseudomorphs after cordierite, and some relict cordierite. Exposures of lithologically identical granite (Plate 6, fig. d) east of Squaw Lake, previously included in the Squaw Lake granodiorite of Fyffe and Pronk (1985), are considered part of unit SNm. However, one sample (WXNB-137) collected from the Squaw Lake intrusion just east of Island Lake is amphibole-bearing and may not be genetically related to the muscovite-bearing portions. Further mapping is required to delineate intrusions in the area immediately south of Map 1751A.

A ten-point whole-rock Rb-Sr isochron from the eastern part of the suite gave an age of  $387 \pm 7$  Ma with an initial  $^{87}\text{Sr}/^{86}\text{Sr}$  ratio of 0.703 (Fyffe, 1982). Mineral ages obtained by Whalen and Theriault (1990) from unit SNm samples include a muscovite K-Ar age of  $414 \pm 5$  Ma and a Rb-Sr age of  $381 \pm 4$  Ma from one sample and a Rb-Sr muscovite age of  $425 \pm 4$  Ma and a biotite age of  $397 \pm 4$  Ma from another sample. A U-Pb monazite age of  $417 \pm 1$  Ma obtained from a unit SNg sample collected only one half kilometre south of the margin of Map 1751A has been interpreted as the intrusion age of the North Pole Stream granite (Bevier and Whalen, 1990a). Overlap of the K-Ar and U-Pb ages suggests that emplacement of all phases belonging to this suite was at a fairly high level (1.5-2.5 km?) and was followed by rapid cooling; an interpretation which is supported by the presence of miarolitic cavities in the muscovite-bearing granite phases. These results support the suggestion of Whalen (1988) that muscovite-bearing phases represent a high level, possible roof-zone portion of the North Pole Stream suite. The biotite granite sample dated by the U-Pb technique is from a deeper level (3-4 km?) of the intrusion and could have been above the closing temperature of monazite at the time of emplacement and solidification of the muscovite-bearing phases in the roof of the intrusion. The younger whole-rock Rb-Sr age of Fyffe (1982) can be interpreted as supporting the suggestion that in deeper level portions of the intrusion the Rb-Sr system remained open longer than near the roof zone.

#### *G15 – Redstone Mountain granite (map units SRd and SRg)*

The northern end of the Redstone Mountain granite, located in the southwest corner of Map 1751A (Crouse, 1977; Fyffe and Pronk, 1985) is a pink to scarlet red, medium grained,

biotite-amphibole granite (Plate 6, fig. e), which is similar to map unit SEag (Plate 5, fig. b). This intrusion, which extends about 23 km south of Trousers Lake, is much finer grained, even aplitic, where it is cut by Highway 108. Associated with it are dykes and bodies of fine- to medium-grained, pyroxene-amphibole diabase and gabbro (unit SRd). Based on epidote alteration and biotite recrystallization within this granite in close proximity to the North Pole Stream granite, unit SRg is thought to slightly predate unit SNg. Using a combination of the Rb-Sr age of  $409 \pm 25$  Ma for this granite (Fyffe and Pronk, 1985) and the U-Pb age of  $417 \pm 1$  on the North Pole Stream granite (Bevier and Whalen, 1990a), the Red Stone Mountain granite was emplaced between 417 and 425 Ma.

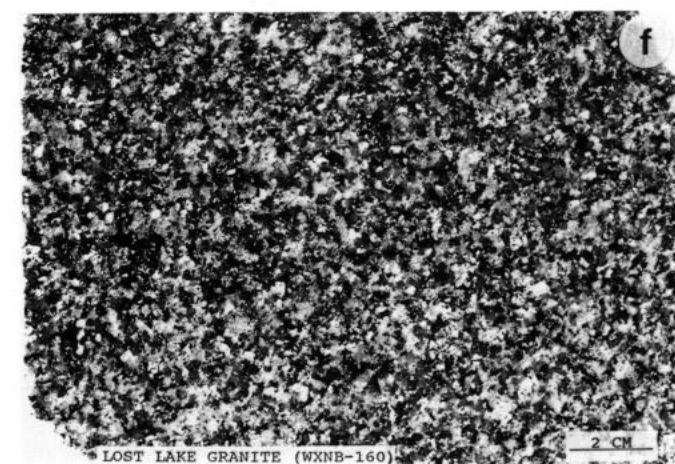
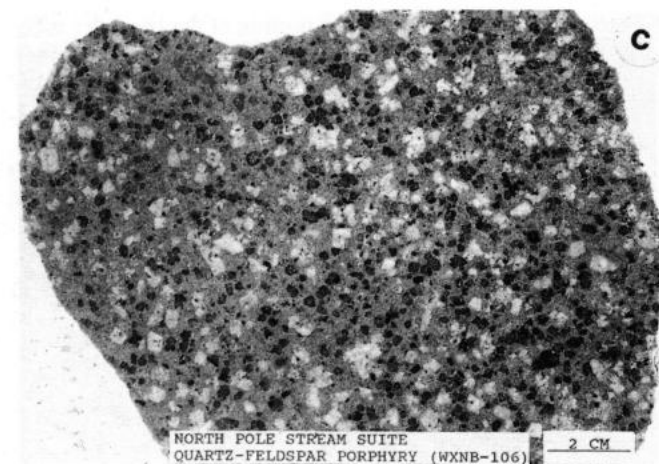
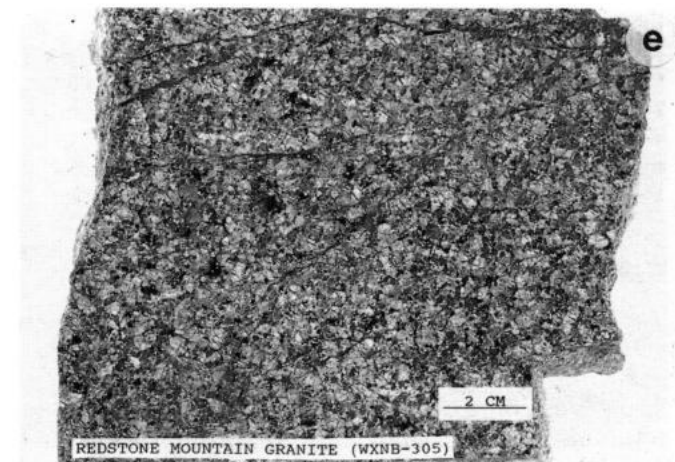
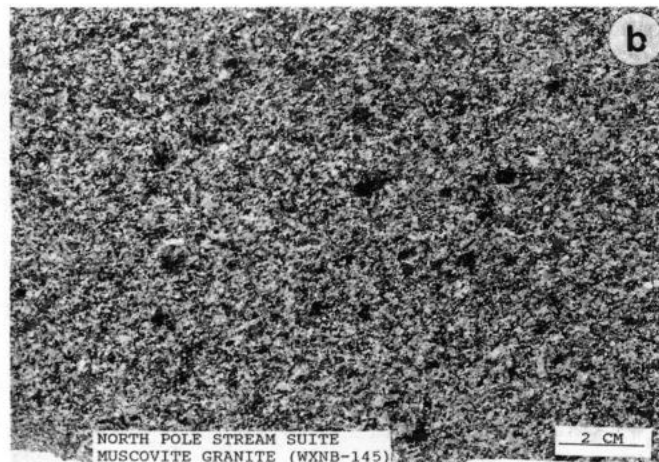
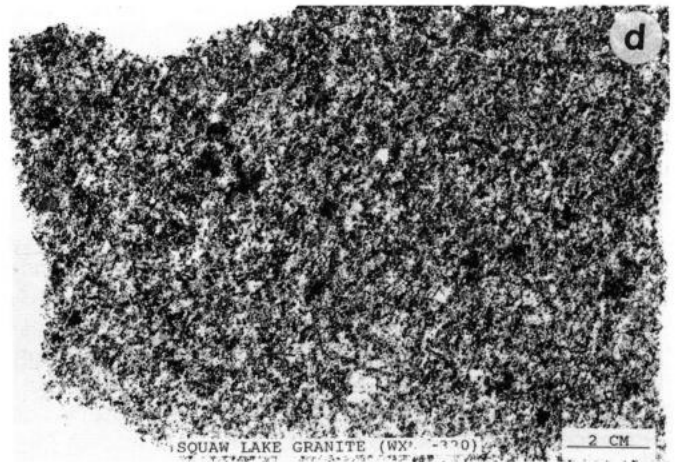
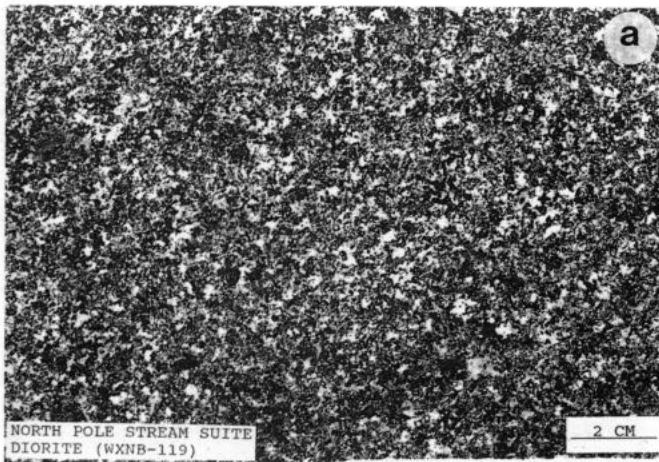
#### *G16 – North Dungarven River granite*

The North Dungarven River granite (see Fig. 1), as defined by Irrinki (1978), is an irregularly shaped 13 by 2 km body which includes a diverse spectrum of non-comagmatic lithologies. Lithologies sampled for this study include; biotite-amphibole quartz gabbro and tonalite, amphibole-biotite quartz diorite, white biotite granodiorite, K-feldspar porphyritic biotite granite and grey biotite- muscovite granite. Though paucity of outcrop prevented Irrinki (1978) from subdividing this body, evidence from outcrops on new logging roads in this area suggest subdivision of this "granite" into different intrusive units or bodies is possible. Irrinki (1978) describes a weak foliation in portions of this body but, based on its intrusive relationship with the Fox Ridge granite, considered it to be of post-Ordovician age.

#### *G17 – Lost Lake granite*

The Lost Lake granite (see Fig. 1), as defined by Crouse (1981a) and St. Peter (1981), is comprised of two subtypes or phases; (1) a grey to pink, fine- to medium-grained, massive to weakly foliated, equigranular, biotite granite to granodiorite; and (2) pink, medium grained, equigranular to subporphyritic, biotite-muscovite granite (Plate 6, fig. f). The first phase is weakly foliated and quartz and feldspar display cataclastic textures. This fabric is locally overgrown by late muscovite. Lost Lake samples collected in this study were mainly granodiorites but also included a tonalite and a granite.

Poole (1980) obtained a Rb-Sr whole rock model age of  $412 \pm 12$  Ma and a muscovite-whole rock age of  $424 \pm 24$  Ma from the Lost Lake granite. K-Ar and Rb-Sr muscovite ages obtained by Whalen and Theriault (1990) from the two Lost Lake granite phases are identical within standard errors, with an average age of 403 Ma. They interpreted their data and that of Poole (1980) as indicating that deformation and recrystallization of the Lost Lake granite has completely reset muscovite, both for the Rb-Sr and K-Ar systems. The 403 Ma age would thus be that of a deformation event with the intrusion age being  $>403$  Ma.



### Plate 6

#### Siluro-Devonian Gander Zone granite samples

- a. Amphibole-biotite quartz diorite (WXNB-119); North Pole Stream suite (map unit SNd) (pluton G14). GSC 204779-V
- b. Biotite-muscovite granite (WXNB-145); North Pole Stream suite (map unit SNm) (pluton G14). GSC 204779-M
- c. Quartz-feldspar-biotite porphyry dyke rock (WXNB-106); North Pole Stream suite (map unit SNp) (pluton G14). GSC 204779-Q
- d. Squaw Lake biotite-muscovite granite (WXNB-320); North Pole Stream suite (map unit SNm) (pluton G14). GSC 204780-R
- e. Biotite-amphibole granite cut by brittle fracture zones (WXNB-305); Redstone Mountain suite (pluton G15). GSC 204779-E
- f. Muscovite-biotite granodiorite (WXNB-160); Lost Lake granite (pluton G17). GSC 204780-S

### G18 – Burnthill Brook granites

The Burnthill Brook granites are a group of five plutons (Burnthill, Dungarvon, Trout Lake, Sisters Brook, and Rocky Brook) which have been recently re-mapped and described in detail by MacLellan et al. (1990) (see Fig. 1). These massive, felsic, texturally heterogeneous, pink and white, biotite granites, have been subdivided at 1:20 000 scale into four units: melanocratic, inequigranular, equigranular, and dyke phases by MacLellan et al. (1990). For this study, inequigranular (feldspar-quartz porphyritic) (Plate 7, fig. a) phases of the Burnthill and Trout Lake plutons and inequigranular (Plate 7, fig. b) + melanocratic (granodioritic) phases of the Dungarvon pluton were sampled. Some of these phases contain traces to a few modal per cent of muscovite.

Rb-Sr, K-Ar, and  $^{40}\text{Ar}$ - $^{39}\text{Ar}$  geochronological work on these intrusions is summarized in MacLellan et al. (1986, 1990). These authors consider the  $^{40}\text{Ar}$ - $^{39}\text{Ar}$  results to be the most reliable and conclude that these intrusions crystallized at 380 Ma (Middle Devonian) followed within 1 Ma by formation of associated mineral deposits, except for mineralization in the Trout Lake pluton which formed at about 376 Ma.

### G19 – Beatle Mountain granite

The Beatle Mountain granite (St. Peter, 1981), contains three subunits: muscovite-biotite granite, biotite-muscovite granite, and muscovite granite. The first, most northern phase, is described by St. Peter (1981) as being pink, fine- to medium-grained, equigranular to subporphyritic, and containing zones rich in rafts or xenoliths of biotite schist (1 to 10 cm). Sample WXNB-166, collected from an inclusion-rich portion of this subunit (Fig. 14), is biotite-rich (22%) and contains the peraluminous phases muscovite (16%), cordierite (7%), and sillimanite (2%). Other subunits in this body were found to be either too poorly exposed or deeply weathered to sample. Intrusive relationships indicate that this granite postdates the Juniper Barren granite (St. Peter, 1981). Based on the recent Silurian age of Whalen and Theriault (1990) for the Bogan Brook granodiorite, the Beatle Mountain granite could be either late Silurian or as young as Middle Devonian, as suggested by St. Peter (1981).

### G20 – Juniper Barren granite

Portions of this granite have been mapped by Crouse (1981a) and St. Peter (1981, 1982), who have described it as being mainly a massive, light grey to pink, medium- to coarse-grained, equigranular to subporphyritic, biotite granite. The intrusion also includes minor muscovite-biotite and biotite-muscovite granite, garnetiferous aplite and pegmatite. At its northern end, adjacent to the Catamaran fault, St. Peter (1981) has recognized altered and mylonitic equivalents of the Juniper Barren granite. Samples (WXNB-168, 170) collected from near the contact of this granite with the Bogan Brook granodiorite (intrusion G21) contain traces of amphibole and minor biotite-rich inclusions (Plate 9, fig. c). No isotopic dating has been performed on this intrusion, however, based on its unfoliated character, St. Peter

(1981) concluded that it was a late Acadian pluton of Devonian age. Data of Whalen and Theriault (1990) on the Bogan Brook granodiorite (see below) suggest this intrusion is of Silurian age.

### G21 – Bogan Brook granodiorite

The Bogan Brook granodiorite (St. Peter, 1981) is a small body of hornblende-biotite and biotite granodiorite bordering the southeastern margin of the Juniper Barren granite. Samples (WXNB-169, 170) collected from close to the contact of this body with the Juniper Barren granite are fine grained, grey, equigranular, biotite-muscovite tonalite and granodiorite which contain common biotite-rich meta-sedimentary inclusions. Sample WXNB-169 also contains cordierite and a trace of sillimanite. The author interprets these samples as being from a "contaminated" contact zone or envelope of the Juniper Barren granite. Field relationships described by St. Peter (1981) are compatible with this interpretation.

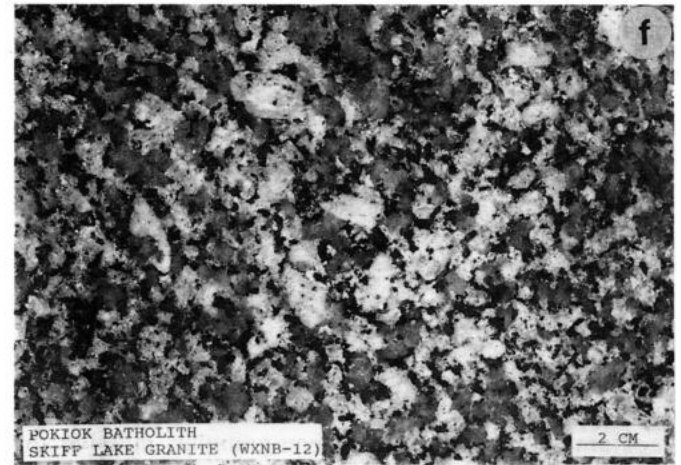
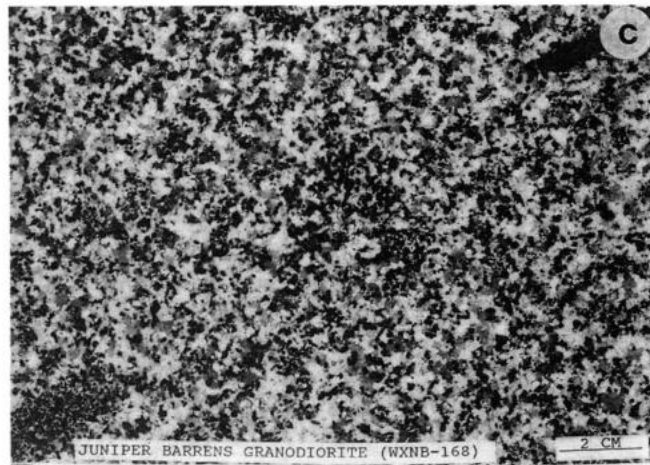
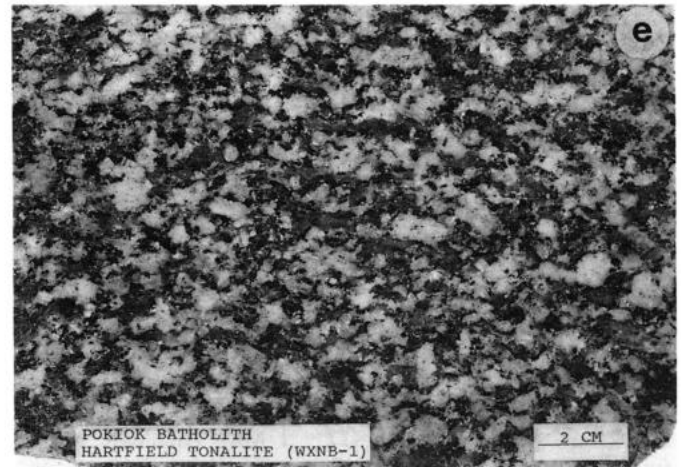
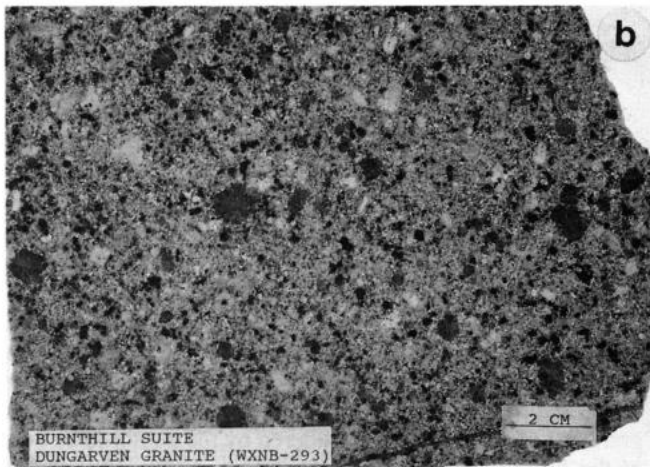
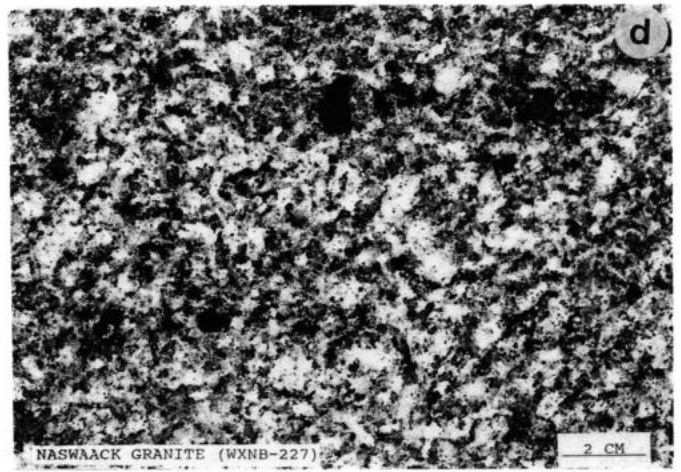
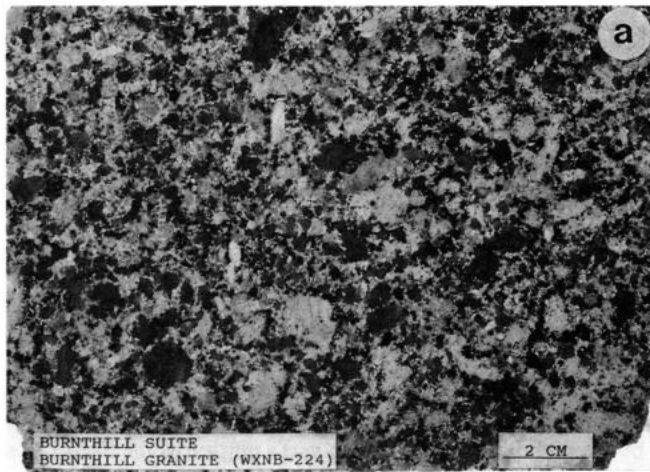
This pluton, considered by St. Peter (1981) to be only slightly older than the Juniper Barren granite, has been dated by Whalen and Theriault (1990). One muscovite separate from sample WXNB-169 gave a Late Silurian K-Ar age of  $421 \pm 6$  Ma and an Early Silurian Rb-Sr age of  $433 \pm 4$  Ma. These ages suggest an Early Silurian intrusion age for both the Bogan Brook granodiorite and the Juniper Barren granite.

### G22 – Nashwaak granite

This granite, which was formally named by Anderson (1968), has been recently re-mapped by Crouse (1981a, b) and St. Peter (1981). The northeastern portion of the body described by Crouse (1981a) consists of light grey, medium grained, equigranular, biotite granite and biotite-amphibole granodiorite. The western and southern portions of this body (St. Peter, 1981; Crouse, 1981b) comprise light grey to pink, fine- to medium-grained, equigranular, muscovite-biotite granite (Plate 7, fig. d) and minor biotite-muscovite granite



**Figure 14.** Metasedimentary and quartz-inclusion rich portion of the Beatle Mountain granite (pluton G19). GSC 204394-K



**Plate 7**

Siluro-Devonian Gander Zone granite samples

- a. Burnthill seriate biotite granite (WXNB-224); Burnthill suite (pluton G18). GSC 204780-K
- b. Dungenarven porphyritic biotite granite (WXNB-293); Burnthill suite (pluton G18). GSC 204780-M
- c. Biotite-amphibole granodiorite (WXNB-168); Juniper Barrens pluton (pluton G20). GSC 204779-D
- d. Muscovite-biotite granite (WXNB-227); Naswaack granite (pluton G22). GSC 204780-O
- e. Biotite granodiorite (WXNB-1); Hartfield tonalite phase of the Pokiok batholith (pluton G23). GSC 204780-H
- f. Biotite granodiorite (WXNB-12); Skiff Lake granite phase of the Pokiok batholith (pluton G24). GSC 204779-J

and pods of granite pegmatite. All four samples of this study are muscovite-bearing (0.4 to 5.5%) granites from the portion of the pluton mapped by St. Peter (1981). One sample (WXNB-227) contains fluorite (5%) and topaz (0.6%).

A minimum age gap of 26 Ma exists between Rb-Sr ( $422 \pm 4$  Ma) and K-Ar ( $386 \pm 5$  Ma) muscovite ages obtained from the Nashwaak granite, an age gap which has been interpreted as reflecting slow cooling of the intrusion following emplacement in the Early Silurian (Whalen and Theriault, 1990).

#### *Pokiok batholith – (intrusions G23, G24, G25, and G26)*

Lutes (1987), has compiled and described the geology of the Pokiok batholith, including all earlier work. In this bulletin, descriptions of the various components of the batholith are based on Lutes (1987) and the author's work. The Pokiok batholith has been subdivided by Lutes (1987) into three main components, which are from oldest to youngest: Hartfield tonalite, Skiff Lake granite, and Hawkshaw granite. The last two components are composite. In this report, a muscovite-biotite granite phase, which Lutes (1987) considered part of the Hawkshaw granite, has been termed the Allandale granite (Ruitenberg and Fyffe, 1982).

All earlier geochronological work on the batholith is summarized in Lutes (1987) and Whalen and Theriault (1990). Earlier K-Ar and Rb-Sr whole rock ages were contradictory. U-Pb ages from this batholith reported by Bevier and Whalen (1990a, b) are: Hartfield phase (sphene:  $415 \pm 1$  Ma); Skiff Lake phase (zircon:  $409 \pm 2$  Ma); Hawkshaw phase (sphene:  $411 \pm 1$  Ma); Allandale phase (monazite:  $402 \pm 1$  Ma). Significant age gaps exist between the Hartfield tonalite, the Skiff Lake-Hawkshaw granites and the Allandale granite. Grouping of the finer grained muscovite-biotite granite with the Hawkshaw granite, as has been done by Lutes (1987), is not appropriate. This granite is apparently a significantly younger phase of the batholith. All these finer grained two-mica granite phases in the Pokiok batholith, including those within the Skiff Lake phase, may be co-genetic younger intrusions which should be grouped together and called the Allandale phase. Such an approach would be analogous to that of Ruitenberg and Fyffe (1982).

#### *G23 – Hartfield tonalite*

This small (50 km<sup>2</sup>), northeast-trending intrusion occurs on the western margin of the Pokiok batholith. It consists of grey, medium- to coarse-grained, equigranular, massive to moderately foliated, biotite-hornblende tonalite and granodiorite (Plate 7, fig. e) which contains common schistose metasedimentary xenoliths. Venugopal (1979) interpreted this tonalite to be a syntectonic intrusion. A U-Pb titanite age of  $415 \pm 1$  Ma (Bevier and Whalen, 1990a) suggests a Late Silurian age of crystallization for this intrusion.

#### *G24 – Skiff Lake granite*

The Skiff Lake granite, which forms the southwestern portion of the Pokiok batholith, occupies an area of about 550 km<sup>2</sup>. It consists of grey, coarse grained, biotite-muscovite K-feldspar porphyritic granite and white, equigranular, fine- to coarse-grained muscovite-biotite and biotite-muscovite granite (Plate 6, fig. f) to granodiorite with associated muscovite-bearing pegmatite. The author, based on his own mapping and sampling, questions the appropriateness of the subdivision by Lutes (1987) of the Skiff Lake granite into five map units, based on texture (porphyritic or equigranular) and mineralogy (muscovite- and/or biotite-bearing). Also Lutes' subunit Hpg of the Hawkshaw granite, a grey, coarse grained, equigranular to porphyritic, biotite granodiorite is considered by the author to be identical to and a portion of the Skiff Lake granite (samples WXNB-22, 23, 26, 31).

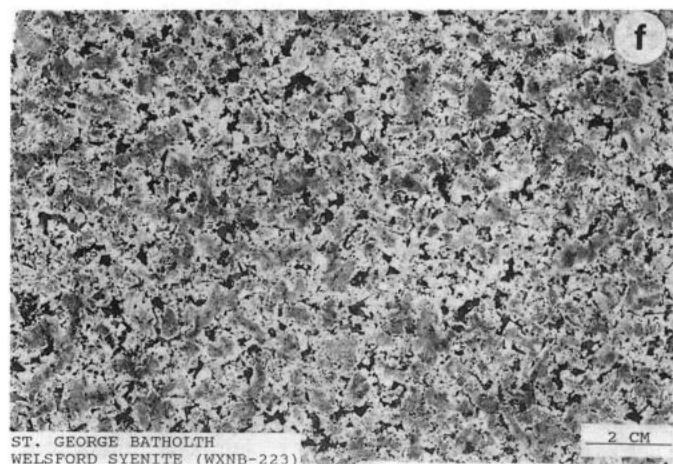
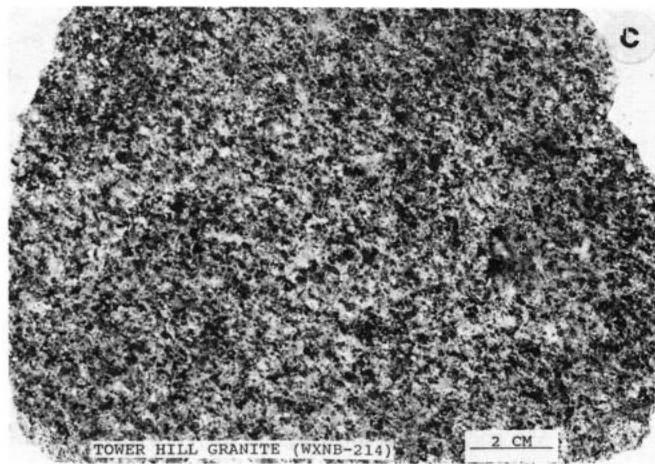
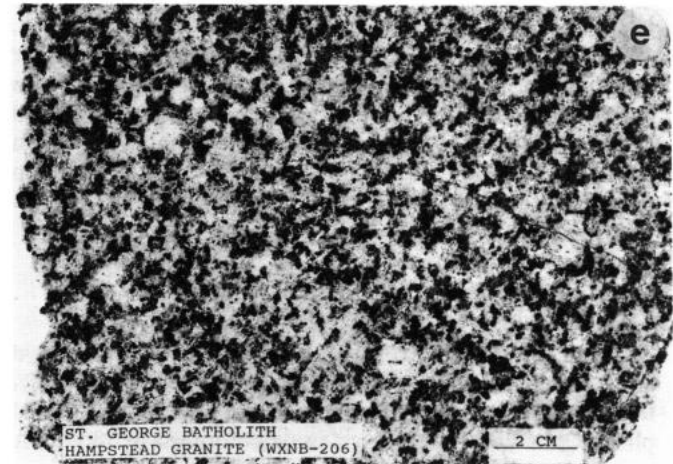
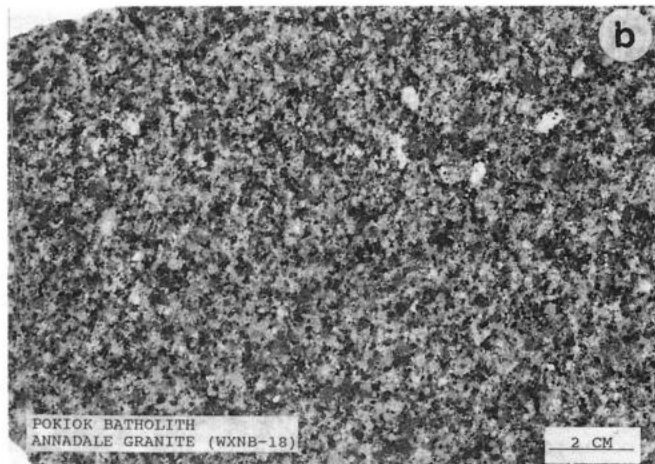
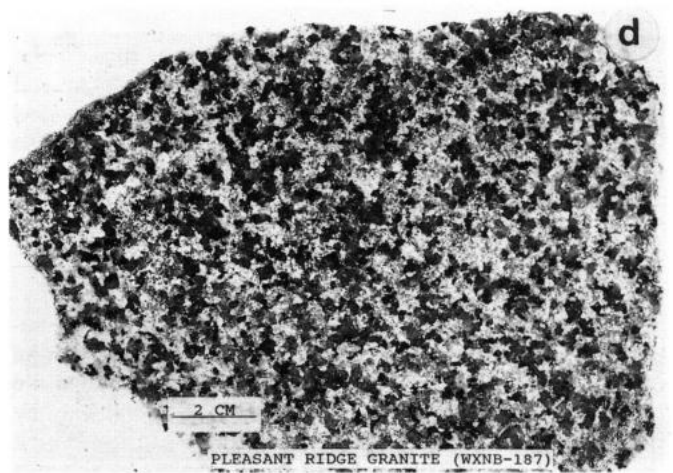
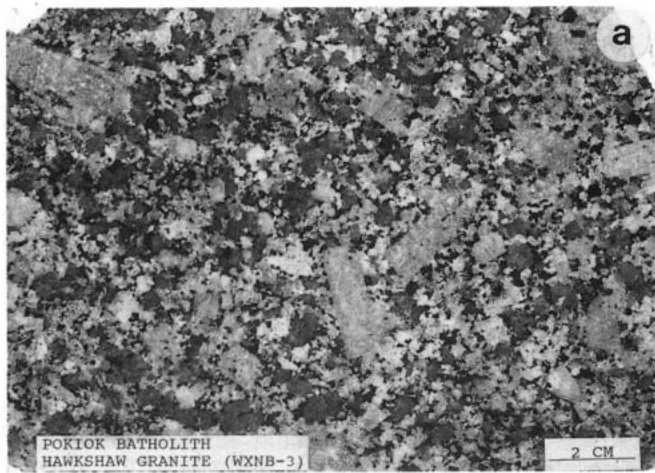
A U-Pb zircon age of  $409 \pm 2$  Ma from this granite (Bevier and Whalen, 1990a) suggests a Late Silurian age of crystallization. Rb-Sr, K-Ar, and <sup>40</sup>Ar/<sup>39</sup>Ar mica ages suggest that it took a minimum of 9 Ma and a mean time of 18 Ma for the Skiff Lake granite to cool from <600°C to 350°C (Whalen and Theriault, 1990).

#### *G25 – Hawkshaw granite*

The Hawkshaw granite, with an area of about 700 km<sup>2</sup>, forms most of the eastern half of the Pokiok batholith. It consists mainly of coarse grained, pink K-feldspar, porphyritic, biotite granite (Plate 8, fig. a; Fig. 15) to granodiorite with minor equigranular, pink, biotite granite. Other subunits of this granite (Lutes, 1987) are considered by the author to be part of the Skiff Lake granite (subunit Hpg, Lutes, 1987) or to constitute a separate phase, the Allandale granite (subunits Hem and Hpm, Lutes, 1978).



**Figure 15.** Glomerocrystic patch of K-feldspar megacrysts and fine grained, biotite-rich inclusions in K-feldspar porphyritic granite, Hawkshaw phase (pluton G25) of the Pokiok batholith. GSC 204394-C



### Plate 8

#### Gander and Avalon zone granite samples

- a. K-feldspar porphyritic, biotite granite (WXNB-3); Hawkshaw granite phase of the Pokiok batholith (pluton G25). GSC 204780-G
- b. Biotite-muscovite granite (WXNB-18); Annadale granite phase of the Pokiok batholith (pluton G26). GSC 204779-T
- c. Muscovite-biotite granite (WXNB-214); Tower Hill stock (pluton G28). GSC 204779-A
- d. Muscovite granite (WXNB-187); Pleasant Ridge stock (pluton G28). GSC 204780-Q
- e. Amphibole-biotite granodiorite (WXNB-206); Evandale granodiorite phase of the Saint George Batholith (pluton A1). GSC 204780-P
- f. Amphibole-pyroxene syenite (WXNB-223); Welsford complex phase of the Saint George Batholith (pluton A2). GSC 204779-Y

A U-Pb titanite age of  $411 \pm 1$  Ma from this granite suggests a Late Silurian age of crystallization. K-Ar and Rb-Sr muscovite ages from one sample can be interpreted as indicating that it took a minimum of 5 Ma and a mean time of 17 Ma for the Hawkshaw granite to cool from  $<600^\circ$  to  $350^\circ\text{C}$  (Whalen and Theriault, 1990).

#### *G26 – Allandale granite*

The Hawkshaw granite is cut by various pink to white, fine- to medium-grained, equigranular, muscovite-biotite granite (Plate 8, fig. b) bodies which in this report are called the Allandale granite. This name was employed previously by Ruitenbergh and Fyffe (1982) for these phases of the Pokiok batholith. Lutes (1987) included these granites as subunits Hem and Hpm of the Hawkshaw granite. However, a new U-Pb monazite age of  $402 \pm 1$  Ma (Bevier and Whalen, 1990a, b) demonstrates this granite to be a distinctly younger intrusive phase of the Pokiok batholith. K-Ar and Rb-Sr mica ages overlap with the U-Pb monazite age, suggesting rapid cooling of much of this phase in  $<1$  Ma (minimum) to  $<4$  Ma (average) (Whalen and Theriault, 1990) an interpretation compatible with its fine-grained to patchy medium-grained texture.

#### *G27 – Lake George Sb deposit granite*

Associated with the Lake George antimony mine (Procyshyn and Morrissy, 1989) is a grey to white, seriate to porphyritic, biotite-amphibole granite. Amphibole forms euhedral, zoned phenocrysts which are in part pseudomorphed by biotite. A composite drill core sample (WXNB-327) was obtained from Consolidated Durham Mines and Resources Inc. The presence of amphibole in this intrusion suggests it may be genetically distinct from any of the above described phases of the adjacent Pokiok batholith.

#### *G28 – Tower Hill and Pleasant Ridge granites*

These small stocks of beige, medium grained, equigranular muscovite-biotite granite (Plate 8, fig. c, d) have been mapped and described by Butt (1976). The Tower Hill intrusion is a fluorite- and topaz-bearing granite. Marginal portions of this stock are cut by quartz veins and pegmatites. Butt (1976) reports a Rb-Sr whole rock isochron age of  $422 \pm 15$  Ma from the Tower Hill granite.

#### *G29 – Beech Hill granite*

This small stock (Ruitenbergh, 1967; Butt, 1976), consists of fine grained, beige, feldspar-quartz-biotite granite porphyry and equigranular, medium grained granite. Butt (1976) reported a Rb-Sr whole rock isochron age of  $349 \pm 11$  Ma for the stock.

## **Economic geology**

Though they outcrop over a significant portion of this zone, Gander granites have, with a few exceptions, proven to date to be remarkably barren. Those of Ordovician age contain only one significant showing, the base metal vein and porphyry copper type showings associated with the Gibson granodiorite (pluton G10) (Thomas and Gleeson, 1987). In this showing on Connel Mountain, 19 million tonnes grading 0.18% copper have been outlined within altered quartz diorite and granodiorite.

In 1972 Canadian Occidental Petroleum Ltd. undertook work to evaluate the source of Mo, Cu, and Zn geochemical stream anomalies in the area of Bear Lake, 4 km east of Serpentine Lake in Map 1751A. Mapping by the author in this area indicated the presence of fracture-related sulphide mineralization (not indicated on map) with associated alteration cutting foliated felsic granite (unit Oge).

Gander zone Siluro-Devonian granites host two mines and a number of major and minor showings. The granite-related (pluton G27) Lake George antimony mine has been described by Procyshyn and Morrissy (1989). Silurian turbiditic metasedimentary rocks host vein deposits which form part of a complex polymetallic hydrothermal centre which includes a W-Mo stockwork zone. Intrusive progenitors for Late Devonian-Early Mississippian age W-Mo and Sn mineralization at Mount Pleasant in southeastern New Brunswick (see Sinclair and Kooiman, 1989) were not analyzed for this study. The other major Devonian granite-related deposits are the W-Sn-Mo-U mineral occurrences associated with the felsic, high level, multi-phase Burnthill Brook granites (pluton G18) (McLellan et al., 1990; Gardiner, 1989). These showings, including the Burnthill Mine and Sisson Brook deposit, consist of a complex group of endogranitic and exogranitic mineralized veins systems.

Related to high level, highly fractionated phases of the North Pole Stream suite (pluton G16), at the southwestern edge of Map 1751A, are showings of Zn, Cu, Pb, and U-Mo in fractured and silicified granite and adjacent sedimentary rocks. These showings occur in what is interpreted as the upper level or roof zone of the North Pole Stream granite suite. Other small vein-type showings associated with various Siluro-Devonian granites include: the Pabineau Lake Mo-Be showing in the Pabineau Falls granite (pluton G11); several Be showings in the Lost Lake granite (pluton G17); and several Mo and Be-Mo showings in the Hawkshaw granite (pluton G25).

Two mafic intrusive bodies in Map 1751A are the subject of past and current exploration interest for Ni, Cu, and Pt+Pd. The Portage Brook troctolite, which is located around Popple Depot at the northern end of the map area (map unit SEmP), contains probable magmatic-derived sulphide concentrations

(pyrrhotite, pentlandite, and chalcopyrite) of around 3-5% in some thin anorthosite layers with limited lateral continuity (Paktunc, 1988a). Platinum-group elements are mainly below detection limits. The Goodwin intrusion (map unit SEmG), which is located on the northeast side of Map 1751A, consists of cumulate rocks in which pyrrhotite with subordinate pentlandite and chalcopyrite are widespread. Drilling has outlined in excess of five million tonnes with 0.34% Cu, 0.28% Ni, and 0.03% Co and low platinum-group element concentrations (Paktunc, 1988b).

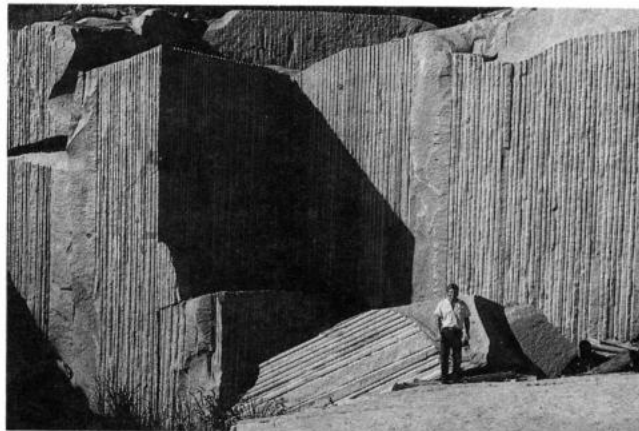
A number of areas with potential for gold mineralization have been recognized. (1) Zones of extensive quartz veining and dyking occur in Tetagouche Group rocks incorporated in roof pendants in the Mount Elizabeth intrusive complex (pluton G12). (2) Along their contact with the alkaline granite suite (units SEag-SEah), Devonian felsic volcanic rocks (unit Sf) contain disseminated and fracture-filling pyritic zones. (3) Deformed alkaline granites north and east of Serpentine Lake (unit Oge) are cut by sulphide-bearing veins with associated alteration haloes. (4) All the deformed granites are cut by major shear zones which could have acted as conduits for gold-bearing fluids. A small area of greisen alteration containing traces of molybdenite was recognized in biotite granite (unit SEpg) of the Mount Elizabeth complex (pluton G12) and a brecciated and silicified zone was identified in alkaline granite (unit SEag) south of Mount Edwards.

## Avalon Zone

### Introduction

The Avalon Zone, characterized by late Precambrian to Cambrian rocks, extends from Newfoundland southeast along the Appalachian orogen (Williams and Hatcher, 1983). In southern New Brunswick, typical Avalonian age volcanic, sedimentary, and gabbroic to granitic plutonic rocks, are intruded by Siluro-Devonian granites and overlain unconformably or structurally by post-Cambrian supracrustal rocks. The tectonic evolution of this zone and its spatial relationship during the Early Paleozoic the Gander Zone is still controversial (e.g. Nance, 1987). Only geochemical data on Siluro-Devonian intrusions are presented in this report. However, through collaborative research with other workers in this area, data has also been collected on late Precambrian Avalonian intrusions. Reference will be made to this data in later sections for comparative purposes.

All except one of the studied Siluro-Devonian granites within the Avalon Zone represent different components or phases of the northeast-trending Saint George Batholith. This batholith was emplaced at or near the tectonic junction between the Gander and Avalon zones. On its southeast margin it intrudes a complex sequence of late Precambrian Avalonian rocks (Currie, 1987). On its southwestern margins it intrudes Silurian to Devonian volcanic and sedimentary rocks (Gardiner, 1987) and on its northwest margin it intrudes Ordovician and Silurian rocks (Ruitenbergh, 1967). A number of major faults (Pendar Brook, Ketchum Brook, and Wheaton Brook) played a major role in controlling the development and emplacement of this batholith (McLeod, 1987).



**Figure 16.** Quarry within the Evandale granodiorite (pluton A1) phase of the Saint George Batholith. GSC 204394-J

### Granite descriptions

#### A1 – Evandale granodiorite

This oval intrusion (Ruitenbergh, 1970), located northeast of the Saint George Batholith, adjacent to the Saint John River, consists of equigranular, medium grained, pink, biotite-amphibole granodiorite to granite (Plate 8, fig. e). The four samples from this body (WXNB-206 to 209) were all collected from different building stone quarries (Fig. 16).

#### A2 – Welsford and Jake Lee Mountain complexes

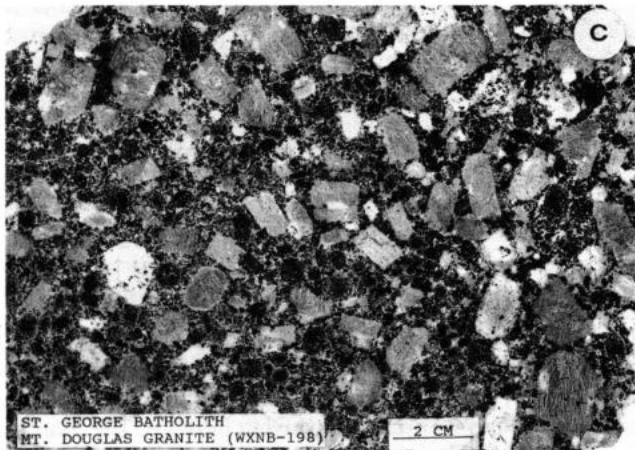
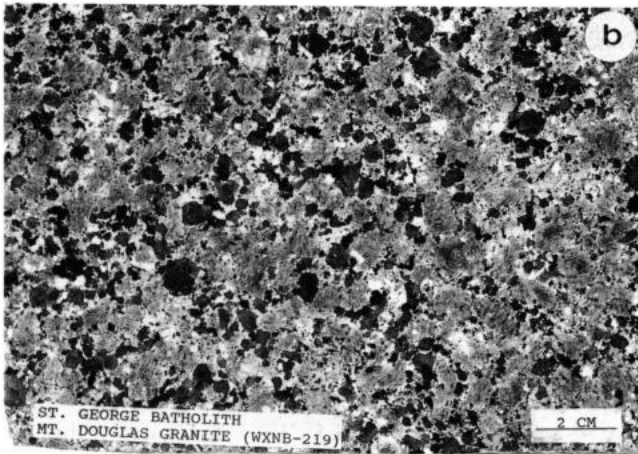
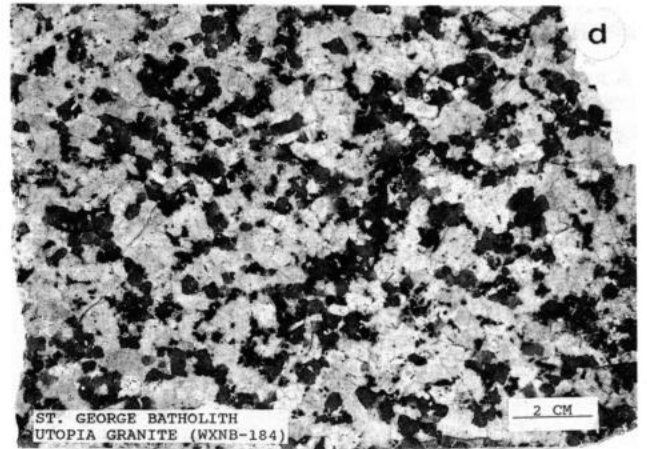
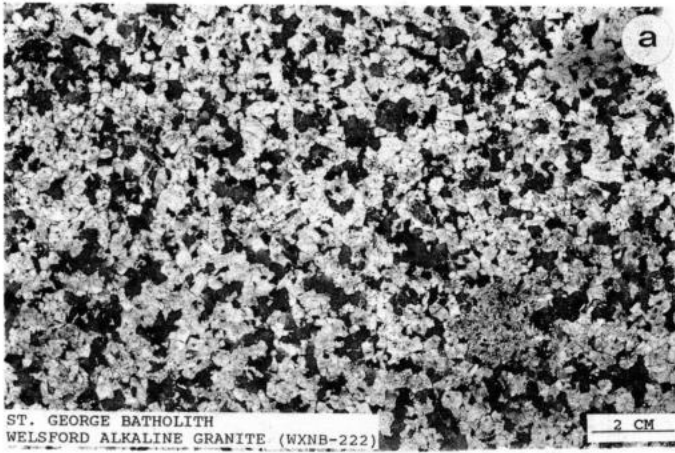
The Welsford complex, an elongate, northeast-trending protrusion at the east-end of the Saint George Batholith, has recently been described by Payette and Martin (1987) and mapped by McCutcheon and Ruitenbergh (1987). The Jake Lee Mountain complex (Currie, 1987) is located within the south-central portion of the Saint George Batholith. These complexes, which are intruded by the Mount Douglas granite, are thought to represent remnants of a once more extensive, possibly continuous intrusion. The lithologically diverse group of alkaline intrusive rocks within these complexes include: grey, medium grained, equigranular, biotite quartz syenite and beige, amphibole-pyroxene syenite (Plate 8, fig. f); pink, fine grained, amphibole-biotite-pyroxene quartz monzonite; and pink, fine- to medium-grained, feldspar porphyritic amphibole-biotite granite and beige, fine- to coarse-grained, equigranular, amphibole-pyroxene alkali granite (Plate 9, fig. a). Some phases exhibit extensive granophyric textures and contain miarolitic cavities.

The Welsford complex was interpreted by Payette and Martin (1987) as being comagmatic with Silurian volcanics of the Jones Creek Formation which it intrudes. The Silurian age of this complex has been substantiated by a U-Pb zircon age of  $422 \pm 3$  Ma obtained from an alkali granite (Bevier, 1989).

**A3 – Mount Douglas granite**

The Mount Douglas granite (McCutcheon, 1981), which forms the eastern lobe of the Saint George Batholith, has recently been mapped by McLeod (1987, 1990). It consists of multiple phases of comagmatic, texturally diverse, beige

to red, felsic biotite granite. There are fine- to coarse-grained, equigranular to seriate and porphyritic phases (Plate 9, fig. b, c) as well as aplites and pegmatites. A Late Devonian U-Pb zircon age ( $367 \pm 1$  Ma; Bevier, 1989) confirms it to be the youngest component of the Saint George Batholith.



**Plate 9**

Avalon Zone granite samples.

- a. Amphibole-pyroxene alkali granite (WXNB-222); Welsford complex phase of the Saint George Batholith (pluton A2). GSC 204779-X
- b. Seriate biotite granite (WXNB-219); Mt. Douglas granite phase of the Saint George Batholith (pluton A3). GSC 204779-N
- c. Feldspar porphyritic, biotite granite (WXNB-198); Mt. Douglas granite phase of the Saint George Batholith (pluton A3). GSC 204779-B
- d. Biotite granite (WXNB-184); Utopia granite phase of the Saint George Batholith (pluton A4). GSC 204779-K
- e. K-feldspar megacrystic, biotite-amphibole granodiorite (WXNB-195); Magaguadavic granite phase of the Saint George Batholith (pluton A5). GSC 204779-W

#### A4 – Utopia granite

The Utopia granite (Ruitenbergh and Fyffe, 1982; Gardiner, 1987), which forms a southwestern portion of the Saint George Batholith, consists of beige to pink, equigranular, medium grained, biotite granite (Plate 9, fig. d). The remarkable textural uniformity of this granite is disturbed only by rare felsic aplite dykes and xenoliths. A U-Pb zircon age of  $430 \pm 3$  Ma (Early Silurian) from this granite (Bevier, 1989) indicates that it is the oldest component of the Saint George Batholith.

#### A5 – Magaguadavic granite

The Magaguadavic granite (Ruitenbergh and Fyffe, 1982; Gardiner, 1987), which forms a southwestern portion of the Saint George Batholith, consists of white to pink, coarse grained, K-feldspar megacrystic, biotite-hornblende granite and granodiorite (Plate 9, fig. e) and seriate, biotite granite. A U-Pb zircon age of  $396 \pm 1$  Ma from this granite (Bevier, 1989) indicates an Early Devonian age of crystallization for the Magaguadavic granite.

#### A6 – Bocabec complex

The Bocabec complex (Ruitenbergh, 1967; Fyffe, 1971; Gardiner, 1987) forms the southwestern end of the Saint George Batholith. It includes gabbro-norite, diorite, granodiorite, and quartz monzonite to granite. The medium- to coarse-grained, equigranular, pyroxene-amphibole-biotite gabbro-norite is locally layered. The biotite granite component in this complex is lithologically identical to the Utopia granite. Based on mapped intrusive relationships, however, Gardiner (1987) concluded that the Bocabec complex predates the Utopia granite. A study of the southwest portion of this complex by Fyffe (1971) suggested that intermediate or hybrid (granodioritic and monzonitic) compositions in this complex were formed by interaction between felsic magmas and solid mafic intrusions. Field relationships observed by the author resemble those exhibited by the already described McGerrigle and Mt. Elizabeth complexes. This would suggest that the Bocabec complex is the result of interaction between a mafic magma and the Utopia granite magma and thus of the same age ( $430 \pm 3$  Ma).

#### Economic geology

The economic potential of various components of the Saint George Batholith has been outlined by Ruitenbergh and Fyffe (1982) and McLeod (1988, 1990). In the eastern portion of the batholith, there are Sn-W bearing greisen and alteration zones related to the youngest, most highly differentiated phases of the Mount Douglas granite (pluton A3). Associated with the Evandale granodiorite (pluton A1) is an extensive zone of porphyry type Cu-Mo mineralization and associated with the Welsford complex (pluton A2) are base metal sulphide veins and breccia fillings. The phases in the western portion of the batholith (plutons A4 and A6) are host to numerous vein and fracture-fill-type Mo and Cu mineral occurrences, particularly near their contacts. Equigranular

portions of the Magaguadavic granite (pluton A5) are locally greisenized and contain disseminated W and Sn with associated Pb and Cu.

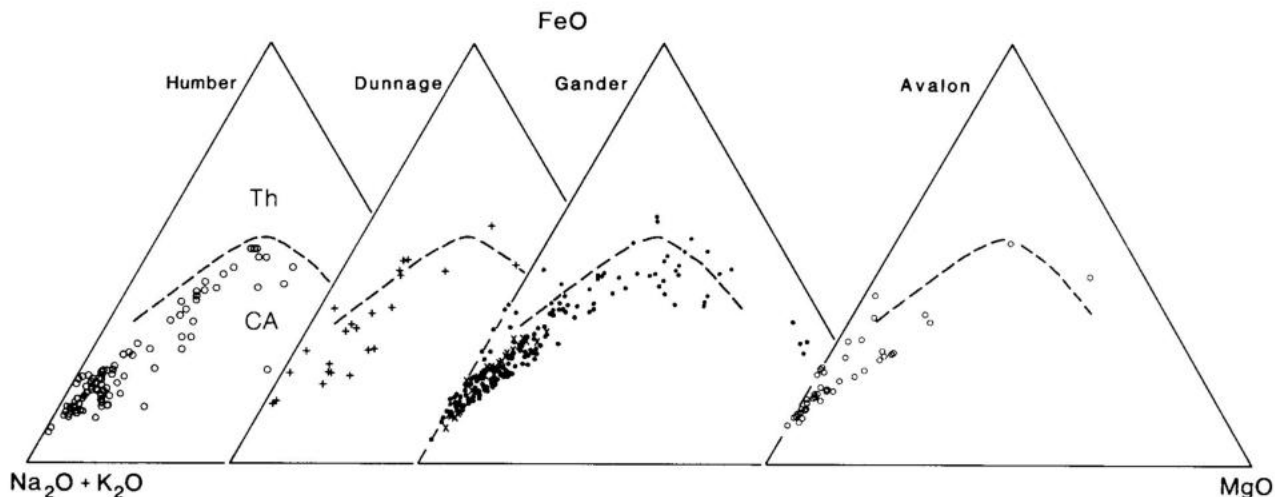
## GEOCHEMICAL AND TECTONOMAGMATIC CHARACTERISTICS OF GRANITES AND ASSOCIATED MAFIC INTRUSIONS

### Introduction

This section provides a geochemical overview or summary which highlights similarities and differences between plutons both within and between zones. In general, Appalachian granites exhibit distinctive zone-specific geochemical characteristics. Gander Zone granites appear to have been derived from mixtures of crustally and mantle-derived components, whereas in other zones granites exhibit features indicative of generation from mantle-derived protoliths. A surprising number of these I-(infracrustal) type plutons are very felsic with A-type affinities. Associated mafic phases are rare and tend to have volcanic-arc to shoshonite-like affinities. Although these plutons are not easily "pigeon-holed" as being typical of any particular tectonic process or environment, a transitional within-plate to volcanic arc setting can be suggested based on the geochemical evidence.

Plutonic magmatic associations can be identified on the basis of the trends which suites define on modal quartz-plagioclase-K-feldspar (QKP) diagrams (Lameyre, 1987; see Fig. 2) or major element chemical plots, such as AFM diagrams (Irvine and Baragar, 1971). In the case of the granites covered in this report, most plot in the calc-alkaline field near the alkali corner (Fig. 17), reflecting their generally leucocratic rather than calc-alkaline character. This inability of AFM diagrams to resolve small but important major element differences between granite suites has been discussed by Debon et al. (1986). As an alternative to AFM diagrams, Debon and Le Fort (1982) developed a number of major element-based chemical-mineralogical diagrams which provide both granite typology and magmatic association information (see Fig. 18, 19, 20). As in the I- and S-type granite classification (Chappell and White, 1974; White and Chappell, 1977), a measure of aluminous character ( $A = \text{Al} - (\text{K} + \text{Na} + 2\text{Ca})$ ) is the key index in these diagrams. Other parameters are B ( $\text{Fe} + \text{Mg} + \text{Ti}$ ), a measure of dark minerals; Q ( $\text{Si}/3 - (\text{K} + \text{Na} + 2\text{Ca}/3)$ ), a measure of quartz; and F ( $555 - (\text{Q} + \text{B})$ ) which is proportional to feldspars (+muscovite).

Based on aluminous character ( $A = \text{Al} - (\text{K} + \text{Na} + 2\text{Ca})$ ) (see Fig. 20), Debon and Le Fort (1982) distinguish three main types of magmatic association; cafemic (mainly or completely from mantle-derived source materials), aluminous (mainly or completely derived by anatexis of continental crust), and aluminous-cafemic (intermediate between the other two types, i.e. mixed mantle-crustal protolith). Mafic end-members of cafemic associations plot in the metaluminous domain (i.e.  $A < 0$ ), though their felsic members may enter the peraluminous domain ( $A > 0$ ), i.e. these suites start with amphibole and/or pyroxene but often end with biotite alone



**Figure 17.** AFM diagrams for New Brunswick and Gaspésie granites grouped by tectonostratigraphic zone; Gander Zone granites are subdivided by age into Ordovician (x's) and Siluro-Devonian granites (dots). AFM dividing line between calc-alkaline (CA) and tholeiitic (Th) fields from Irvine and Baragar (1971).

or two mica rocks. Aluminio-cafemic associations usually but not exclusively plot in the peraluminous domain (i.e.  $A > 0$ ). They differ from aluminous associations in their negative slopes and location of their mafic components in or close to the metaluminous domain ( $A = 0$  to 5) in Figure 20. Though these suites are micaceous (biotite±muscovite), mafic end-members are often amphibole-bearing. Mafic end-members of aluminous associations are rooted in the peraluminous domain ( $A > 40$ ), whereas felsic end-members often plot close to the metaluminous domain ( $A = 10$  to 15), i.e. these suites have positive to slightly negative trends. Aluminous suites almost always consist of two mica rocks, with or without additional aluminio-silicates. Subdivisions of cafemic and aluminio-cafemic granite associations (subtypes) recognized based on topology and evolutionary trends in Figures 18, 19, and 20 are tholeiitic, calc-alkaline, monzonitic, alkaline, and peralkaline.

Representative granite "spidergram" type plots, a frequently employed method of trace element presentation, are presented in Figure 21. As granites are commonly considered to have crustal protoliths, the continental crust composition of Taylor and McLellan (1985), rather than MORB or primordial mantle, has been employed as the normalizing composition. In Figure 22, chondrite normalized REE plots are presented for the same samples as are plotted in Figure 21. Plots of various major and trace element concentrations and ratios for granites with  $\text{SiO}_2 > 60$  wt.% versus distance along a south-north cross section (A-B in Fig. 1) are presented in Figure 23. These plots serve a number of purposes. Firstly, they permit easy comparison between different plutons or suites within zones. Secondly, they portray major granite chemical contrasts between zones and the spatial variations in granite geochemistry across the orogen. This latter aspect of these plots will be discussed in detail (see Granite geochemical and isotopic variations across

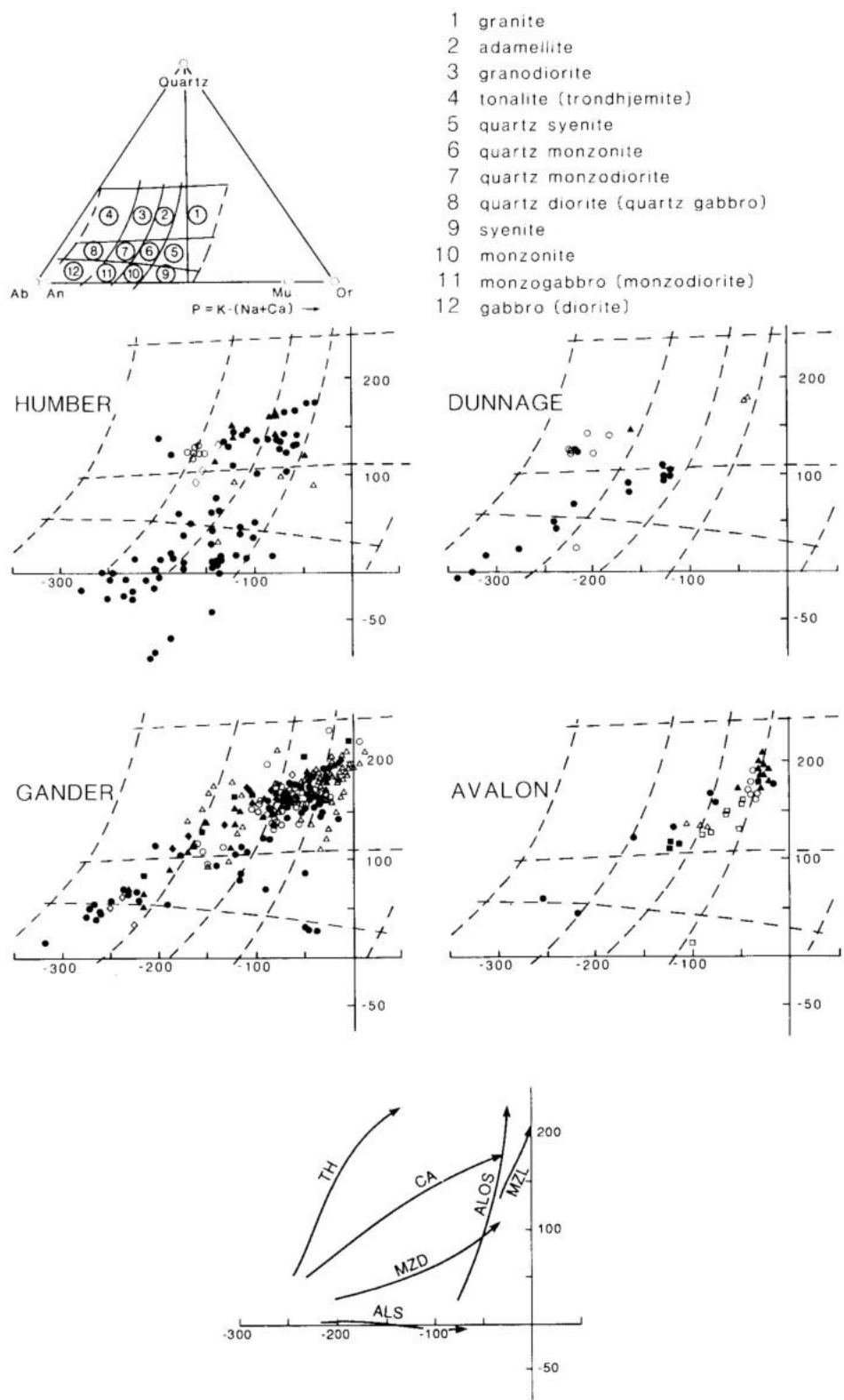
the orogen, below). Other granite plots discussed in this section (Fig. 24, 25, 26, 27, below) provide information on tectonomagmatic affinities or characteristics.

For the sake of brevity, no attempt has been made in this section to provide an exhaustive analysis of data from each and every pluton or suite. In modal and geochemical diagrams (Fig. 2 and 17 to 23; see also 24 to 27 below) intrusions have been subdivided or grouped by the zone which they intrude. This approach, plus the use of a common set of symbols for most of these plots (Table 1), will greatly facilitate comparison by the reader of granites between and within zones.

## Granite geochemical characteristics

### Humber Zone

All data collected from the McGerrigle complex (H1)(J.B. Whalen, unpub. data) have been plotted in Figures 2 and 17 to 23, and 24 to 30 (see below); representative analyses can be found in the appendices. In comparison to the McGerrigle plutonic complex, which contains a wide spectrum of intrusive rock types ( $\text{SiO}_2 = 44$  to 77 wt.%), there is a limited compositional range within other Humber intrusions (Fig. 18 and 19). Mines Gaspé (H2) and Mont Hog's Back and Mont Chauve (H3) intrusions are of granite to granodiorite composition. Mont Brown (H3) is of quartz monzodiorite to granodiorite composition and Mont Vallières-de-St-Real (H5) is of quartz monzonite to quartz syenite composition. These metaluminous, sodium-rich plutonic rocks (Fig. 23a, b, c) plot in the biotite±amphibole or clinopyroxene±amphibole±biotite stability fields in Figure 20. Those samples which plot in the field of biotite±muscovite exhibit petrographic evidence of alteration. The distribution of Humber granites in Figures 2, 18, 19, and 20 indicate they belong to a monzonitic suite or sub-type of a cafemic (mantle-derived protolith) magmatic association.



**Figure 18.** Distribution of granites in the four tectonostratigraphic zones in the 'nomenclature' (Q-P) diagram of Debon and Le Fort (1982); key to symbols in Table 1. The "Q" and "P" parameters are in gram-atoms  $\times 10^3$  in 100 g of rock or mineral. Each field corresponds to a petrographic type as labelled in the top diagram. For comparison, typical trends of different subtypes of calc-alkaline or aluminous-calc-alkaline associations from Debon et al. (1986) are shown: TH – tholeiitic, CA – calc-alkaline, MZD – MZL – dark and light coloured monzonitic respectively, ALS – ALOS – alkaline saturated and oversaturated respectively.

In their trace element characteristics (Fig. 21a, 22a, and 23d-k), McGerrigle samples exhibit a large range in the elements from U to Sc and all have positive Nb anomalies and negative Cs anomalies. Particularly notable is the marked enrichment of this suite in Nb relative to other plutons in the orogen (see Fig. 23f). Miaskite (WXMG-16) and tinguite (WXMG-94) phases contain the greatest concentrations of U to Sc. Hybrid suite monzonites (e.g. WXMG-29) and quartz syenites (e.g. WXMG-44) are less enriched in U through Sc than the undersaturated felsic rocks. The main volume of granites in the complex (see WXMG-60 in Fig. 21a, b) is less enriched in high field strength elements than hybrid suite rocks. Within the hybrid suite portion of the complex is a geochemically different granite phase (e.g. WXMG-28 in Fig. 21a and 22b). This granite exhibits a distinctly different heavy rare-earth element (relative to light rare-earth element) depleted pattern, as well as being more depleted in all elements from U to Sc than other McGerrigle suite samples. Cutting the granite suite at the southern margin of the complex are a number of quartz-feldspar porphyry dykes. Although only X-ray spectrometry trace element data is

available for these samples, these dykes are lithologically and chemically similar to the Mines Gaspé intrusions (see WXMG-103 in Fig. 21b and 22b).

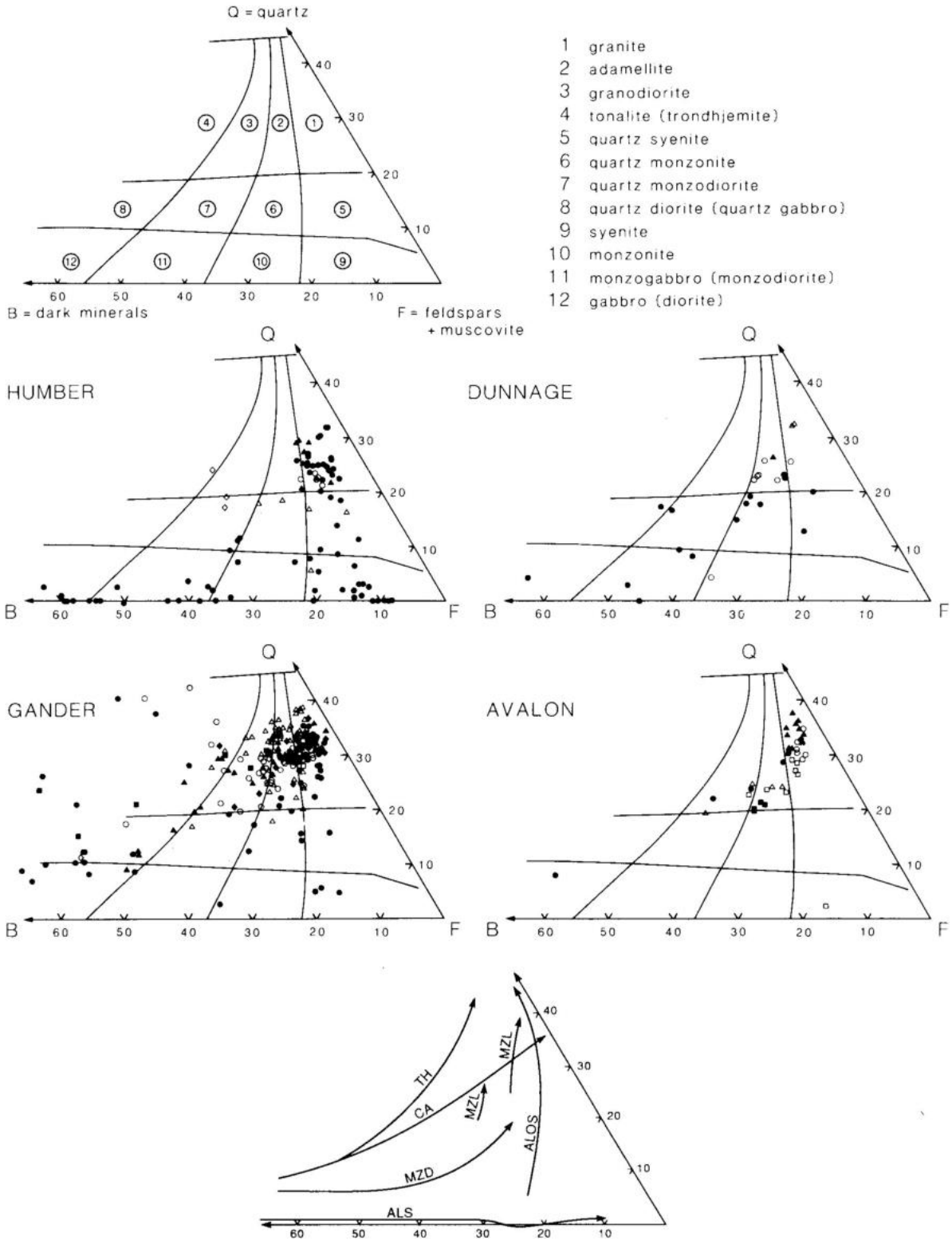
In spite of some hydrothermal alteration, normalized patterns for 7 samples of Mines Gaspé intrusions (pluton H2) (not shown) are very similar, except for higher concentrations of K and Rb in the most altered samples. All Mines Gaspé samples are depleted in incompatible elements relative to the bulk of the McGerrigle suite, have negative Cs and Nb anomalies and strongly fractionated heavy rare-earth elements depleted rare-earth elements patterns (see WXMG-103 in Fig. 21b and 22b). These features are similar to those of the Mont Hog's Back and Mont Chauve intrusions (see WXMG-32 in Fig. 21b and 22b), except that the latter contain about 50% lower concentrations of incompatible elements.

The Mont Brown intrusion (pluton H3)(WXMG-110 in Fig. 21b, 22b) exhibits a similar pattern to that of the Mines Gaspé intrusions, except that it is less heavy rare-earth

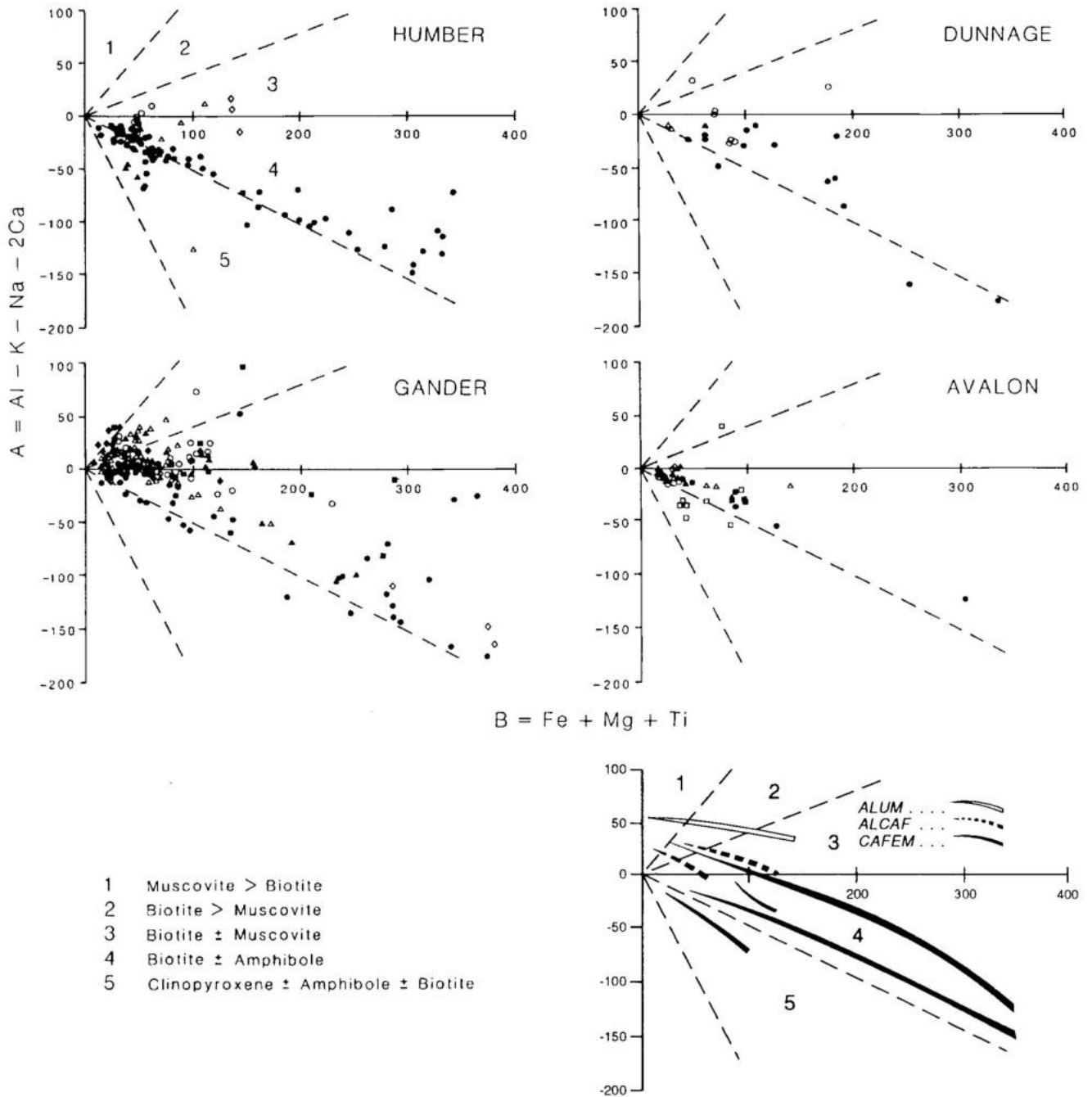
**Table 1.** Symbol key for chemical plots

ZONE	SYMBOL	PLUTON OR SUITE	CODE#
HUMBER	(●)	Mont McGerrigle	H1
	(Δ)	Murdochville	H2
	(◊)	Mont Brown	H3
	(O)	Monts Hogs Back & Chauve	H4
	(Δ)	Mont Vallieres	H5
DUNNAGE	(O)	Mt. Squaw Cap & Sugar Loaf	D1, D2
	(●)	Benjamin River & Charlo Stocks	D3, D4
	(Δ)	Anitouri Lake	D5
	(Δ)	Nicholas Deny	D6
GANDER	(Δ)	Ordovician granites	G1 to G10
	(□)	Devonian granites	G11, G18
	(●)	Mt. Elizabeth	G12
	(Δ)	North Pole Stream & Miramichi	G13, G14
	(◊)	Redstone Mtn	G15
	(◆)	Lost Lake, Nashwaak, Tower Hill, Beech Hill	G17, G22, G28, G29
	(O)	Pokiok batholith	G23 to G27
	(■)	Other granites	G16, G19, G20, G21
AVALON	(■)	Hampstead	A1
	(□)	Welsford & Jake Lee Mtn.	A2
	(Δ)	Mt Douglas	A3
	(O)	Utopia	A4
	(Δ)	Magaguadavic	A5
	(●)	Bocabec	A6

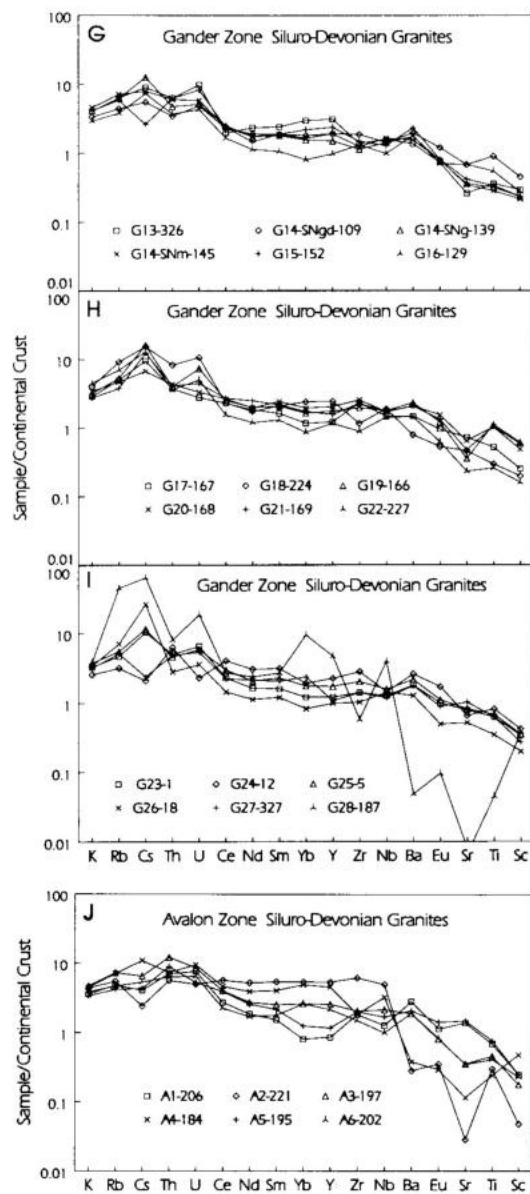
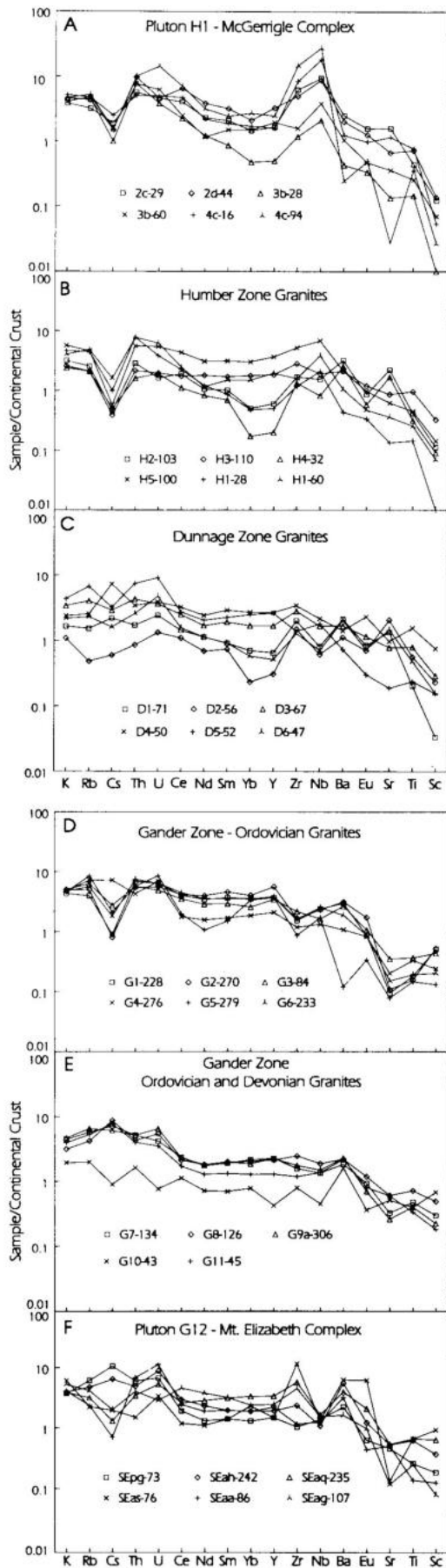
Symbol key for geochemical plots (Fig. 2, 18, 19, 20, 23, 24, 25, 26, 27, and 29). Each pluton has a code number; the first letter identifies the zone (H-Humber, D-Dunnage, G-Gander and A-Avalon) in which it occurs (see Fig. 1). To reduce the number of symbols employed, the same symbol has been employed for plutons or groups of plutons with shared characteristics.



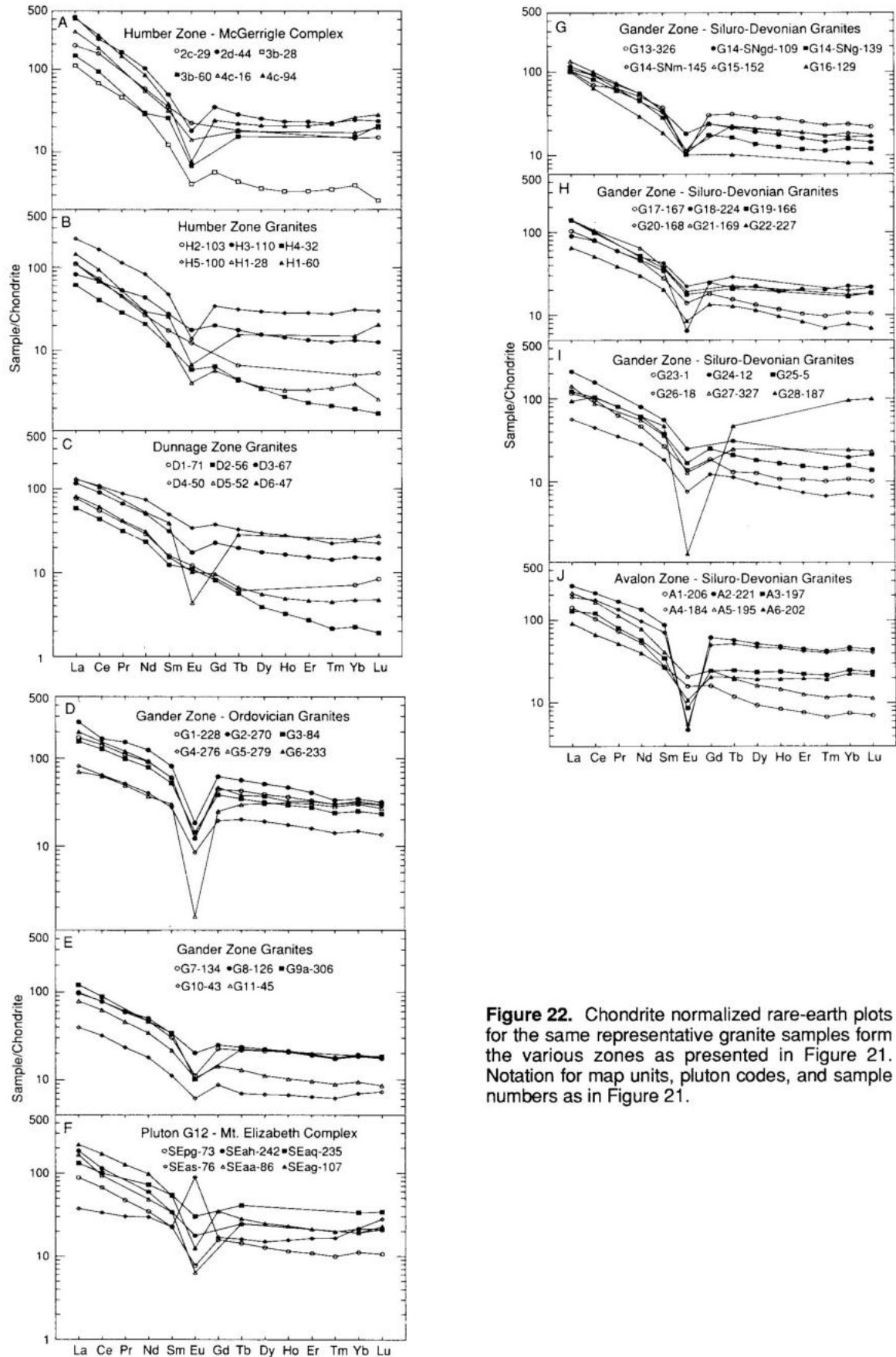
**Figure 19.** Distribution of granites in the four tectonostratigraphic zones in the triangular quartz-dark minerals-feldspar+muscovite diagram ('Q-B-F' diagram) of Debon and Le Fort (1982); key to symbols in Table 1. The three parameters are in gram-atoms  $\times 10^3$  in 100 g of rock or mineral. Each field corresponds to a petrographic type as labelled in the top diagram. For comparison, typical trends of different subtypes of calc-alkaline or alumino-calcic associations from Debon et al. (1986) are shown: TH – tholeiitic, CA – calc-alkaline, MZD -, MZL – dark and light coloured monzonitic respectively, ALS -, ALOS – alkaline saturated and oversaturated respectively.



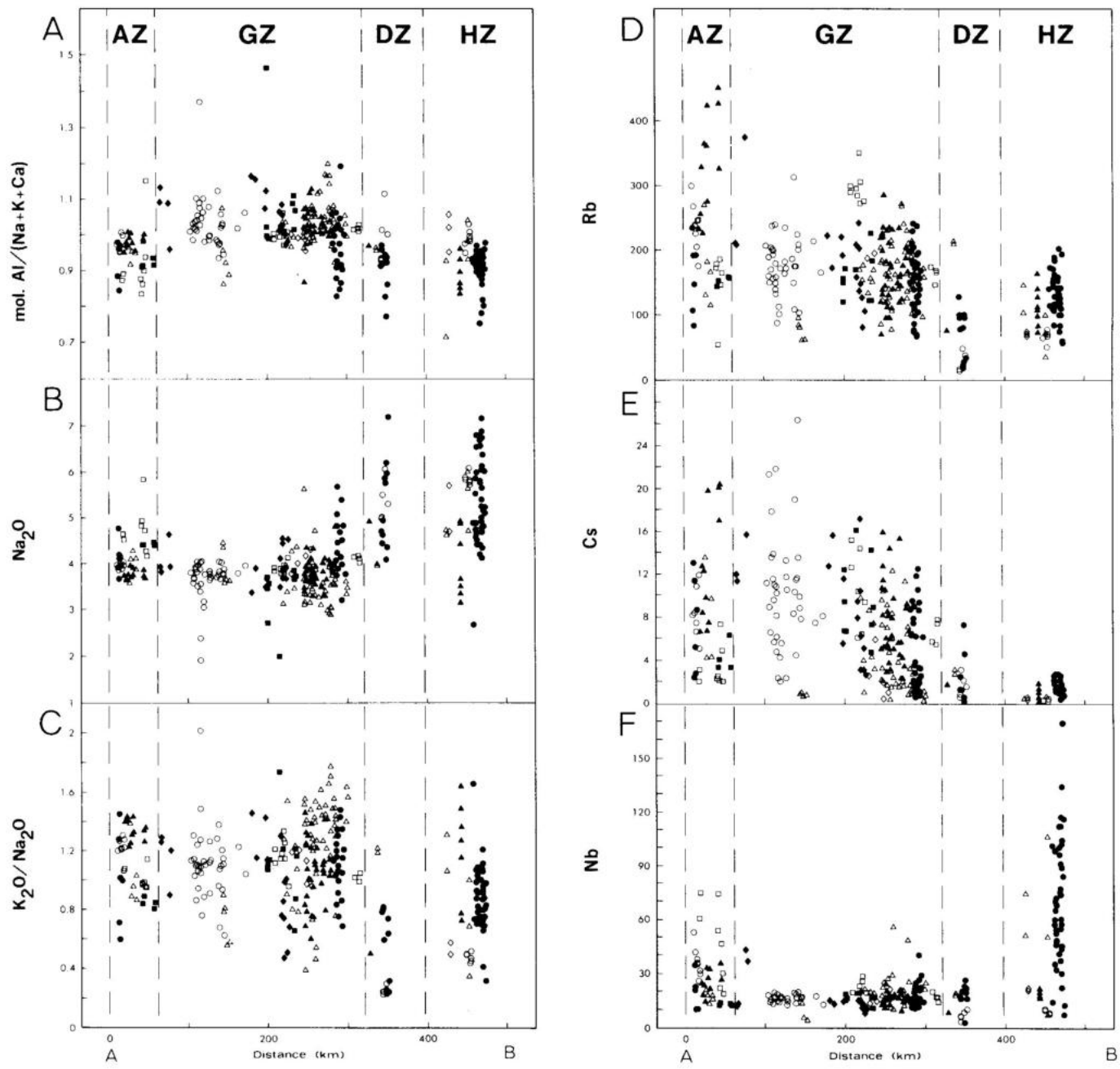
**Figure 20.** Distribution of granites in the four tectonostratigraphic zones in the 'characteristic minerals' diagram of Debon and Le Fort (1982); key to symbols in Table 1. The two parameters are in gram-atoms  $\times 10^3$  in 100 g of rock or mineral; A is the 'aluminous index' and B is proportional to the dark mineral content. This diagram separates peraluminous rocks or minerals (positive A values) from metaluminous ones (negative A values). Labelled sectors (1 to 5) correspond to areas characterized by specific mineralogical compositions, as given at the bottom of the figure. The trends of the three main types of magmatic associations (see insert) from Debon et al. (1986) are distinguished: ALUM – aluminous, ALCAF – alumino-cafemic, CAFEM – cafemic.



**Figure 21.** Trace element abundances of representative granite samples from the various zones normalized to the present continental crust values of Taylor and McLennan (1985). In figure A and F, patterns for different phases of the McGerrigle and Mt. Elizabeth plutonic complex are plotted; map units are followed by sample number, e.g. 2c-29 is sample WXMG-29 from map unit 2c. In the other plots, the pluton code number, as in Figure 1, is followed by the sample number (WXMG or WXNB prefix omitted). Elements are arranged, from left to right, in order of increasing bulk-partition-coefficient values for granite mineralogies.



**Figure 22.** Chondrite normalized rare-earth plots for the same representative granite samples from the various zones as presented in Figure 21. Notation for map units, pluton codes, and sample numbers as in Figure 21.



**Figure 23.** Plots of distance (in km) along a south-north cross-section (A-B in Fig. 1) versus selected major and trace element concentrations and ratios for New Brunswick and Gaspésie granitic rocks with SiO<sub>2</sub> >60 wt.%. Positions of zone boundaries are shown as vertical dashed lines; zone abbreviations as follows; Avalon (AZ), Gander (GZ), Dunnage (DZ), and Humber (HZ). Pluton symbol key given in Table 1.

element depleted than the latter. Mont Brown rare-earth element patterns more closely resemble those of the Mont Vallieres-de-St-Real intrusion and the McGerrigle suite.

Normalized patterns for seven samples collected from the Mont Hog's Back and Mont Chauve intrusions (pluton H4) are all essentially identical (see WXMG-32 in Fig. 21b, 22b). These intrusions are depleted in incompatible elements relative to the McGerrigle suite, have negative Nb and Cs anomalies, and strongly fractionated heavy relative to light rare-earth element depleted patterns.

The Mont Vallieres-de-St-Real intrusion (pluton H5) exhibits very similar normalized patterns (see WXMG-100 in Fig. 21b and 22b) to those of McGerrigle hybrid suite monzonites, rocks to which they also bear a lithological similarity. Cutting the Mont Vallieres-de-St-Real intrusion are rare dykes which are lithologically and chemically similar to the not very distant Mont Hog's Back intrusion. This suggests that emplacement of that intrusion post-dated emplacement of the Mont Vallieres-de-St-Real intrusion, a sequence which is supported by the whole rock K-Ar ages of de Romer (1974).

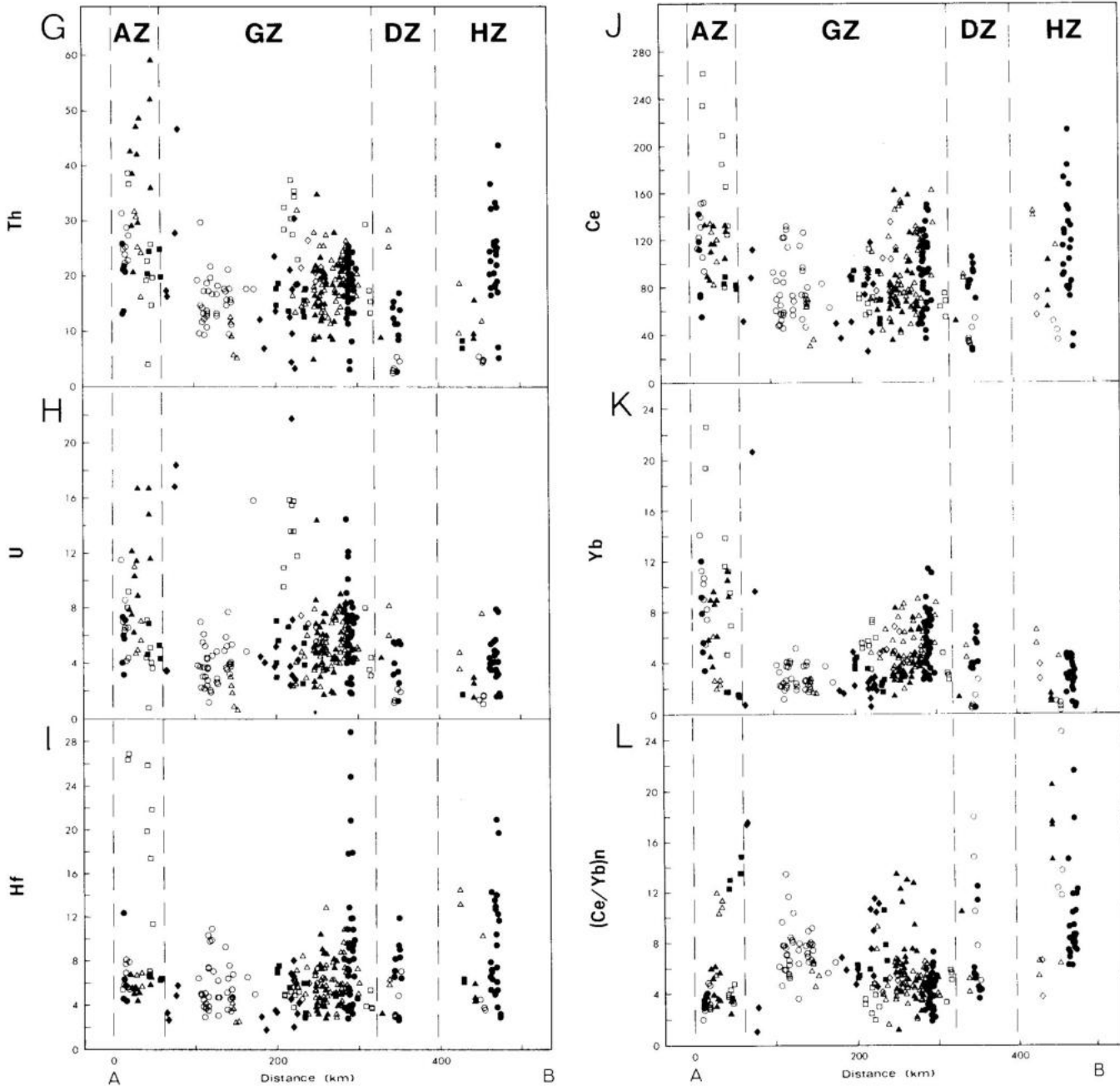


Figure 23 (cont'd.)

Based on their normalized geochemical pattern discussed above, the Humber Zone granites can be grouped into those characterized by incompatible element enrichment with positive Nb anomalies, (McGerrigle suite and Mont Vallieres-de-St-Real intrusion) and those with negative Nb anomalies which are depleted in incompatible elements (Mont Hog's Back, Mont Chauve and Mines Gaspé intrusions). The geochemical characteristics of the Mont Brown intrusion lies between these two groups. Based on available radiometric ages (about 390 versus 375 Ma; see Appendix 1) and the characteristics of dykes cutting the

McGerrigle pluton and the Mont Vallieres-de-St-Real intrusion, the incompatible element enriched magmatism predated the incompatible element depleted magmatism.

### Dunnage Zone

The Benjamin River complex (D3) contains a range of intrusive rock compositions from gabbro to adamellite (Fig. 2, 18, 19). Other individual Dunnage Zone intrusions have a restricted compositional range. The Mt. Squaw Cap, Sugar Loaf, and Nicolas Deny intrusions (D1, D2, and D6) are mainly tonalitic in composition and the Anitouri Lake pluton (D5) is granitic. Except for samples with some petrographic evidence of some alteration, these metaluminous and sodium-rich (Fig. 23a, b) granites plot in the biotite± amphibole stability field in Figure 20. The distribution of Dunnage granites in Figures 2, 18, 19, and 20 suggests a calc-alkalic to monzonitic suite or sub-type of a cafemic (mantle-derived protolith) magmatic association.

Though individual Dunnage Zone intrusions are compositionally restricted, this group of intrusions exhibits a moderate variation in trace element concentrations (Fig. 21c, 22c, and 23d-k). Felsic components of the Benjamin River complex (D3, WXNB-67) and Charlo stocks (D4, WXNB-50) have similar relatively flat K to Nb patterns. The Anitouri Lake granite (D5) has a similar pattern except for an enrichment in K to U and negative Cs and Nb anomalies. The Mt. Squaw Cap stocks (D1, WXNB-71) and Nicolas Deny pluton (D6, WXNB-47) exhibit distinctly different heavy relative to light rare-earth element depleted patterns. The Mt. Sugar Loaf plug (D2, WXNB-56) is depleted in K to Y and has a steeper heavy rare-earth element depleted pattern than other intrusions. Patterns for plutons D3, D4, and D5 resemble the incompatible element enriched group of Humber Zone intrusions and patterns for plutons D1, D2, and D6 resemble the incompatible element depleted group of Humber intrusions. However, Dunnage granites lack the pronounced Cs and Nb anomalies of Humber Zone granites. Available radiometric ages (381 versus 372 Ma; see Appendix 1) suggest that the incompatible element depleted magmatism predated the incompatible element enriched magmatism.

### Gander Zone

Prior to a discussion of geochemical data, it should be pointed out that chemical alteration caused by deformation and metamorphism is a potential problem for the Ordovician granites. To evaluate this, analyses were carried out of massive (WXNB-276; Plate 5, fig. a), slightly foliated (WXNB-249), and very strongly sheared (WXNB-290) samples of the Sweat Hill granite (pluton G4). These data, located in Appendix 4, suggest that significant alteration in more mobile elements (K, Na, Ba, Sr, and Rb) occurred only in intensely deformed portions of this intrusion. These results and the presence of relatively consistent chemical variation within individual intrusions suggest that most original chemical features of Ordovician intrusions are preserved. Chemical data can thus be used to characterize Ordovician magmatism; however, detailed petrogenetic treatment of these data would require caution.

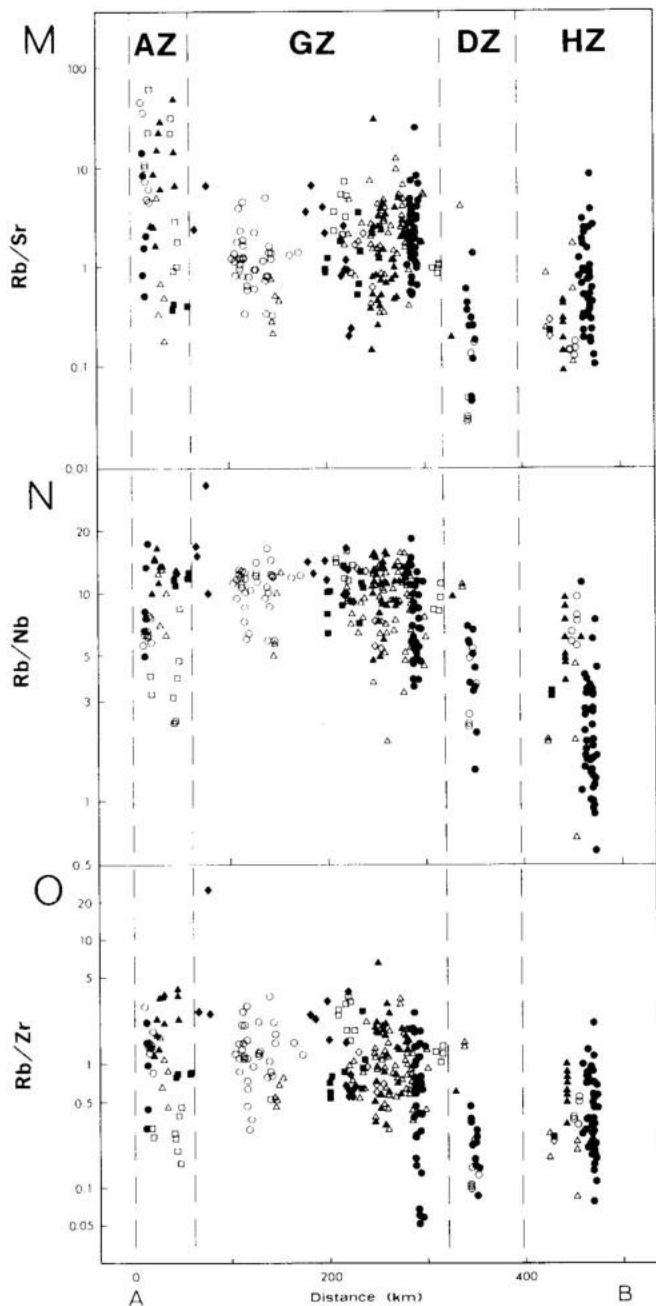


Figure 23 (cont'd.)

Gander Zone granitic rocks exhibit a restricted compositional range. Almost all Ordovician plutons and most Siluro-Devonian intrusions are, based on modal compositions (Fig. 2), granites *sensu stricto* or, based on major element data (Fig. 17, 18) adamellites and granites. Most of the more mafic samples (see Fig. 2, 17 to 19) are from volumetrically minor components of the Mt. Elizabeth, North Pole Stream, and Redstone Mountain suites (plutons G14, G16 and G17). Many intermediate composition samples from these suites exhibited field evidence (Plate 4, fig. d; Fig. 8, 9, 13) indicative of their derivation by mixing of felsic and mafic magmas. Molecular  $Al/(Ca+Na+K)$  values for granites with  $SiO_2 > 60$  wt.% varies from 0.83 to 1.47 with an average of 1.02, i.e. many samples are slightly peraluminous (see Fig. 23a). It is not surprising, therefore, that in the characteristic minerals diagram (Fig. 20), a major portion of Gander Zone granites plot in the biotite>muscovite and biotite±muscovite fields. Though, many Gander Zone granites plot in the crustal melts field in Figure 2, less felsic compositions define a calc-alkalic trend. These "calc-alkaline" phases can be interpreted as reflecting a mantle contribution or component (see Nature of granite protoliths and implications for crustal structure beneath orogens, below). In this same diagram, samples from the Mt. Elizabeth complex alkaline granite suite (pluton G14) exhibit an alkalic to monzonitic trend. In keeping with these observations, Figures 18, 19, and 20 suggest that Gander Zone granites belong to a aluminio-cafemic (mixed crustal-mantle protolith) magmatic association. The Mt. Elizabeth, North Pole Stream, and Redstone Mountain suites (plutons G14, G16, and G17), have a greater affinity to cafemic associations, i.e. a larger volume of mantle-derived component.

Representative samples of the least deformed portions of the Ordovician plutons exhibit, with only a few exceptions, remarkably similar and consistent trace element characteristics (Fig. 21d, 21e, 22d, 22c, and 23d-k). The Gibson and Benton stocks (pluton G10), which are separated by about 80 km from other Ordovician intrusions (Fig. 1), have a flatter crust-normalized pattern and markedly lower concentrations of K to Nb. The Sweet Hill granite (pluton G4) contains lower concentrations of Ce to Ba than other plutons. The Serpentine River granite (pluton G5) is enriched in heavy relative to light rare-earth elements and depleted in the compatible elements Ba to Sc. The very felsic Popple Depot and Health Steele granites (plutons G1 and G2) have similar distinctly greater Sc values. The northern plutons, except for the Sweet Hill granite (G4), exhibit distinct negative Nb anomalies (Fig. 21d), whereas more southern plutons, except for the Gibson intrusion (G10), exhibit positive Nb anomalies. The northern group of plutons is characterized by more pronounced negative Eu anomalies than the southern group (Fig. 22d, e).

With the exception of a few intrusions, Siluro-Devonian Gander Zone plutons exhibit trace element characteristics identical to Ordovician intrusions (Fig. 21e to 21i, 22e to 22i, and 23). Most plutons have flat to slightly positive Cs anomalies. The Redstone Mountain, Skiff Lake, and Lake

George intrusions (plutons G15, G24, and G27) have negative Nb anomalies. As well as having negative Nb anomalies, the Mt. Elizabeth complex alkaline granite suite (pluton G12, units SEag, SEah, SEaq, SEas, and SEaa) exhibits heavy rare-earth element relative to light rare-earth element enrichment and positive Zr anomalies. The syenite (unit SEas, WXNB-76) chondrite normalized rare-earth element pattern is notable for its marked positive Eu anomaly, a feature indicative of cumulate feldspar in this unit. Of the Siluro-Devonian granites in Gander Zone, the Tower Hill stock (pluton G28) has the most unusual trace element characteristics. On the crust-normalized plot, it exhibits major enrichment in Cs to U, Y, and Zr and marked depletion in Ba to Ti (Fig. 21i). Its chondrite normalized rare-earth element pattern (Fig. 22i) is quite flat with a remarkable negative Eu anomaly. These features suggest extreme crystal fractionation.

### Avalon Zone

Like Gander Zone granites, most Siluro-Devonian Avalon Zone intrusions are, based on modal data (Fig. 2), granites *sensu stricto* or, based on major element data (Fig. 18, 19), adamellites and granites. In contrast to those in the Gander Zone, these granites are metaluminous and more enriched in sodium (Fig. 23a, b). In the characteristic minerals diagram (Fig. 20), the Welsford and Jake Lee Mountain complexes plot in the clinopyroxene±amphibole±biotite field, whereas the rest of the Avalon granites plot in the biotite±amphibole field. In the QKP plot (Fig. 2), Avalon plutons plot mainly in the crustal melts field. More mafic compositions plot on a calc-alkalic trend, whereas samples from the Welsford and Jake Lee Mountain complexes (pluton A2) plot on a alkalic trend. Classification of magmatic associations based on Figures 18, 19, and 20, indicates the Welsford-Jake Lee Mountain complexes follows a cafemic peralkaline oversaturated trend whereas other Avalon Zone granites plot in the area of felsic end-members of various other sub-types of cafemic (mantle-derived protolith) magmatic associations.

There is a considerable degree of trace element variation in Avalon Zone granites (Fig. 21j, 22j, and 23d-k), especially when their consistent felsic character is taken into consideration. The Welsford complex (pluton A2) and the Utopia granite (pluton A4) have similar fairly flat K to Nb patterns and are depleted in Ba to Sc (Fig. 21j). Both these intrusions contain higher rare-earth element concentrations, are less depleted in heavy relative to light rare-earth elements and have marked negative Eu anomalies (Fig. 22j) compared to other Avalon Zone granites. These other granites can be subdivided into: (a) granites with steep heavy rare-earth element depleted patterns and only slight negative Eu anomalies (Evandale and Magaguadavic plutons, A1 and A5); and (b) granites with less steep heavy rare-earth element depleted patterns and moderate Eu anomalies (Mt. Douglas and Bocabec plutons, A3 and A6) (Fig. 22j). These two groups, based on rare-earth element patterns, are also prominent in Figure 23d.

### ***Granite tectonomagmatic characteristics***

Classification of Appalachian granites according to genetic type (i.e. I-, S-, or A-type) is ambiguous. Modally, the granites lack the quartz enrichment of S-type granites and plot in the fields of both I- and A-type granites (Fig. 2). Most Humber and Dunnage granites are amphibole-bearing, metaluminous granites (Fig. 20, 23a), and thus clearly of infracrustal (I-) type. This designation agrees with their classification as cafemic associations (see Fig. 18, 19, 20), i.e. granites which had mantle-derived protoliths. In contrast, most Gander Zone granites are felsic, amphibole-free, biotite granites. Ordovician granites often contain metamorphic muscovite and garnet, whereas magmatic muscovite is present in only a small number of Siluro-Devonian granites. The granites generally have Al indices less than the value of 1.1 which divides I-type from S-type granites (Chappell and White, 1974) (Fig. 23a). Also, their Na<sub>2</sub>O content is generally >3.2 wt.% (Fig. 23b), as is characteristic of I-type granites, and some plutons are amphibole-bearing (G14, G16, G17, G21, G23, and G27). These features suggest that Gander Zone granites are I-type.

The ambiguity of this I-type designation is in keeping with the Debon and Le Fort (1982) classification (see Fig. 18, 19, 20) of Gander granites as forming an aluminous-cafemic association, i.e. granites derived from mixed mantle-crustal protoliths. Similar Na<sub>2</sub>O contents to Gander granites, coupled with their metaluminous and amphibole-bearing (in plutons A1, A2, A5, and A6) character, clearly indicates that Avalon Zone granites are I-type. This is in agreement with their designation in the Debon and Le Fort (1982) plots (Fig. 18, 19, and 20) as a felsic cafemic association, i.e. granites derived from mantle-derived protoliths.

A-type granites, an I-subtype, are highly felsic, alkali-rich granites which are characterized by elevated contents of high-field strength elements and high values of elemental ratios such as K<sub>2</sub>O/MgO and Ga/Al (Whalen et al., 1987a). Figures 24a to 24d show the distribution of Appalachian granites on discrimination diagrams based on these features (see also Fig. 23f, i, j, k). In Humber Zone, the McGerrigle suite and the Mt. Vallieres pluton (H1 and H5) plot mainly in the A-type granites field, whereas other granites plot in the I-type field. Similarly, some phases of the Benjamin River complex and Charlo stocks (D3 and D4) plot in the A-type field, whereas other Dunnage granites plot in the I-type field. The bulk of Gander Zone granites plot in the I-type field, though many plutons exhibit features transitional between I- and A-type granites (anomalous I-types?). In Avalon Zone, the Welsford and Jake Lee Mountain complexes (A2) and Utopia granite (A4) display clear A-type characteristics, whereas the Evandale and Magaguadavic intrusions (A1 and A5) are clearly normal I-types. Other Avalon granites (Mt. Douglas and Bocabec plutons, A3 and A6) display transitional I- to A-type features. In summary, though a major portion of Appalachian I-type plutons contain elevated high-field strength element contents, only a small number can be definitively "pigeon-holed" as A-type granites.

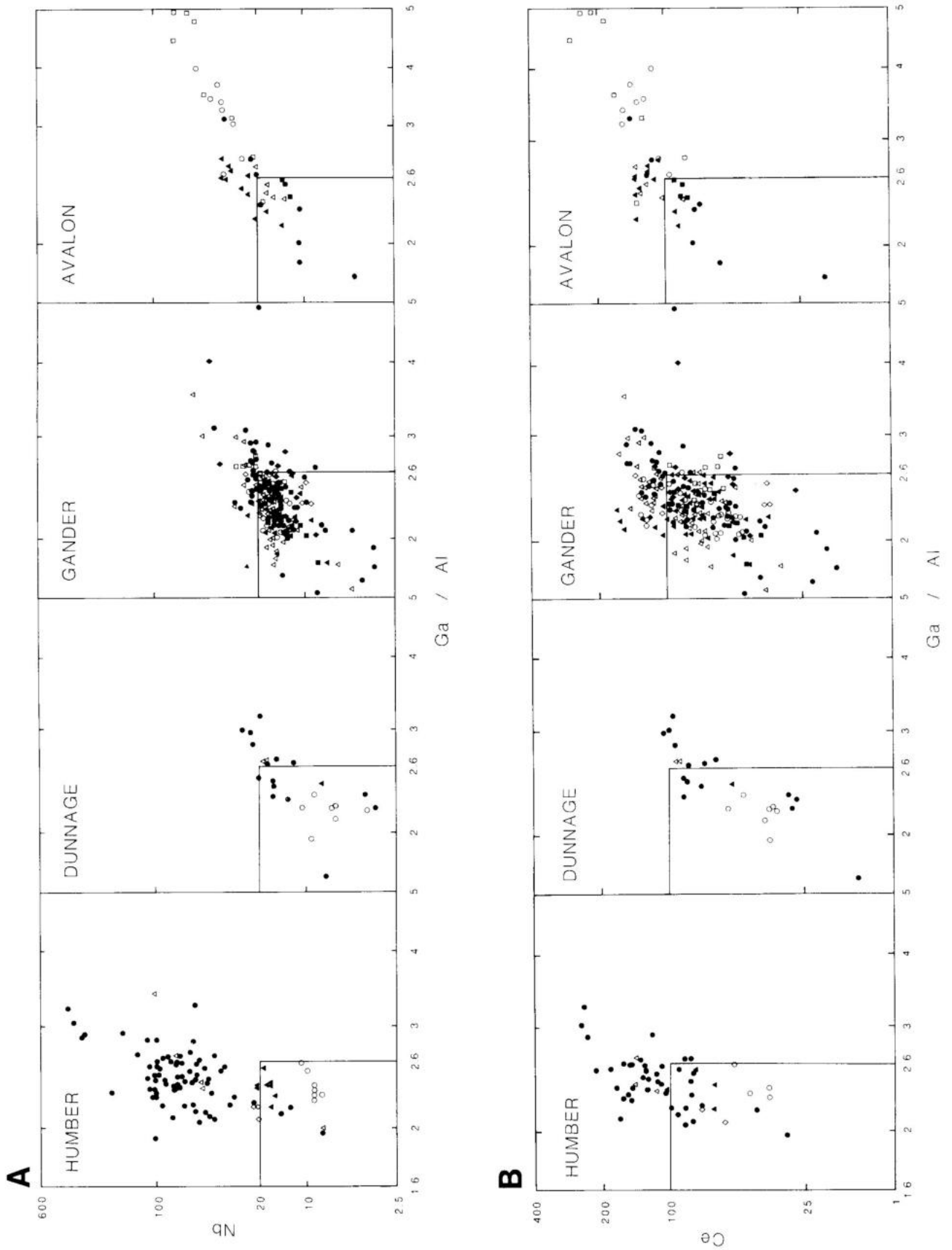
One potential method of determining the tectonic setting in which granites formed is by the use of discrimination diagrams, a method which has proved very valuable in studies of mafic volcanic rocks. Pearce et al. (1984) have proposed a tectonic classification of granites based on discrimination diagrams using Rb, Y, Nb, Yb and Ta data. Plots of the Appalachian granites on the Rb-Nb+Y and Nb-Y diagrams are presented in Figures 25 and 26.

In Humber Zone plots, the two granite grouping discussed above are readily apparent; the incompatible-element-enriched granites, and the Mont Brown intrusion, plot in the within-plate-granite (WPG) field, whereas the incompatible-element-depleted intrusions plot in the volcanic arc granite (VAG) field. One Mont Vallieres-de-St-Real and two McGerrigle suite samples which plot in the volcanic arc granite field are dykes rocks thought to form part of the incompatible-element-depleted granite group or suite. Three other McGerrigle suite samples which plot in the volcanic arc granite field are hybrid suite granites (e.g. WXMG-28). This suggests that, in addition to its many other components, the McGerrigle complex contains two distinctly different granite magmas. Field evidence suggests the within-plate-granite type magmatism predated the volcanic arc granite type magmatism.

In Dunnage Zone, the Anitouri Lake granite (D5) and portions of the Benjamin River complex and Charlo stocks (D3 and D4) plot in the within-plate-granite field and other granites plot in the volcanic arc granite field. Based on available age (see Appendix 1), the volcanic arc granite magmatism predates the within-plate-granite magmatism, the opposite relationship to the adjacent Humber Zone. In Gander Zone, all Ordovician granites, except for Gibson and Benton samples (pluton G10), plot in the within-plate-granite field. Gander Siluro-Devonian granites straddle the boundary between the within-plate-granite and volcanic arc granite fields. Based on these diagrams, it can be suggested that in Gander Zone a major Ordovician within-plate-granite magmatic event was followed by Siluro-Devonian "mixed" or transitional volcanic arc granite-within-plate-granite type magmatism. Most granites in Avalon Zone plot in the within-plate-granite field, except for Evandale and Magaguadavic intrusions (A1 and A5) which plot in the volcanic arc granite field. Based on available ages, this would suggest that in Avalon Zone within-plate-granite type magmatism both predated (plutons A2 and A4) and postdated (pluton A3) volcanic arc granite type magmatism (pluton A5). In summary, based on these diagrams, all zones are intruded by plutons which have within-plate and volcanic-arc type characteristics. No intrusions resembling ocean-ridge or syn-collisional granites are present. These rather ambiguous results will be further discussed below (see Petrogenesis and tectonic significance of the granite magmatism).

### ***Tectonomagmatic characteristics of comagmatic mafic intrusions***

Discrimination of tectonic settings based on geochemical signatures has been much better developed for mafic volcanic rocks than for granitic rocks. For this reason, geochemistry



**Figure 24.** Distribution of the New Brunswick and Gaspésie granite data, subdivided by zone, on the Ga/Al versus (A) Nb, (B) Ce, (C) Zr, and (D)  $K_2O/MgO$  diagrams of Whalen et al. (1987a); the box in the diagrams encloses the field of I- and S-type granites, outside this box is the field of A-type granites; pluton symbol key given in Table 1.

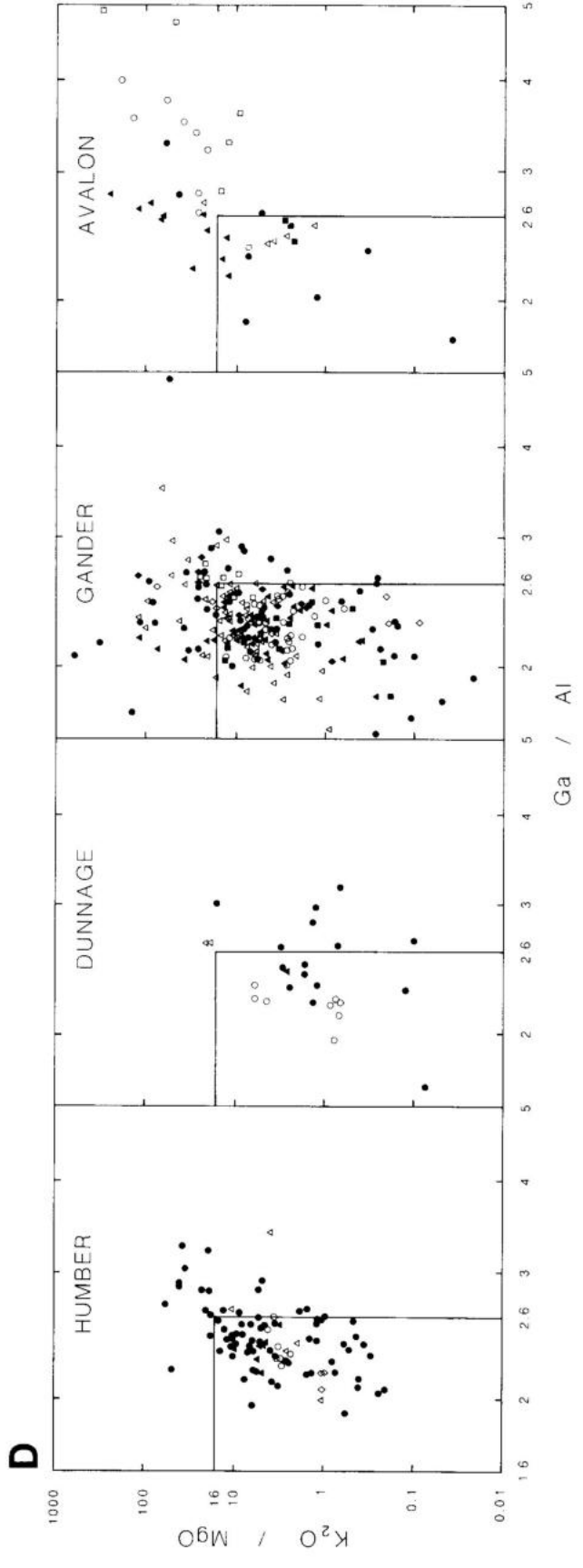
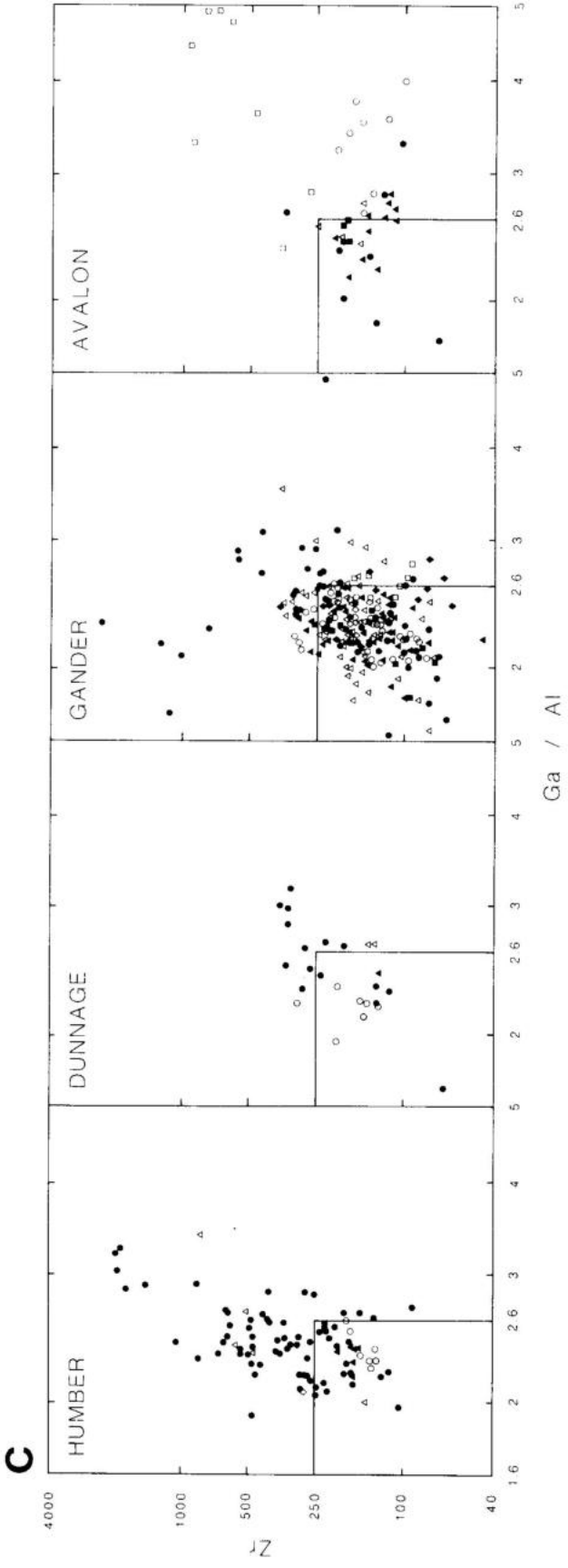
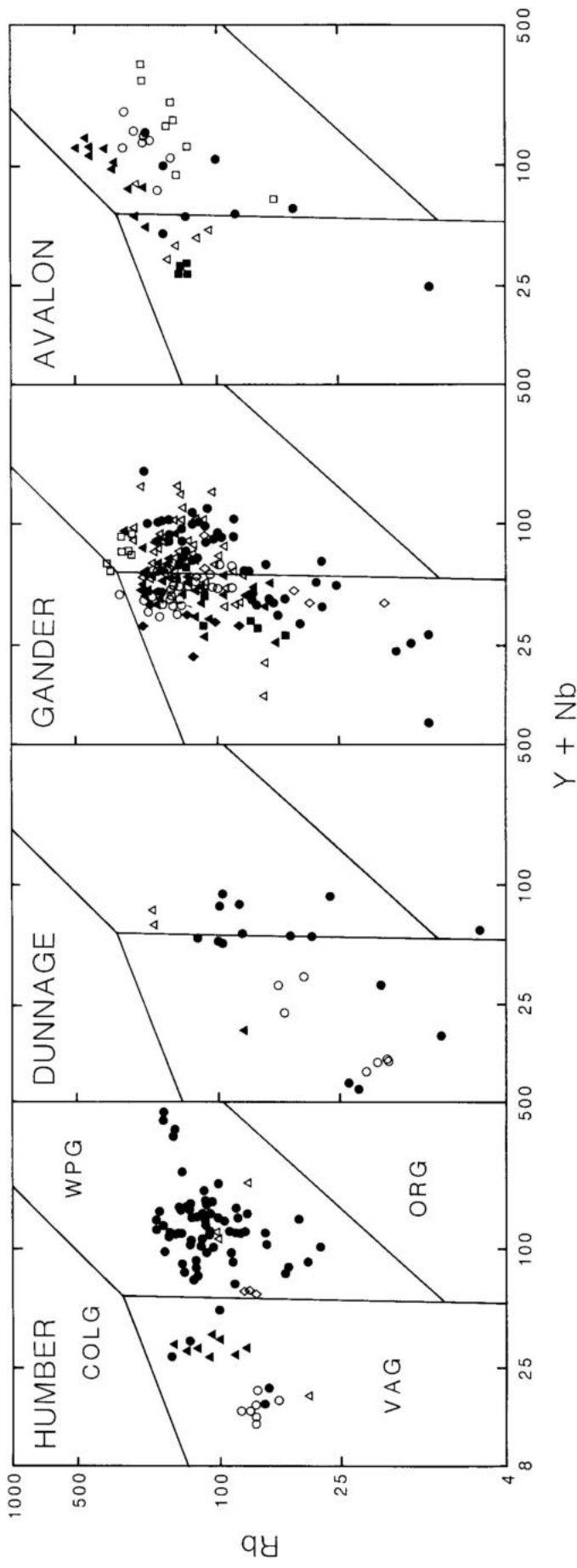
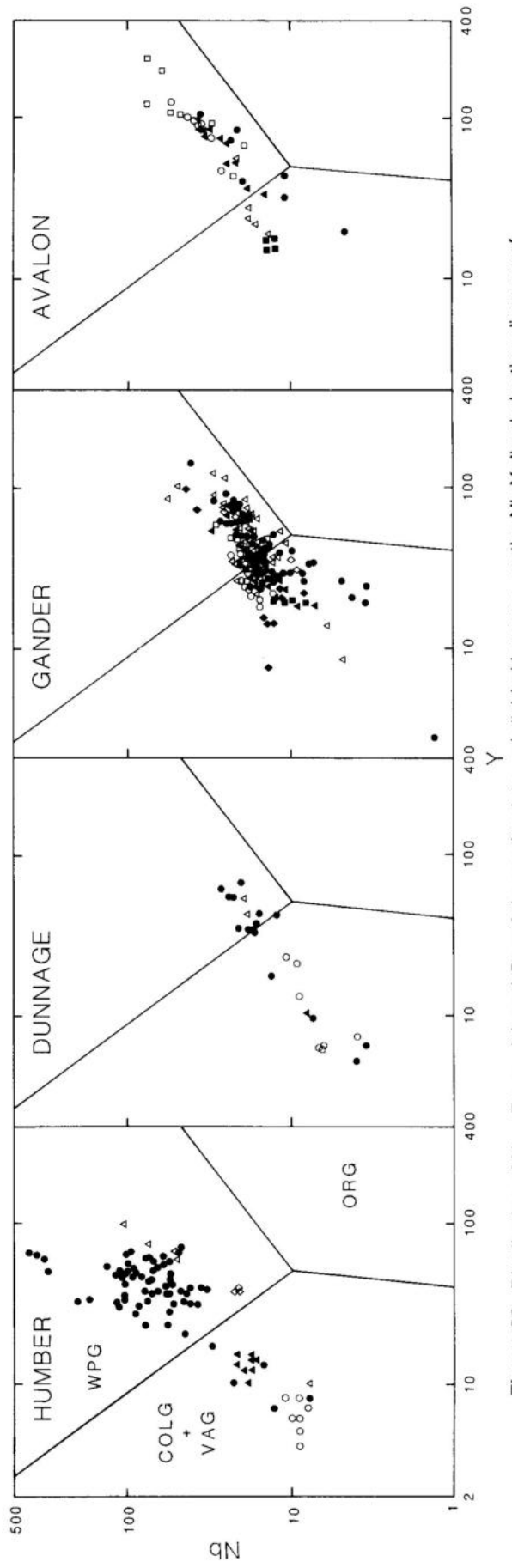


Figure 24. (cont'd.)



**Figure 25.** Distribution of New Brunswick and Gaspésie granite data, subdivided by zone, on the Rb-(Nb+Y) discrimination diagram of Pearce et al. (1984). Fields for syn-collision (COLG), volcanic arc (VAG), within plate (WPG), and ocean ridge (ORG) granites are indicated; pluton symbol key given in Table 1.

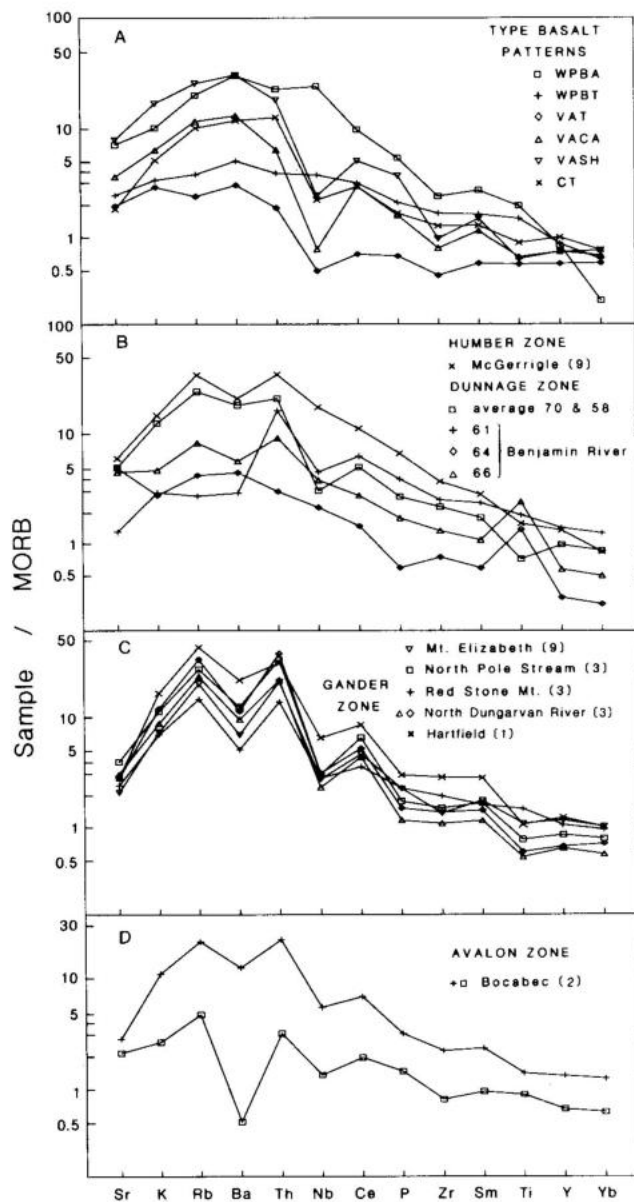


**Figure 26.** Distribution of New Brunswick and Gaspésie granite data, subdivided by zone, on the Nb-Y discrimination diagram of Pearce et al. (1984). Fields for syn-collision (COLG) + volcanic arc (VAG), within plate (WPG), and ocean ridge (ORG) granites are indicated; pluton symbol key given in Table 1.

on contemporaneous or comagmatic mafic intrusive rocks may be an approach to deduce the tectonomagmatic signature of granite magmatism. As only a small portion of studied plutons contain associated mafic phases, this approach has restricted applicability. It must be mentioned that, unlike volcanic rocks, there is a potential problem of mafic plutonic rocks not representing liquid compositions, i.e. the presence of cumulate phases. In addition, their close spatial association with felsic plutonic rocks enriched in alkalis may have enriched their K, Rb, and Ba contents. In Figure 27, MORB normalized "spidergram" type plots are presented for mafic intrusive phases associated with various plutons in the different zones. Where multiple, chemically similar samples were analyzed from individual plutons, average compositions are presented. The elements Sr, K, and Ba, which might be enriched by contamination from associated felsic magmas, are plotted together on the left side of these plots. For comparison purposes, representative or type basalt patterns from various tectonic settings are also presented in Figure 27a.

In Humber Zone, data from the mafic end-member in the Mont McGerrigle complex (H1) (Fig. 27b) closely resembles that of within-plate alkaline basalts. Andesitic (SiO<sub>2</sub> about 57 wt.%) Dunnage Zone samples (WXNB-70 from Mt. Squaw Cap stocks (D1) and WXNB-58 from Benjamin River complex (D3)) resemble shoshonitic volcanic-arc magmas. Patterns for samples WXNB-61, 64, and 66 (see Plate 2, fig. b), also from the Benjamin River complex, most closely resemble those of tholeiitic within-plate basalts. Positive Ti anomalies in samples 64 and 66 are probably due to cumulate Fe-Ti oxides. The positive Th anomaly in 61, a mafic feldspar-amphibole porphyry, may also be due to a cumulate phase. In Gander Zone, the patterns of mafic intrusions (Fig. 27c) are all very similar, except for some variation in concentration of elements present. These patterns resemble that of calc-alkaline volcanic-arc (VACA) basalts but with a greater enrichment in K, Rb, and Th, similar to that found in shoshonitic volcanic-arc (VASH) rocks. Negative Nb anomalies in Gander Zone patterns are less pronounced than in calc-alkaline volcanic-arc and shoshonitic volcanic-arc basalts and all patterns have marked negative Ba anomalies. In Avalon Zone, two Bocabec complex (A6) samples have quite different patterns (Fig. 27d); one (WXNB-178) resembles Gander Zone patterns (i.e. calc-alkaline volcanic-arc) and the other (WXNB-204) resembles a volcanic arc tholeiite (VAT) but with a marked negative Ba anomaly.

In Humber Zone, both mafic plutonic rocks and associated granites have within-plate geochemical signatures. In Dunnage Zone, mafic rocks resemble both tholeiitic within-plate and shoshonitic calc-alkaline magmas. Associated granites have similar mixed volcanic arc granite (VAG) – within plate granite (WPG) signatures. Agreement in Humber and Dunnage zones between tectonic settings deduced using mafic versus felsic rocks helps validate this approach. Siluro-Devonian mafic plutonic rocks in Gander and Avalon zones have affinities to volcanic arc mafic



**Figure 27.** Incompatible element abundances in mafic intrusive rocks associated with New Brunswick and Gaspésie granitic rocks normalized to NMORB values of Pearce et al. (1981). The relatively mobile elements (Sr, K, Rb, and Ba) are plotted on the left side of the diagrams; otherwise the elements are arranged in order of increasing bulk-partition-coefficient values for basalt mineralogies. (A) Averages for alkaline (WPBA) and tholeiitic (WPBT) within-plate basalts and tholeiitic (VAT), calc-alkaline (VACA) and shoshonitic (VASH) volcanic-arc basalts from Pearce (1982); average for continental tholeiites (CT) from Holm (1985); (B) Humber and Dunnage zone mafic intrusive rocks; the McGerrigle complex pattern is the mean of 9 similar samples; Dunnage Zone patterns from labelled samples (WXNB- prefix omitted); (C) Gander Zone patterns from labelled plutons, number after label indicates the number of samples averaged; (D) Avalon Zone patterns.

volcanics whereas associated granites have mixed volcanic arc granite-within-plate-granite signatures. This contrast may reflect derivation of these granites from mixed crustal-mantle protoliths (see Granite tectonomagnetic characteristics, above). The mafic rocks may reflect the prevailing tectonic environment (i.e. volcanic arc) whereas the granites may image the older crustal contribution. These results will be discussed further in Petrogenesis and tectonic significance of the granite magmatism, below.

## ISOTOPIC CHARACTERISTICS OF THE GRANITES

### Introduction

Nd, O, Pb, and Sr isotopic data has proven to be a very powerful tool in resolving questions regarding granite petrogenesis. It has also provided key information pertaining to crustal evolution and the nature of the deep continental crust. This is one of the first large scale granite studies to generate an integrated data set that includes Nd, O, and Pb isotopic analyses. In most previous granite isotopic studies, such as Ayuso and Bevier (1991), only analyses for one isotopic system (Pb) are interpreted without accompanying whole rock petrographic, major, or trace element data.

The main intention of this section is to provide an isotopic overview or summary which highlights similarities and differences between zones (see Table 2, Fig. 28). An introduction to the terminology and relative merits of various isotopic systems is provided first. This is followed by summaries of results for each isotopic data set. Implications of the integrated geochemical and isotopic data set are discussed below. In general, the combined isotopic data suggests that granites in Humber, Dunnage and Avalon zones were generated mainly from relatively young ( $0.8 \pm 0.1$  Ga), mantle-derived protoliths. Higher  $\delta^{18}\text{O}$  and  $^{207}\text{Pb}/^{204}\text{Pb}$

values in Avalon Zone granites may reflect a minor volume of supracrustal rocks in their source. In contrast, the isotopic data indicates that Gander Zone granites were generated from older ( $1.5 \pm 0.5$  Ga) crustal sources which included a major supracrustal component.

Neodymium data presented in this report are from cooperative work with E. Hegner and G. Jenner (e.g. Whalen et al., 1989) and O data is from cooperative research with F. Longstaffe. Co-authored papers based on the Nd and O data will be published separately. Lead data on the author's New Brunswick samples has been published by Bevier (1987) and Ayuso and Bevier (1991). Lead data on Gaspésie samples is from cooperative work with C. Gariépy. As well, published U-Pb and Sr isotopic data available from some of the plutons is discussed below. For the sake of completeness, all this isotopic data, including previously unpublished Nd, O, and Pb data, is tabulated with other chemical data on the same samples in Appendix 4, and summarized by zone in Table 2 and by pluton in Appendix 1.

### Overview of the Nd, O, Pb, U-Pb, and Sr isotopic systems as applied to granitic rocks

Neodymium isotopic studies of granites can provide information pertaining to questions of crust-mantle differentiation and crustal recycling (DePaolo, 1981a; Farmer and DePaolo, 1983; Patchett and Bridgewater, 1984).  $\epsilon_{\text{Nd}}$  values represent the deviation (in parts in  $10^4$ ) of the initial  $^{143}\text{Nd}/^{144}\text{Nd}$  ratio in the sample (the ratio at time of magma crystallization and equivalent to that of the protolith) from that assumed for the bulk silicate earth. The bulk earth reservoir is assumed to be equivalent to the chondrite uniform reservoir (CHUR). Positive  $\epsilon_{\text{Nd}}$  values indicate a time integrated light rare-earth element depleted source material (e.g. the depleted mantle); whereas negative values indicate a time-integrated light rare-earth element enriched source

**Table 2.** Summary of isotopic information on Appalachian granites

Zone	Al/(Na+K+Ca)	$\epsilon_{\text{Nd}}$	$\epsilon_{\text{Nd}}$ (0.4 Ga)	$T_{\text{DM}}$ (Ga)	$\delta^{18}\text{O}$	$^{206}\text{Pb}/^{204}\text{Pb}$	$^{207}\text{Pb}/^{204}\text{Pb}$	$^{208}\text{Pb}/^{204}\text{Pb}$
Humber	$0.89 \pm 0.07$ (0.73/0.99)	$3.7 \pm 1.1$ (0.4/5.4)	$3.8 \pm 1.1$ (0.4/5.6)	$0.8 \pm 0.1$ (0.6/1.1)	$7.1 \pm 0.8$ (5.6/9.2)	$18.361 \pm 0.252$ (18.022/19.035)	$15.562 \pm 0.24$ (15.515/15.616)	$38.137 \pm 0.317$ (37.801/39.095)
Dunnage	$0.91 \pm 0.05$ (0.83/0.97)	$2.5 \pm 1.8$ (0.1/4.5)	$2.6 \pm 1.8$ (0.2/4.7)	$0.9 \pm 0.1$ (0.7/1.1)	$7.3 \pm 0.8$ (6.5/8.9)	$18.288 \pm 0.076$ (18.212/18.410)	$15.585 \pm 0.004$ (15.578/15.589)	$38.049 \pm 0.028$ (38.005/3.075)
Gander Ordovician	$1.02 \pm 0.06$ (0.89/1.15)	$-2.3 \pm 1.7$ (-5.4/0.1)	$-2.8 \pm 1.8$ (-6.1/-0.2)	$1.5 \pm 0.2$ (1.1/1.7)	$9.0 \pm 0.7$ (8.2/10.1)	$18.543 \pm 0.137$ (18.353/18.770)	$15.692 \pm 0.010$ (15.675/15.709)	$38.429 \pm 0.144$ (38.232/38.707)
Silurian- Devonian	$1.03 \pm 0.07$ (0.85/1.17)	$-1.9 \pm 1.0$ (-4.2/-0.3)	$-2.0 \pm 1.1$ (-4.4/-0.4)	$1.4 \pm 0.1$ (1.1/1.7)	$8.6 \pm 1.1$ (5.6/10.4)	$18.391 \pm 0.105$ (18.276/18.708)	$15.667 \pm 0.021$ (15.628/15.702)	$38.284 \pm 0.077$ (38.089/38.420)
Avalon Precambrian	$1.03 \pm 0.12$ (0.77/1.15)	$1.0 \pm 1.8$ (-3.7/3.3)	$-1.3 \pm 1.9$ (-5.1/2.1)	$1.2 \pm 0.1$ (1.0/1.4)	$7.6 \pm 3.5$ (2.5/12.5)	$18.561 \pm 0.175$ (18.284/18.818)	$15.694 \pm 0.026$ (15.640/15.727)	$38.420 \pm 0.178$ (38.009/38.645)
Silurian- Devonian	$0.95 \pm 0.04$ (0.88/1.00)	$1.9 \pm 0.7$ (1.1/3.3)	$1.9 \pm 0.6$ (1.2/3.2)	$1.0 \pm 0.1$ (0.9/1.1)	$8.3 \pm 0.6$ (7.2/9.1)	$18.382 \pm 0.092$ (18.236/18.528)	$15.636 \pm 0.013$ (15.612/15.649)	$38.194 \pm 0.094$ (38.046/38.277)

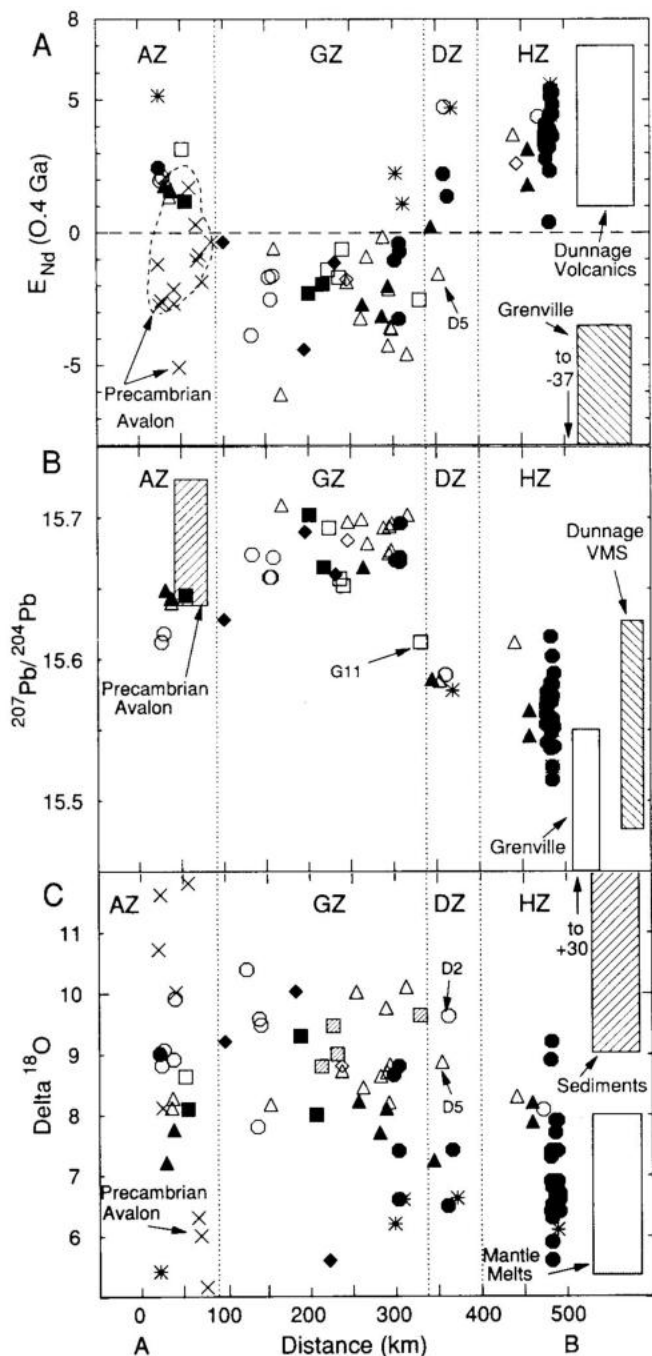
Listed above by zone are mean  $\pm 1$  standard deviation and ranges (in brackets); for Gander and Avalon Zones, granites are sub-divided by age. Data summarized from Appendix 4; Pb data (other than Humber Zone) that of Ayuso and Bevier (1991). See discussion in text.

(e.g. old continental crust or enriched mantle). The Nd model age ( $T_{DM}$ ) for a sample reflects the time when its isotopic composition was equivalent to that in the depleted mantle, i.e. the time when its isotopic evolution curve intersects the model curve for the isotopic evolution of the depleted mantle. In the case of protoliths composed of mixtures of mantle-derived and older crustal components,  $T_{DM}$  ages represent a weighted mean separation age of the different source components. The crustal component may be significantly older than  $T_{DM}$  and thus this model age has no real geological significance. However,  $T_{DM}$  ages do provide a maximum for

the geological age of the precursor material. A complete discussion of the  $\epsilon_{Nd}$  notation and  $T_{DM}$  are given in DePaolo (1988).

A notable advantage of the Sm-Nd isotopic system over Rb-Sr and U-Th-Pb is that rare-earth elements are much less mobile under near-surface conditions, in part because of their low solubility. The fact that a Nd daughter atom can occupy the same site as its Sm parent means that problems, such as that of Pb loss in the U-Th-Pb system, are absent. As the concentrations of rare-earth elements in potential mantle and crustal sources are not significantly different, the Nd signature of a magma is not greatly affected by minor inputs or contributions. For example, assimilation of small volumes (<5%) of old crustal material by a mantle-derived granite magma probably would not change its positive (>+3)  $\epsilon_{Nd}$  signature. Thus, Nd data can be used to reveal the primary bulk characteristics of the granite protolith.

Oxygen isotopic data are expressed as  $\delta^{18}O$  values, which represents the per mil deviation of the sample relative to a standard (standard mean sea water, SMOW). Variations in  $\delta^{18}O$  result from a range of processes, including condensation, evaporation, diagenesis, and crystallization.  $\delta^{18}O$  values <8 are typical of mantle-derived magmas. Rocks which have at some time resided at the surface, such as sedimentary rocks or weathered or hydrothermally altered rocks, typically have  $\delta^{18}O$  values >10.  $\delta^{18}O$  values of 6 to 8 are typical of mantle or lower crustally derived granites whereas granites containing a supracrustal component have  $\delta^{18}O$  >+8. Oxygen isotopic studies of granites are very useful in establishing source rock characteristics and can also play a unique role in determining the origin of fluids involved in producing granitic magmas (see summary of Taylor, 1988). As oxygen is a major rock constituent,  $\delta^{18}O$  values of



**Figure 28.** Plots of distance (in km) along a south-north cross-section (A-B in Fig. 1) versus (A)  $\epsilon_{Nd}(0.4 \text{ Ga})$ , (B)  $^{207}\text{Pb}/^{204}\text{Pb}$ , and (C)  $\delta^{18}\text{O}$  for New Brunswick and Gaspésie granitic rocks. In (A), fields for Dunnage volcanic rocks (Jenner, pers. comm., 1991), Grenville basement (based on data of Dickin and McNutt (1989); Patchett and Ruiz (1989); Daley and McLelland (1991)) and New Brunswick Precambrian Avalon basement (Whalen et al., 1989) are also plotted. In (B), fields for Grenville basement (Ayuso et al., 1988), Dunnage volcanic massive sulphide deposits (VMS) (Swinden and Thorpe, 1984) and Precambrian Avalon basement (Ayuso and Bevier, 1991) are also plotted. In (C), fields for mantle-derived melts and supracrustal rocks (sediments) (based on data of Taylor (1980, 1988)) are also plotted. Positions of zone boundaries are shown as vertical dashed lines; zone abbreviations as follows: Avalon (AZ), Gander (GZ), Dunnage (DZ), and Humber (HZ). Pluton symbol key given in Table 1, except that gabbro samples are shown with an asterisk symbol. Data points for unusual samples mentioned in the text are labelled by their pluton code number (D2, D5, and G11).

magmas or rocks are not easily affected, either by wall rock contamination or alteration processes. When used in conjunction with Nd and Pb isotopic data, as in this study, O data is invaluable for identifying the presence of a supracrustal component in granites. For example,  $\delta^{18}\text{O}$  values  $>8$  would be predicted for a granite with a juvenile Nd signature, if that granite was derived by melting of a young mantle-derived metavolcanic protolith.

The following points concerning interpretation of Pb isotopic data are condensed from Ayuso and Bevier (1991). Lead isotopic signatures inherited by granites from their source regions are a function of the contrasting geochemical behaviour of parental elements (U and Th) and their half-lives. Different regions of the crust exhibit a degree of provincialism in daughter isotopic ratios in accordance with the effective U/Pb and Th/U ratios during their evolution. Due to the relatively short half-life of  $^{235}\text{U}$  compared to  $^{232}\text{Th}$ , recent changes in U/Pb do not markedly affect variation in  $^{207}\text{Pb}/^{204}\text{Pb}$ . Precambrian crust subjected to high-grade metamorphism shortly after its formation will evolve along an evolution path controlled by lower U/Pb ratios and thus lower  $^{207}\text{Pb}/^{204}\text{Pb}$  than if metamorphism occurred much later. Although low to moderate  $^{207}\text{Pb}/^{204}\text{Pb}$  values can reflect a number of different age sources, high  $^{207}\text{Pb}/^{204}\text{Pb}$  values are clearly indicative of an ancient crustal component. Elevated  $^{208}\text{Pb}/^{204}\text{Pb}$  values indicate derivation from sources which have evolved with elevated Th/U and low U/Pb, as inferred for the lower crust and granulite facies rocks.

An important fact about Pb isotopic data is that it is very sensitive to small scale or minor crustal interactions. For example, due to the low Pb content of mantle-derived rocks versus felsic continental crust, addition of only a small crustal component ( $<10\%$ ) can impart a crustal Pb isotopic signature to a mantle-derived magma. In general terms, Pb data may only provide information concerning minor source components or contributions whereas Nd and O data, which are relatively insensitive to such minor contributions, can be relied on to indicate the bulk or main characteristics of the granite protolith.

In addition to providing information on the age of crystallization of granitic rocks, U-Pb zircon dating may indicate the presence of xenocrystic zircons. Isochron upper intercept ages indicate the bulk average age of inherited zircon components, whereas single grain analyses can provide precise data on the different ages of grains present. It should be borne in mind that elaborate procedures are usually followed to obtain the clearest and best zircons for U-Pb analysis (see Krogh, 1982; Parrish et al., 1987). If no inherited or xenocrystic zircon component is identified in a sample, it may only indicate the success of these procedures rather than the absence of such a component. Alternatively, as the solubility of zircon in melts is dependent on the aluminum index of the melt (Watson, 1979), lack of an inherited zircon component in a granite may simply reflect its metaluminous or I-type character. Even when a xenocrystic zircon component is identified in a granite, the volume of that age component present in the protolith remains unknown. For example, Whalen et al. (1991) identified the presence of  $1.87 \pm 0.54$  Ga xenocrystic zircon in a juvenile ( $\epsilon_{\text{Nd}}=+3.4$ )

Devonian granite (pluton H1), i.e. the zircon only reflects a volumetrically minor source or assimilated component. Neodymium isotopic analyses are a more reliable method than conventional U-Pb zircon analyses of detecting the presence of and bulk average age of recycled older crustal components in granites.

The use of strontium isotopic data to infer granite source rock characteristics has a long history (e.g. Krogh and Davis, 1969; Faure and Powell, 1972). Granites with initial  $^{87}\text{Sr}/^{86}\text{Sr}$  values ranging from 0.703 to 0.707 have been interpreted as containing only relatively minor amounts of older sialic crustal material, whereas granites with initial ratios in the range 0.708 to 0.741 indicate moderate to major contributions from old crust, often in the form of sedimentary material. Due to the sensitivity of the Sr isotopic system to alteration processes (Faure, 1986), it has proven to be much less useful than the Nd system for obtaining information on the nature of granite protoliths. For this reason, no attempt was made to obtain Sr data in this study.

### *Nd isotopes*

To facilitate comparison, both  $\epsilon_{\text{Nd}}$  values at the time of crystallization and at 0.4 Ga are presented in Table 2. Except for Precambrian Avalon and Grenville data, only small differences exist between  $\epsilon_{\text{Nd}}$  and  $\epsilon_{\text{Nd}}(0.4 \text{ Ga})$  values for the studied granites. For reference,  $\epsilon_{\text{Nd}}(0.4 \text{ Ga})$  values for depleted mantle are +5 to +8 and continental crust of Precambrian age ranges from -4 to more than -20.

$\epsilon_{\text{Nd}}(0.4 \text{ Ga})$  values of granites from different zones are summarized in Table 2 and plotted in Figure 28a. In Dunnage Zone, the Anitouri Lake granite (D5) (see Fig. 28a), with a  $\epsilon_{\text{Nd}}(0.4 \text{ Ga})$  value of -1.6, was left out of the summary presented in Table 2. The location of this granite close to the recently redefined Dunnage-Gander boundary (van Staal and Fyffe, 1991), and the fact that it intrudes a thrust slice of Gander Zone supracrustals, may mean that it is sampling a "Gander" rather than a "Dunnage" source. Also not included in values presented in Table 2, though they are plotted in Figure 28a, are gabbroic rocks. Mafic rocks from every zone have positive  $\epsilon_{\text{Nd}}(0.4 \text{ Ga})$  values, as would be expected for mantle-derived rocks. The similar positive  $\epsilon_{\text{Nd}}(0.4 \text{ Ga})$  values (+0.2 to +5.6) from Siluro-Devonian Humber, Dunnage, and Avalon granites indicate melting of relatively young and juvenile sources (range in depleted mantle model ages,  $T_{\text{DM}}=0.6\text{--}1.1$  Ga). Consistent negative  $\epsilon_{\text{Nd}}(0.4 \text{ Ga})$  values (-5.4 to 0.1) from both Ordovician and Siluro-Devonian Gander granites indicates reworking of the same, significantly older (range in depleted mantle model ages,  $T_{\text{DM}}=1.1\text{--}1.7$  Ga), crustal protolith during a number of different partial melting events.

### *O isotopes*

High  $\delta^{18}\text{O}$  values from particular plutons such as Mt. Brown (H3) ( $\delta^{18}\text{O}=13.67$ ; not plotted) and Mt. Sugar Loaf (D2) ( $\delta^{18}\text{O}=9.6$ ) (Fig. 28c) are considered, based on petrographic evidence, to reflect deuteric or hydrothermal alteration, not primary magmatic signatures. The Anitouri

Lake granite (D5), which has a "Gander-like" Nd signature, has a high  $\delta^{18}\text{O}$  value (8.9) relative to other Dunnage Zone granites. Gabbroic rocks from across the transect, as would be predicted of clearly mantle-derived magmas, have low  $\delta^{18}\text{O}$  values (<8).  $\delta^{18}\text{O}$  data from these above noted samples were not included in the compilation presented in Table 2.

Similar low  $\delta^{18}\text{O}$  values ( $7.1 \pm 0.8$ ) from Humber and Dunnage zones are in the range of mantle or lower crustally derived magmas. Higher  $\delta^{18}\text{O}$  values ( $8.7 \pm 1.0$ ) from both Ordovician and Siluro-Devonian granites in Gander Zone suggest they include a significant contribution from supracrustal rocks. Intermediate  $\delta^{18}\text{O}$  values ( $8.3 \pm 0.6$ ) from Siluro-Devonian granites in Avalon Zone may reflect a minor supracrustal component.

### **Pb isotopes**

Regional Pb isotopic studies have been used in the Appalachians to constrain sources of granitic rocks and in terrane correlation (Ayuso, 1986; Ayuso et al., 1988; Ayuso and Bevier, 1991). Mainly on the basis of  $^{207}\text{Pb}/^{204}\text{Pb}$  signatures, Ayuso and Bevier (1991) subdivided Maine and New Brunswick granites into three different geographic groups: (1) northern (Humber) group, least radiogenic; (2) southern (Avalonian) group, most radiogenic; and (3) central group, with intermediate Pb values. These workers concluded, based on similarities in Pb signatures, that Grenvillian basement was the protolith for the northern group and that Precambrian Avalonian basement was the source for the southern group. The central group was interpreted as being derived from a mixture of Grenvillian and Avalonian components. Based on the distribution of these groups, Grenville basement was inferred to underlie Humber and western Dunnage zones and Avalonian basement was inferred to underlie Gander and Avalon zones.

Humber and Dunnage zone granites exhibit similar low  $^{207}\text{Pb}/^{204}\text{Pb}$  values (15.515-15.616) (Table 2, Fig. 28b). These granites contain lower concentrations of U and somewhat lower Th than granites in other zones (Fig. 23g, 23h). Except for the "anomalous" ( $^{207}\text{Pb}/^{204}\text{Pb} = 15.612$ ) Pabineau Falls granite (G11) in the Bathurst area, Ordovician to Devonian granites in Gander Zone have identical elevated  $^{207}\text{Pb}/^{204}\text{Pb}$  signatures (15.628-15.709). The Pabineau Falls Pb signature may reflect or image underlying thrust slices of Dunnage Zone rocks (see van Staal and Fyffe, 1991). Siluro-Devonian Avalon Zone granites are characterized by somewhat lower  $^{207}\text{Pb}/^{204}\text{Pb}$  signatures (15.612-15.649) than many Gander Zone granites. Like Gander Zone granites, Precambrian Avalon Zone basement also has elevated  $^{207}\text{Pb}/^{204}\text{Pb}$  signatures (15.640-15.727). If only the Pb isotopic data is considered, the interpretation of Ayuso and Bevier (1991) summarized above appears reasonable. However, Nd and O isotopic data make it probable that the "crustal sources" of Humber-Dunnage and Gander zone granites were neither Grenvillian or Avalonian basement, despite similarities in Pb signatures between granites and these potential basement sources. This is discussed further below in Nature of granite protoliths and implications for crustal structure beneath the orogen.

### **U-Pb isotopes**

U-Pb zircon information is available for only a few of the granite samples collected for this study and also for some Precambrian Avalonian basement rocks. In Humber and Dunnage zones, the only pluton for which U-Pb zircon inheritance information has been published is the McGerrigle pluton (H1). A granite (WXMG-46) from this complex gave an upper intercept age of  $1.87 \pm 0.54$  Ga, indicating a Proterozoic average age for the inherited zircon component (Whalen et al., 1991).

Ordovician granites in the Gander Zone gave the following upper intercept ages; South Renous (G8 - WXNB-126) =  $1.4 \pm 0.3$  Ga; Mullin Stream Lake (G6 - WXNB-233) =  $1.4 \pm 0.8$  Ga; Serpentine River (G5 - WXNB-279) =  $2.2 \pm 0.2$  Ga; Sweat Hill (G4 - WXNB-276) =  $1.5 + 0.7/-0.5$  Ga; Fox Ridge (G7 - WXNB-134) =  $1.2 \pm 0.02$  Ga (M. Bevier and J. Whalen, unpub. data, 1988). Roddick and Bevier (1988) report ion microprobe ages for xenocrystic zircon in a Meridian Brook granite sample (G3 - WXNB-84) of 720, 1030, 1050, 1200, 1380, 1520-1580, 1650, and 1900 Ma. They also report a similar range in xenocrystic zircon ages from the Devonian Pabineau Falls granite (G11 - sample WXNB-45). It is likely that a similar range in xenocrystic zircon ages is present in other Gander granites.

In the Gander Zone in Newfoundland, both zircon populations in sediments and inherited grains in granites contain a predominance of  $1.5 \pm 0.2$  Ga grains (G. Dunning, pers. comm., 1989). In general, similar middle Proterozoic ages are rare in the adjoining Grenville shield (see Gower et al., 1990). Studies of some Precambrian Avalonian granites and orthogneisses indicate the presence of both early (2.3-2.7 Ga) and middle (1.0-1.7 Ga) Proterozoic detrital zircon grains (Bevier and Barr, 1990; Bevier et al., 1990).

### **Sr isotopes**

Recent precise U-Pb dating in this portion of the Appalachian orogen (e.g. Bevier and Whalen, 1990b) has demonstrated that Rb-Sr geochronology, like K-Ar dating, can not be trusted to yield valid crystallization ages. Strontium initial ratios calculated for 36 whole rock samples from the McGerrigle complex (pluton H1), using analytical data from La Rocque (1986) and new U-Pb crystallization ages (Whalen et al., 1991), range from 0.702-0.712. This variation could be interpreted as reflecting hybridization of magmas with significantly different Sr isotopic compositions, i.e. mantle and crustally derived melts. However, Nd isotopic data on components of this suite exhibit little dispersion; all are juvenile ( $\epsilon_{\text{Nd}} = +2$  to  $+5$ ). Some alteration process has probably affected Sr but not Nd, one possible candidate being post-emplacment magmatic fluids which were also responsible for the mineral deposits adjacent to this complex. As Sr isotopic data can give such misleading petrogenetic information, Sr whole rock isotopic analyses were not carried out in this study.

Published initial  $^{87}\text{Sr}/^{86}\text{Sr}$  data tabulated in Appendix 1 are most complete for Avalon Zone granites and sparse for Humber and Dunnage zone granites. There is almost a complete overlap in values from the different zones: Humber (0.702-0.712), Dunnage (0.703-0.706), Gander (0.703-0.737), and Avalon (0.705-0.709). Except for high values (0.712 to 0.737) for Tower Hill and Beech Hill stocks (G28 and G29) and some McGerrigle complex granites (H1), all initial  $^{87}\text{Sr}/^{86}\text{Sr}$  values fall between 0.703-0.708. Values from Avalon Zone granites fall at the higher end of this range. With the exception of the small Tower Hill and Beech Hill stocks, initial  $^{87}\text{Sr}/^{86}\text{Sr}$  values suggest that the granites were not mainly derived from older sialic crust and contain a major mantle or lower crustal component.

## A GRANITE GEOCHEMICAL AND ISOTOPIC TRANSECT OF THE CANADIAN APPALACHIANS: CONSTRAINTS ON SOURCES AND IMPLICATIONS FOR CRUSTAL STRUCTURE

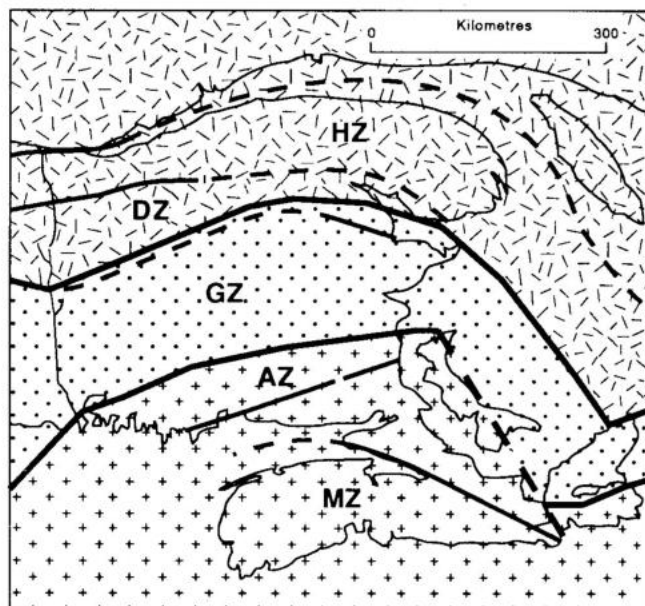
### Introduction

Granites as large-scale, easily accessible, samples or "probes" of the lower continental crust have particular importance for addressing problems related to the nature of the lower crust beneath orogenic belts. Large scale transect studies of granite plutons across orogenic belts have demonstrated the existence of geochemical and isotopic asymmetry (Pitcher, 1982; White and Chappell, 1983; Bateman, 1983; Farmer and DePaolo, 1983; Saunders et al., 1980). The cause of this asymmetry, whether a direct image of regional differences in lower crustal lithology (White and Chappell, 1977; McCulloch and Chappell, 1982; Chappell and Stevens, 1988) or varying degrees of mixing between mantle-derived and crustal components (DePaolo, 1981b; Farmer and DePaolo, 1983), remains controversial. Both views, however, consider it a reflection of greater involvement of old crust toward the continent. Demonstration of such asymmetry, therefore, assists in recognition of major crustal sutures and ocean-continent geometry (Reed et al., 1983; Borg et al., 1987; Debon et al., 1986).

Recent deep seismic transects across the Canadian Appalachian orogen have outlined three major lower crustal blocks (LCBs): Grenville, Central, and Avalon (Keen et al., 1986; Marillier et al., 1989) (Fig. 29). Grenville lower crustal block, interpreted as the tectonically overridden edge of the Grenville craton, underlies Humber Zone and western Dunnage Zone. It abuts Central lower crustal block east of the Baie Verte-Brompton (B-B) Line under Dunnage Zone. Based on seismic data in Maine, Spencer et al. (1989) interpreted basement south of the Baie Verte-Brompton Line to consist of allochthonous Chain Lakes type basement rocks underlain by a thinned autochthonous Grenville basement, and overlain by thrust slices of Ordovician arc-type rocks. North of the Baie Verte-Brompton Line allochthonous slices of continental shelf and rise rocks overlie a much thicker autochthonous Grenville basement. Central lower crustal

block, believed to be continental in composition, underlies eastern Dunnage Zone and Gander Zone. This implies that Dunnage Zone oceanic sequences are allochthonous with respect to this thick continental lower crustal block. It remains unresolved whether Gander Zone rocks are allochthonous or autochthonous with respect to Central lower crustal block. Avalon lower crustal block abuts Central lower crustal block along a steep vertical strike-slip fault corresponding to the surface trace of the Gander-Avalon Zone boundary. Avalon lower crustal block is considered to be autochthonous with respect to its cover rocks and basement to Avalon Zone. Of these three seismically defined lower crustal blocks, only Grenville can be studied directly. Basement to other zones has not been recognized. Granite studies are an indirect method of "mapping" these lower crustal blocks and obtaining information pertaining to their age and affinities.


During this study granite data was obtained from within all tectonostratigraphic zones, except for Meguma Zone, and from above all the seismically defined lower crustal blocks along an approximate southeast to northeast transect (Fig. 1).



### LEGEND

#### Lower crustal blocks

 Grenville

 Central

 Avalon

Boundaries between different tectonostratigraphic zones . . . - - -

**Figure 29.** Interpreted regional extent of lower crustal blocks (LCBs) beneath the Canadian Appalachians (modified from Stockmal et al., 1990). Zone abbreviations as follows; Meguma (MZ), Avalon (AZ), Gander (GZ), Dunnage (DZ), and Humber (HZ).

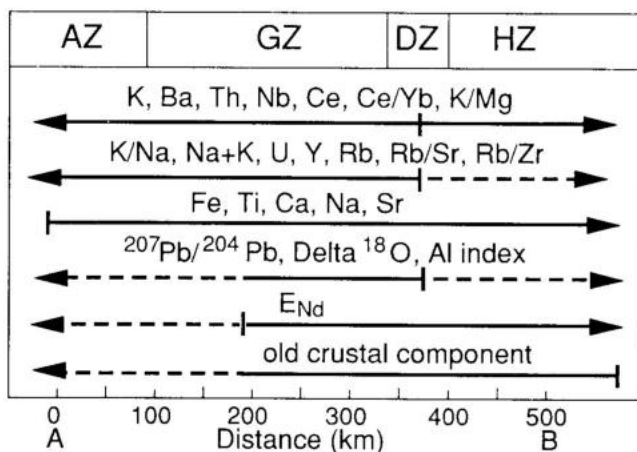
In the following sections, granite geochemical variations across the orogen, the nature of their protoliths and implications for crustal structure will be discussed.

### **Granite geochemical and isotopic variations across the orogen**

For the purposes of examining chemical variations across the Appalachian orogen, Gaspésie and New Brunswick granite data are projected on a south-north cross-section (labelled A-B in Fig. 1) in Figures 23, 28, and 30. The most significant spatially-related geochemical and isotopic variations across the orogen seem to occur in "jumps" corresponding to the Dunnage-Gander and Gander-Avalon boundaries rather than as smooth "trends". These jumps or steps can be interpreted as representing major crustal breaks where crustal or basement blocks with different evolutionary histories have been tectonically juxtaposed.

In general, chemical polarities from Dunnage Zone southward and, to a lesser extent, from Dunnage Zone northward (Fig. 30) resemble the ocean to continent chemical variations documented in other orogenic belts (e.g. Reed et al., 1983; Borg et al., 1987). The ratio Rb/Zr, which increases away from the Dunnage Zone (Fig. 23k), has been suggested by Brown et al. (1984) to increase with arc maturity or continental character of an arc. Geochemical variations involving elements such as Zr, Nb, Th, U, and REE may result from late stage fractionation of minor mineral phases. However, their spatially correlated nature suggests they mainly reflect source-related processes or characteristics. More unequivocally than other chemical variations, isotopic trends can be interpreted as reflecting greater involvement of old crustal material going from Dunnage Zone to Gander Zone. The close relationship which exists between mafic and felsic rocks in many suites suggests that chemical variations (Fig. 23, 28, 30) reflect regional differences both in crustal lithologies involved in partial melting and in the degree of interaction between mantle and crustal melts.

Trends summarized in Figure 30 can be interpreted as evidence that the Iapetus suture is located within Dunnage Zone, or at its contact with Humber Zone, and that ocean closure occurred by southeast-directed subduction, both tenants of classic (e.g. Williams, 1979) and recent (van Staal et al., 1991) Appalachian tectonic models. According to the van Staal et al. (1991) model, Middle to Late Ordovician closure of Iapetus resulted in collision between a lower Ordovician arc and Laurentia. As the granites which exhibit geochemical polarity mainly postdate this event, no direct relationship can exist between southeast-directed subduction and the geochemical asymmetry. Siluro-Devonian granites may reflect or image geochemical characteristics of source rocks (e.g. a mixed mantle-crustal underplate) generated during this Ordovician Iapetus closure event, a process termed "remagmatization" by Chappell and Stevens (1988). In the model of van Staal et al. (1991) and van Staal (1987), Iapetus closure is followed by Late Ordovician to Early Silurian closure by northwest-directed subduction of an ensimatic back-arc basin located behind the lower Ordovician arc. Other recent tectonic models (e.g. Bevier and



**Figure 30.** Diagram summarizing major chemical polarities in granite geochemical data across the various tectono-stratigraphic zones along south-north cross-section A-B in Figure 1; zone abbreviations as in Figure 28. Solid lines with arrows indicate the direction of increasing values for good geochemical trends and broken lines indicate trends with poorer correlations.

Whalen, 1990b; Whalen, 1989) have also postulated closure of an ocean basin(s) during this period. Siluro-Devonian granites may directly reflect this latter subduction event or, alternately this back-arc closure may have provided the heat source to "remagmatize" or rework protoliths produced during the first closure event.

### **Nature of granite protoliths and implications for crustal structure beneath the orogen**

Granites may be partial melts from mantle or juvenile (mantle-derived) material added to the lower crust by underplating or, at the other extreme, they may be derived wholly from older continental crust. A spectrum of variable degrees of interaction or mixing between juvenile (mantle) and crustal protoliths lies between these extremes. The interrelationships between  $\epsilon_{\text{Nd}}$ ,  $^{207}\text{Pb}/^{204}\text{Pb}$ , Al index, and  $\delta^{18}\text{O}$  data are particularly useful in resolving questions concerning "supracrustal" versus "mantle" source components (see Table 2 and Fig. 31). In general, studied Appalachian granites exhibit positive correlations of Al index and  $^{207}\text{Pb}/^{204}\text{Pb}$  and a negative correlation of  $\epsilon_{\text{Nd}}$  with  $\delta^{18}\text{O}$ . These relationships can be interpreted as reflecting mixing between metaluminous, juvenile, non-radiogenic "mantle-like" component(s) and a peraluminous (weathered or altered), radiogenic, old crustal component(s). However, based on geochemical and isotopic data presented above, the granites can be subdivided into three geographically distinct groups; Humber-Dunnage, Gander, and Avalon. The fact that none of these groups alone defines trends in Figure 31 suggests that granite chemical variations may be more source-controlled than process-controlled. A simple mantle-crustal mixing model does not readily explain the geographically controlled granite variations. Below,

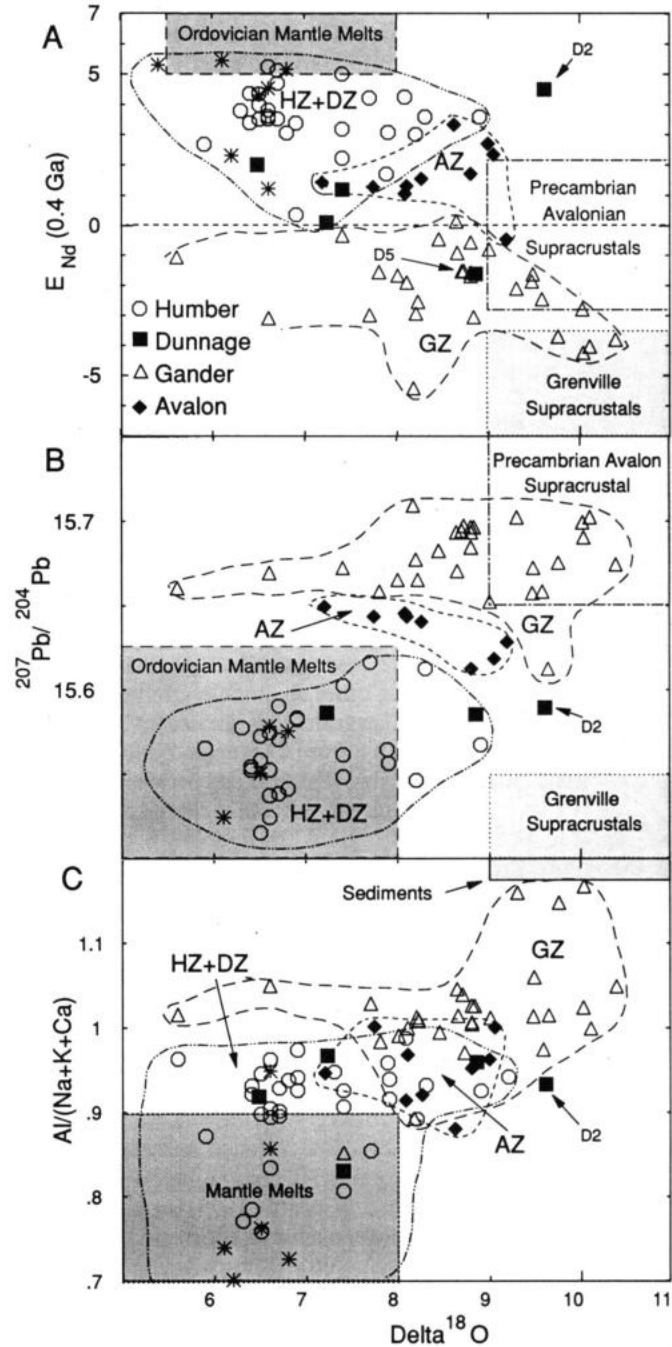
evidence bearing on the protoliths of each granite group will be discussed separately from north to south and direct inferences will be made about the nature of the three seismically defined lower crustal blocks (see Fig. 29) which underlie them.

1. **Humber-Dunnage group:** This group of Siluro-Devonian, metaluminous, amphibole-bearing intrusive rocks spans a compositional spectrum from gabbro to granite and forms a calc-alkalic magmatic association. According to the genetic classifications of Debon and Le Fort (1982) and White and Chappell (1977, 1983) these granites were clearly derived from igneous or reworked mantle-derived (infra-crustal) protoliths. This conclusion is supported by their  $\delta^{18}\text{O}$ ,  $\epsilon_{\text{Nd}}$ , and  $^{207}\text{Pb}/^{204}\text{Pb}$  values which overlap those of mantle-derived magmas (Fig. 31) indicating supracrustal rocks were not a significant source component.

It has been emphasized by Ayuso and Bevier (1991) that the low  $^{207}\text{Pb}/^{204}\text{Pb}$  values of their northern group of granites closely resembles that of Precambrian Grenville crust. However, the field for Dunnage mature arc and arc-rifting massive sulphides deposits in Newfoundland (Swinden and Thorpe, 1984) also overlap the Humber-Dunnage granite field (Fig. 28b). The Pb interpretation is non-unique. Based on the Pb data, both Grenville basement and Ordovician arc-related mantle sources are appropriate protoliths.

The Nd isotopic signature of the Grenville craton, a prime candidate as the substrate to the Appalachian orogen, is not well constrained. Portions of the Grenville province in the Adirondack Highlands (Daly and McLelland, 1991) and in Texas (Patchett and Ruiz, 1989) are underlain by crust with a relatively short crustal residence time ( $T_{\text{DM}} = 0.7$  to  $1.8$  Ga) whereas a segment of the foreland in Ontario has had an extended crustal history ( $T_{\text{DM}} = 1.9$  to  $3.3$  Ga; Dickinson and McNutt, 1989). These Grenville data, with an  $\epsilon_{\text{Nd}}$  (0.4 Ga) range of  $-37$  to  $-3.5$ , are clearly distinct from those of Humber and Dunnage granites (Fig. 28a). Based on this data, melting of Grenville basement to produce these granites, as advocated by Ayuso and Bevier (1991), is not a plausible mechanism. Seismic data indicates that Humber granites are underlain by the Grenville lower crustal block and that there is a junction between Grenville and Central lower crustal blocks beneath the Dunnage Zone (Fig. 29). Isotopic evidence effectively rules out Grenville basement as a significant source component and dictates an isotopically mantle-like igneous protolith of early Paleozoic age for Humber and Dunnage granites. It is possible that the Grenville lower crustal block is not all "Grenville-like", i.e. it is composite. Marine seismic reflection studies in the Gulf of St. Lawrence have indicated the presence of a horizontally layered crust within Grenville lower crustal block, a feature which disappears towards the Grenville craton and, therefore, is not a characteristic of Grenville basement. Marillier et al. (1989) suggest that this layering may be a zone of Paleozoic underplating. Such an underplate, probably formed during the Iapetus Wilson cycle, would be a plausible source for Humber-Dunnage granites. Alternately, juvenile Humber-Dunnage granites might be melts of underthrust modified Paleozoic "oceanic" crust, on which the allochthonous Dunnage supracrustals were originally deposited, or its underlying metasomatized early

Paleozoic mantle. Reworking of this protolith during Siluro-Devonian melting events may have "cratonized" it such that it can not be readily distinguished seismically from overlying Grenville basement. It is also possible that Grenville lower crustal block did not occupy its present position at the time these granites were generated. Major



**Figure 31.** Distribution of the granite data, subdivided by zone, on  $\delta^{18}\text{O}$  versus (A)  $\epsilon_{\text{Nd}}(0.4 \text{ Ga})$ , (B)  $^{207}\text{Pb}/^{204}\text{Pb}$ , and (C) Al index plots. Generalized fields for Ordovician mantle-melts, Precambrian Avalonian and Grenville supracrustals and sediments are based on sources cited in Figure 29. Abbreviations for zones as in Figures 28 and 30.

post-Devonian thrusting has displaced these granites with respect to their source rocks. Though there is evidence for Carboniferous transcurrent movements, there is no evidence for such a major thrusting event.

Clearly, the granite data indicates that the crust beneath these zones is more complex than was suggested by the seismic interpretation. Future seismic interpretations, which take into account this granite study, may substantiate the existence of lower crustal layering or inhomogeneities beneath this area and aid in evaluating the above three theories. At present, some variation on the first or second model appears most reasonable.

2. **Gander group:** This group of Ordovician and Siluro-Devonian, metaluminous to moderately peraluminous, mainly felsic, biotite granites, which includes minor gabbroic and amphibole-bearing granodioritic rocks, belongs to an aluminous-calcic magmatic association. Debon and Le Fort (1982) suggest that such magmatic associations are derived from a mixture of supracrustal and mantle-derived source components. In contrast, the genetic classification of White and Chappell (1977, 1983) suggests that these granites were derived from I-type, or infracrustal sources. Elevated concentrations of high field strength elements in many Gander granites indicate affinities to A-type granites. Elevated  $\delta^{18}\text{O}$  values ( $8.7 \pm 1.0$ ) of Gander granites (Table 2, Fig. 28c) suggests that this aluminous-calcic suite does contain a significant supracrustal source component. Negative  $\epsilon_{\text{Nd}}$  and high  $^{207}\text{Pb}/^{204}\text{Pb}$  values as well as Proterozoic xenocrystic zircon data for Gander granites are consistent with reworking of old crust ( $T_{\text{DM}} = 1.1$  to 1.8 Ga).

$\epsilon_{\text{Nd}}$  values of Gander granites overlap the upper portion of the range reported from the Grenville province (Fig. 28a) and some of their inherited zircons are of Grenville age. However, the distinctly lower  $^{207}\text{Pb}/^{204}\text{Pb}$  signature of North American Grenville basement versus Gander granites suggests that such basement is not a suitable protolith (Fig. 28b). Basement of Grenville age characterized by Pb isotopic characteristics differing from North American Grenville could be a possible source.

Although Precambrian Avalonian rocks and Gander granites have similar  $^{207}\text{Pb}/^{204}\text{Pb}$  signatures (Ayuso and Bevier, 1991),  $\epsilon_{\text{Nd}}$  values in the Precambrian samples (+2 to -5) overlap only in their negative values the range in Gander granites (Fig. 28a). Precambrian Avalonian granites in Nova Scotia (S. Barr and E. Hegner, pers. comm., 1991) and Newfoundland (G. Jenner, pers. comm., 1990) have yielded exclusively positive  $\epsilon_{\text{Nd}}$  values. Whole rock geochemical data, like the Nd isotopic data, suggests that Gander granite sources had a restricted compositional range, were relatively homogeneous over a large area, and were essentially identical during Ordovician and Siluro-Devonian melting events. This evidence indicates that Ayuso and Bevier (1991) were incorrect in inferring, based solely on Pb isotopes, that Gander granites were derived from Precambrian Avalonian basement.

As there is a complete overlap between Nd  $T_{\text{DM}}$  ages and U-Pb zircon inheritance ages (1.1 to 1.8 Ga) from Gander granites, the Nd model ages could be interpreted as true

crustal residence or crust formation ages. However, the correlation between elevated  $^{18}\text{O}$  values, peraluminous character and high  $^{207}\text{Pb}/^{204}\text{Pb}$  and  $\epsilon_{\text{Nd}}$  values in these granites (Fig. 31) may mean that they contain a significant supracrustal (possibly sedimentary) component from which they derive their main chemical signature. In this case,  $T_{\text{DM}}$  ages may only represent the average age of detrital components, not the age of the granite source and the protolith is only constrained to be older than the granites, i.e. pre-Middle Ordovician.

Kerr et al. (1990) inferred that the mainly peraluminous (alumina index >1.1) Gander Zone granites in Newfoundland were completely or in part derived by anatexis of host Gander Group metasedimentary rocks. The rather low Sr initial ratios, metaluminous to slightly peraluminous character, and high sodium content of Gander granites in New Brunswick are more appropriate for melts derived from an altered volcanic or mixed volcanic-sedimentary protolith, rather than a purely sedimentary source. Alternately, these granites could represent mixtures of mantle-derived and sediment-derived melts. It must be borne in mind that the protolith of these granites was apparently homogeneous on a large scale both spatially and temporally. Anatexis of some uniform Proterozoic basement block is judged to be much more plausible method for generating Gander granites than any process which involves blending of Paleozoic supracrustal and mantle-derived melts. It seems unrealistic to suggest that under the various tectonic regimes which existed over space and time in Gander Zone that identical mixtures could be produced. Neither hypothetical Precambrian Grenville or Avalonian supracrustals are entirely appropriate protoliths, though both are more suitable than Ordovician mantle-derived melts (Fig. 31).

Derivation of the voluminous Ordovician to Devonian granites in Gander Zone from similar, compositionally restricted sources suggests that there has been no major basement-cover displacements in Gander Zone since at least Middle Ordovician time. Based on this, Gander Zone is the surface expression of the Central lower crustal block and Gander granites represent the only available samples of this lower crustal block. Based on the above discussions, this Central lower crustal block remains enigmatic for it is like neither Grenville nor Avalonian basement.

3. **Avalon group:** This group of Siluro-Devonian, metaluminous, mainly felsic biotite±amphibole granites forms a calcic granite association derived from I-type (infracrustal) or mantle-derived sources. Some granites are peralkaline A-type granites and most others have some A-type affinities. However, their  $\delta^{18}\text{O}$  values (7.7-9.1) (Fig. 28c), which are only slightly lower than those of Gander granites, may reflect the presence of a supracrustal component. Positive  $\epsilon_{\text{Nd}}$  (0.4 Ga) values (Fig. 28a) indicate derivation from relatively young, juvenile sources, whereas elevated  $^{207}\text{Pb}/^{204}\text{Pb}$  signatures (Fig. 28b) and xenocrystic zircon data indicate an ancient crustal component.

The juvenile Nd signature exhibited by both Siluro-Devonian and Precambrian Avalonian granites in New Brunswick is the same as that of Avalonian granites in Nova

Scotia (S. Barr and E. Hegner, pers. comm., 1991) and Newfoundland (B. Fryer and G. Jenner, unpub. data, 1991). The Al index,  $^{207}\text{Pb}/^{204}\text{Pb}$ ,  $\epsilon_{\text{Nd}}$ , and  $\delta^{18}\text{O}$  characteristics of Avalon granites lie between those exhibited by the Humber-Dunnage and Gander groups (Fig. 31). The Nd data show that the bulk of the protolith of Avalonian granites was juvenile or young, whereas O and Pb data may reflect incorporation into these granites of a minor supracrustal component, either at the source, or during magma ascent from the site of partial melting. These features, as well as inherited zircons, suggest the presence of a volumetrically minor Proterozoic supracrustal (sedimentary?) component in these granites.

Both Nd and Pb signatures of Avalonian granites are distinct from those of North American Grenville (Fig. 28a, b), effectively ruling out such basement as a significant source component. Neodymium data also rules out derivation of Gander and Avalonian granites from similar protoliths. Seismic data (Fig. 29), substantiates that each zone is underlain by different types of basement. Siluro-Devonian Avalonian granites overlap Precambrian Avalonian basement only at the upper end of the range in  $\epsilon_{\text{Nd}}$  (0.4 Ga) values exhibited by basement (Fig. 28a). Either the granites were derived by melting of juvenile components of that basement, or they represent mixtures between Siluro-Devonian mantle-derived magmas and partial melts of less juvenile Avalonian basement. A petrogenetic model of basalt-driven partial melting is compatible with the latter option (compare Granite petrogenesis, below).

The granite data suggests that the Avalon lower crustal block consists mainly of Late Proterozoic or younger crust with a minor pre-Middle Proterozoic crustal component. This basement block probably formed mainly during a late Proterozoic arc-type crust formation event, as outlined by Nance (1987).

## PETROGENESIS AND TECTONIC SIGNIFICANCE OF THE GRANITE MAGMATISM

### Introduction

This section deals mainly with granites as recorders or products of tectonic processes or events. The tectono-magmatic characteristics of both granites and associated mafic rocks were examined in previous sections and that information is integrated below with current ideas on granite petrogenesis and on Appalachian tectonic evolution.

### Granite petrogenesis

In this bulletin, granites were grouped or subdivided on the basis of which tectonostratigraphic zone they intrude because a direct correlation exists between zonal distribution and geochemical and isotopic characteristics. In contrast, a recent compilation on all Canadian Appalachian granites (Currie, in press) subdivided granites firstly by age, then grouped them by basic petrological features. This approach has merit when considering details of granite petrogenesis and tectonic implications. In Table 3, plutons covered in this report are grouped according to the genetic granite "types" identified by Currie (in press). The petrogenesis of each granite group is discussed separately below based on the new data collected during this study.

**Group 1** – Types 5a ( $460 \pm 20$  Ma) and 7a ( $405 \pm 15$  Ma) – deformed and massive peraluminous granites in Gander Zone.

These granites together record continuous plutonism from Middle Ordovician to Early Devonian in Gander Zone. Their most distinctive characteristic is their granitic, *senso stricto*, composition. Ordovician granites (Type 5a) are chemically

**Table 3.** Age and petrological subdivision of New Brunswick and Gaspésie granitic plutons

Group	Type <sup>1</sup>	Age (Ma)	Distribution <sup>2</sup>	Pluton Codes <sup>3</sup>	Description
1	5a	$460 \pm 20$	GZ	G1 to G10	deformed peraluminous granite plutons
	7a	$415 \pm 15$	GZ	G13,16,22,23,24, 25,26,28	massive peraluminous granite plutons
2	6	$425 \pm 15$	AZ	A2	alkaline to peralkaline plutons
3	8	$405 \pm 15$	HZ, DZ, GZ, AZ	H1,3; D3,4,6; G12, 14,15; A4,5,6	composite "basalt-driven" plutons
4	9b	$360 \pm 15$	HZ, DZ, GZ; AZ	H2,4,5; D5; G11,18, 29; A1,3,4	mainly high-silica and alkali granite plutons lacking mafic phases

<sup>1</sup> Pluton type classification of Currie (in press).  
<sup>2</sup> Tectonostratigraphic zones plutons intruded into: HZ = Humber, Dz = Dunnage, GZ = Gander, Az = Avalon.  
<sup>3</sup> Code for individual plutons as located in Fig. 1 and listed in Appendix 1.

and isotopically indistinguishable from Siluro-Devonian granites (Type 7a) with similar silica contents. Their evolved compositions relative to continental crustal estimates (Fig. 21d-i) and their close modal resemblance to other granites of crustal origin (Fig. 2) suggest these plutons result from anatexis of continental crustal material. Geochemical and isotopic evidence suggests derivation from old ( $1.5 \pm 0.2$  Ga) infracrustal or mixed crustal-mantle sources.

Type 5a granites have unequivocal within-plate granite (WPG) signatures, in keeping with the tectonic model proposed by van Staal (1987) for Ordovician magmatism in this area. Both felsic volcanism and plutonism are interpreted to be a response to continental crustal attenuation and partial melting in a back-arc setting. Type 7a granites exhibit mixed within-plate granite-volcanic-arc granite signatures, suggesting involvement of and/or contributions from mantle-derived components. Siluro-Devonian granite magmatism is a product of partial melting of the same protolith (Middle Proterozoic continental basement?) as Type 5a granites. The heat source or process responsible for melting this basement is problematic but lower crustal partial melting due to lithospheric delamination during Iapetus or back-arc basin closure could be responsible.

**Group 2** – Type 6 ( $425 \pm 15$  Ma) – alkaline to peralkaline plutons.

In the study area, only the Welsford and Jake Lee Mountain complexes (A2) belong to this group. These high-level peralkaline plutons can be unambiguously classified as A-type granites (see Fig. 2, 24, and 26). In a recent review of the petrogenesis of such granites, Whalen et al. (1987a) concluded that they represented second generation melts from a protolith from which an I-type granite had been previously extracted. Both these granites and Precambrian I-type granites in Avalon Zone have similar juvenile Nd signatures, as would be predicted for remelts from the same protolith from which the Precambrian granites were extracted. Localization of these granites and other phases of the St. George Batholith at or near the fault-controlled Gander-Avalon boundary, suggests emplacement in an extensional or dilational zone. Crustal melting was probably driven by mantle-derived heat, either from basaltic magmas or conductive heat loss.

**Group 3** – Type 8 ( $405 \pm 15$  Ma) – composite, "basalt-driven" plutons.

In these intrusions, a close temporal and spatial association with mantle-derived magmas indicates a genetic link between mafic and felsic phases. Their bimodal nature plus geochemical and isotopic evidence suggests that mafic and felsic magmas are derived from distinctly different sources. Though some contain spectacular evidence for interaction between these two end-members, volumes of hybrid or intermediate magmas are usually small. In general, it is thought that mafic mantle-derived magmas provide the heat required to generate felsic magmas from lower crustal protoliths. Type 8 and type 7a granites may be generated by

similar processes except that in type 8 plutons genetically-related mafic magmas have been emplaced along with felsic magmas.

The most outstanding example of a type 8 pluton, the McGerrigle Mountains complex (pluton H1), has been studied in considerable detail. Other good examples include the Mt. Elizabeth complex (G12) and the Bocabec complex (A6). A number of these plutons (H1, D3, and G14) have associated hydrothermal mineralization (base metal or U), a characteristic which may be due to the association with mafic rocks. The McGerrigle complex is discussed as an example of how this group of granites formed.

Geological (Whalen, 1985; Whalen 1987a; Fig. 5), geochemical (Whalen and Garipey, 1986), and geochronological (Whalen et al., 1991) evidence demonstrated intricate small scale variation of physical and chemical properties within the McGerrigle complex (H1) and suggested that this resulted from interaction between at least one granitic, one mafic, and one felsic undersaturated magma. A speculative petrogenetic model can be provided based on experimental studies of crustal melting by injection of basaltic sills (Huppert and Sparks, 1988) and the magma-mixing model for petrogenesis of the hybrid suite. Mildly alkaline mafic magmas, produced by small degrees of partial melting of incompatible-element-enriched mantle, are injected as sills into juvenile underplated lower crust material. Melting of this lower crust produces a plastic layer, which inhibits the rise of the mafic layer. Fractionation of this "trapped" mafic layer produces the undersaturated felsic component to the suite. The fact that the mafic layer cannot rise until the silic layer becomes unstable and rises could explain the slightly older age obtained from the granite suite. It was emplaced first and preheated the host rocks prior to emplacement of the hybrid suite. The high degree of hybridization exhibited by the hybrid suite could be explained by a long residence/mixing time before, during, and following emplacement. The "Nb signature" of the suite (see Fig. 23f) was obtained at this stage from exchange with undersaturated felsic magmas. Interaction between a hot ( $\sim 1200^\circ\text{C}$ ), low viscosity, mafic magma, and a cooler ( $\sim 700^\circ\text{C}$ ), viscous, felsic magma can be a very complex process involving remelting and superheating of the felsic magma (see summary of Turner and Campbell, 1986). Such remelting could explain observed intrusive relations of granite into "younger" hybrid suite rocks. The extended period of elevated temperatures ( $>550^\circ\text{C}$ ) within the hybrid suite may have resulted from high thermal flux associated with an underlying hybridizing magma chamber.

**Group 4** – Type 9b ( $360 \pm 15$  Ma) – high-silica and alkali granites lacking associated mafic phases.

This group includes plutons in all zones. The two outstanding examples of this granite type in the area are the Burnthill suite (G18) (MacLellan et al., 1990) and the Mt. Douglas phase (A4) of the Saint George Batholith (McLeod, 1990). In the orogen as a whole the "type" example is the Ackley granite, Newfoundland, the petrogenesis of which has been discussed in some detail by Whalen (1980, 1983). These

granites can be loosely termed "ambiguous" types, i.e. they are evolved I-type granites which have many of the trace and some major element characteristics of A-type granites (see Fig. 2, 23, and 24). Their near minimum melt compositions (Fig. 2), elevated Rb, Th, U, and Rb/Sr (Fig. 23d, g, h, m) and moderate to marked negative Eu anomalies (Fig. 22h, j) suggest large degrees of fractional crystallization. Common features include extensive textural variations, multiple crosscutting phases of similar major element but variable trace element compositions, miarolitic cavities, and associated pegmatitic phases. They typically have associated mineralization (Mo, Sn, W, and U) which exhibits transitional pegmatitic to hydrothermal characteristics.

Ponding of a large volume of granitic magma in a near surface magma chamber, followed by in situ fractional crystallization, vapour saturation, and multiple stages of tapping and injection of evolved and less evolved liquids from this chamber can explain most characteristics of this granite type (Whalen, 1983). The heat source driving the partial melting was probably mantle-derived conductive heat loss (see below). The isotopic characteristics of both the Burnthill and Mt. Douglas granites are identical to those of granites of different ages in the same zone, i.e. Burnthill was derived from old crustal sources and Mt. Douglas from juvenile or young sources. This suggests that the special characteristics of this group of granites are due to post-melting evolutionary processes, as outlined above, rather than being source-related. Tectonic environment may be another controlling factor. Accumulation of large volumes of minimum-melt magma would be facilitated by migration into a dilatation zone such as an inactive fault, and by emplacement in a tectonically "quiet" area where it is free to evolve undisturbed over an extended period. These considerations may explain the observation of Currie (in press) that, though these granites are closely connected with major transcurrent faults, they are posttectonic both to the faults and earlier deformation and metamorphism.

### ***Tectonic models for the granite magmatism***

The geology of the Canadian Appalachians is generally interpreted in terms of opening and closing of the Late Precambrian-Early Paleozoic Iapetus ocean. While a Late Precambrian timing for Iapetus opening is generally accepted, interpretations differ as to whether Iapetus closure was complete by the Middle Ordovician (Williams, 1979), or whether subduction and collisional activity continued into the Silurian or even the Devonian (e.g. Hatch, 1982; Arnott et al., 1986; van Staal, 1987; Whalen, 1989; Bevier and Whalen, 1990b; van Staal et al., 1991). The problem of timing and geometry of Iapetus closure is complicated by the possibility of post-Silurian large-scale transcurrent movements in the orogen and the allochthonous nature of the Dunnage Zone (Keen et al., 1986; Stockmal et al., 1987). Because most granite plutonism in the orogen occurred during this Middle Ordovician to Early Devonian period, these rocks are particularly relevant to understanding the later stages of Iapetus closure. Tectonic models which account for the granite magmatism will be presented in two parts, firstly the Early to Middle Ordovician, then the Siluro-Devonian.

### **Early to Middle Ordovician**

Van Staal (1987) and van Staal et al. (1991) have suggested the following tectonic model for evolution of the Dunnage and Gander zones in New Brunswick. The Tetagouche Group and adjacent Fournier Group, a dismembered oceanic back-arc fragment, formed in different segments of the same Middle Ordovician back-arc basin. Ensialic arc volcanic rocks of the Meductic-Woodstock area (Dostal et al., 1989), which are intruded by the probably consanguineous, late Arenigian Benton and Gibson stocks (pluton G10), are interpreted as remnants of the Early Ordovician part of the Taconic arc. As Iapetus closed by southeast-directed subduction, a back-arc basin opened behind the Taconic arc. Back-arc formation within a continental block was accompanied by crustal attenuation and partial melting, generating voluminous felsic magmatism. Within-plate signatures of both consanguineous Ordovician extrusive (van Staal et al., 1991) and plutonic rocks is compatible with this model. Granite isotopic signatures suggest that this rifted continental basement was neither of "Avalonian" or "Grenvillian" affinity, i.e. its provenance is enigmatic. Iapetus closure by southeast-directed subduction resulted in collision between the Taconic arc and Laurentia in the Caradocian.

### **Siluro-Devonian**

Major volumes of plutonic and volcanic rocks in the Canadian Appalachians, which were previously accepted as being of Devonian age, are actually of Silurian age (e.g. Whalen et al., 1987b; Dunning et al., 1988; Whalen, 1989; Bevier and Whalen, 1990b). Notable features of this Silurian magmatic activity are its widespread distribution in the Canadian Appalachians, the diversity of magmatic types generated, and differences in metamorphic and tectonic overprinting, even in contiguous areas. Whalen (1989) recognized that Silurian activity can not be adequately explained by models which consider all basin closure and major plate movements, other than transcurrent faulting, to be complete by the Middle Ordovician. He suggested that this magmatism could be the product of Late Ordovician to Late Silurian episodic opening and closure of small, discontinuous basins, portions of which may have been floored by oceanic crust. In the model of van Staal et al. (1991) and van Staal (1987), Iapetus closure and collision of the Taconic arc and Laurentia is followed by Late Ordovician to Early Silurian closure by northeast-directed subduction of an ensialic back-arc basin located behind the Taconic arc. The granitic magmatism could be attributed to this tectonic event.

A problem with the above models is the enigmatic nature of the heat source driving widespread Siluro-Devonian granite magmatism. Lithospheric delamination is a process which Sacks and Secor (1990) considered to be common and significant in collisional orogens. At the beginning of continental collision, the descending slab may undergo plate-rifting processes leading to detachment of subducted oceanic lithosphere from continental lithosphere. During detachment, a short-lived episode of extension and thinning of the lithosphere may occur, followed by continued convergence

driven by mantle convection. During lithospheric delamination, hot mantle asthenosphere is faulted against the base of the crust. Subsequent upward conductive heat loss and rapid cooling of the mantle asthenosphere produces regional high-temperature metamorphism, crustal melting, and extensive, widespread synkinematic granites.

Lithospheric delamination accompanying closure of Iapetus and its back-arc basin(s) could have provided a widespread heat source beneath the orogen. Localized and temporal variations in tectonic regime (e.g. extensional, compressive, pre-existing major boundary faults) may, in part, account for emplacement of different petrological types of granites in different portions of the orogen. In addition, this study has clearly demonstrated that many granite characteristics reflect the tectonostratigraphic zone they intrude, i.e. they appear to be source-related rather than process-related.

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## APPENDIX 1

### Summary of major characteristics of Appalachian granites in Gaspésie and New Brunswick

This compilation provides a compact summary on studied granites. Most of this data was collected by the author and is a condensation of information on individual samples tabulated elsewhere in this report. However, the table format and some of the information was obtained from Appendix 1 of Currie (in press). Blanks signify the absence of a feature or, in the case of isotopic data, that no data is available. Other information was obtained from or is contained in quoted references. The structure of the compilation is explained in the following remarks, numbered to correspond to those above the individual headings of the table.

(1) "Z#" is the code used throughout this report to designate individual intrusions or suites. These numbers are shown on the index map (Fig. 1) and are keyed to the tectonostratigraphic zone in which the intrusion occurs; H = Humber Zone; D = Dunnage Zone; G = Gander Zone; and A = Avalon Zone.

(2) "Pluton" is the name used for the intrusion or related suite of intrusions throughout this report. Most of these names are those given for these bodies in the provincial glossary. In some cases, spatially associated similar bodies have been described together.

(3) "Age" is given in millions of years with determinative method abbreviated: K = K-Ar on biotite (KB), muscovite (KM), hornblende (KH) or whole rock (KW); A =  $Ar^{40}/Ar^{39}$ ; R = Rb-Sr whole rock (RW) or muscovite (RM); U = U-Pb on zircon (UZ), monazite (UM), or titanite (US).

(4) "Lithology", the rock type or types, is based on modal data (see Appendix 2) and follows the classification of Streckeisen (1973). A "?" indicates that modal data is lacking and that rock types are based on mineralogy and chemical composition. Rock type abbreviations are as follows: ga = gabbro; do = diorite; mg = monzonite; md = monzodiorite; sy = syenite; ne = nepheline syenite; to = tonalite; gd = granodiorite; g = granite; ag = alkaline granite.

(5) "Mafics" is the mafic mineralogy, arranged in order of decreasing relative abundance; minerals enclosed in brackets are present in only some phases of an intrusive suite: o = olivine; p = pyroxene; h = hornblende; b = biotite; m = muscovite.

(6) "Access" is accessory minerals; minerals enclosed in brackets are present in only some phases of an intrusive suite: s = titanite; f = fluorite; g = garnet; c = cordierite; t = tourmaline; tp = topaz.

(7) "Incl" is the type of inclusions or enclaves: i = igneous; s = sedimentary; m = mafic; f = felsic.

(8) "Cont" is the nature of intrusive contacts: ho = hornfelsed or crosscutting; ca = cataclastic; mi = migmatitic; me = metasomatized.

(9) "Struct" is the internal pluton structure: m = massive; c = composite; p = porphyritic; mc = megacrystic; gn = gneissic; f = foliated; l = layered.

(10) "Mineral" is mineralization by element.

(11) "#An" is the number of samples from which chemical and modal data is summarized in this table. For chemical features, the average content is given when little dispersion exists, whereas a range is given when there is significant variation. Lead and Neodymium isotopic data are from a smaller representative subset of samples.

(12) "SiO<sub>2</sub>" is the silica content in weight per cent.

(13) "Al#" is the aluminum index (molecular Al/(Ca+Na+K)), a measure of the aluminum saturation.

(14) "Rb/Sr" is a fractionation index.

(15) "Sr<sub>i</sub>" is the initial Sr ratio obtained from cited references or from Currie (in press).

(16) " $Pb^{206}/Pb^{204}$ ", " $Pb^{207}/Pb^{204}$ " and " $Pb^{208}/Pb^{204}$ " are Pb isotopic ratios determined on K-feldspars separated from these intrusions; data in Humber Zone from C. Garipey (unpub. data, 1988) and other zones from Bevier (1987) and Auyso and Bevier (1991).

(17) " $\epsilon_{Nd}(0.4 \text{ Ga})$ " is the  $\epsilon_{Nd}$  value calculated at 400 Ma, J. Whalen, E. Hegner, and G. Jenner (unpub. data, 1991).

(18) " $T_{DM}$ " is the Nd model crust formation age in Ga, J. Whalen, E. Hegner, and G. Jenner (unpub. data, 1991).

(19)  $\delta^{18}O$  is the per mil deviation of the sample relative to a standard (standard mean sea water, SMOW).

The second line for each pluton or suite gives the latitude and longitude of the centre or most typical exposure and appropriate references.

APPENDIX 1 (cont'd.)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Z #	Pluton	Age	Lithology	Malics	Access	Incl	Cont	Struct	Mineral	#An	SiO <sub>2</sub>	Al#	Rb/Sr	Sr <sub>i</sub>	Pb <sup>207</sup> /Pb <sup>208</sup>	Pb <sup>207</sup> /Pb <sup>208</sup>	T <sub>DM</sub> (Ga)	δ <sup>18</sup> O		
H 1	McGerrigle complex	391 ± 31UZ	ga, do, to, gd, mz, md, sy, ne, g	h, b, p	s, f	im	ho	m, c	Cu	82	44-76	0.4-1.0	<0.1-24	0.704-0.71	18.022-19.035	15.515-15.616	37.801-39.095	+3.1-+7.5	0.63-0.82	5.6-7.9
H 2	(48 57/65 59) Murdochville	(de Romer, 1977; Whalen, 1985; 1987a; Whalen and Gariépy, 1988; Whalen et al., 1991)	gd, g	b, h	s	—	ho	m, p	Cu, Mo	8	68-71	0.8-1.0	0.1-0.4	—	18.167	15.555	37.892	+2.5	0.93	8.1
H 3	(48 59/65 30) Mont Brown	(Brunner, 1986; Procyshyn et al., 1989; Larocque, 1988)	do(?)	b, h	s	—	ho	m, p	Cu	3	64	1.0	0.2	—	—	—	+2.6	0.97	12.6	
H 4	(48 50/65 42) Monts Hogs Back & Chauve	342 ± 10KW	gd(?)	b	—	—	ho	m, p	Cu	7	70	1.0	0.2	—	—	—	+4.4	0.73	8.1	
H 5	(48 53/66 02, 48 49/66 16) Mont Vallières	371 ± 11KW	mg, g	b, h, p	s	im	ho	m	Cu	5	62-69	0.7-1.0	0.1-1.8	—	18.601	15.612	39.058	+3.7	0.82	8.3
D 1	(48 52/66 00) Mt. Squaw Cap Stocks	(de Romer, 1974; Robert, 1966b)	md, gd(?)	b, (h)	—	—	ho	m, p	—	4	56-70	1.1	0.1	—	—	—	—	—	—	
D 2	(47 53/66 55) Mt. Sugar Loaf stock	(Greiner, 1973; Ferguson and Fyfe, 1985)	gd(?)	p, h	(s)	—	ho	m, p	—	3	65	0.9	<0.1	—	18.293	15.589	38.005	+4.7	0.71	9.6
D 3	(47 59/66 41) Benjamin River complex	370 ± 30RW	ga, do, md, mg, g	h, p, b	(s, f)	im	ho	m, c	Cu, P, REE	11	52-71	0.6-1.0	<0.1-1.5	0.706	18.410	15.578	38.073	+3.4	0.90	6.5
D 4	(47 49/66 19) Chario Stocks	(Irrinki, 1973c; Steward, 1979; Sinclair and Kingston, 1990)	md, mg, g (?)	h, p, b	—	im	ho	m, p	Cu, Mo	4	60-67	0.9	<0.1-0.3	—	—	—	+1.4	1.12	7.4	
D 5	(47 53/66 27) Anitour Lake	372 ± 4UZ	g	b, (h)	l	—	ho	m	—	2	75	1.0	4.4	—	18.212	15.585	38.075	-1.6	1.38	8.9
D 6	(47 49/65 56) Nicholas Denys	Fyfe, 1974; Walker et al., 1991	gd	b	—	—	ho	m	Cu, Mo, W	1	69	1.0	0.2	0.703	18.236	15.586	38.044	+0.2	1.03	7.2
G 1	(47 42/65 53) Heath Steele	Fyfe, 1975; Walker et al., 1991	g	b, m	(f)	—	ho	gn	—	2	76	1.0	6.2	—	18.658	15.694	38.707	-2.1	1.44	8.7
G 2	(47 15/66 08) Popple Depot	(Irrinki, 1972b)	g	b, m	(f)	—	ho	l	—	3	76	1.0	1.9-5.8	—	18.770	15.702	38.528	-4.6	1.72	10.1
G 3	(47 26/66 29) Meridian Brook	(Whalen, 1990; Helmsstädt, 1971)	g	b, m, (h)	(s, g)	—	ho, ca	gn	—	10	65-73	0.9-1.1	0.4-3.1	—	18.554	15.686	38.432	-3.6	1.56	8.5
G 4	(47 19/67 45) Sweet Hill	(Whalen, 1990; Roddick and Bever, 1988)	g	b, m	—	—	ca	gn, mc	—	7	70-73	1.2	1.4-5.8	—	18.353	15.675	38.232	-4.3	1.69	9.8
G 5	(46 18/67 05) Serpentine River	(Crouse, 1979; Irrinki, 1977a; Whalen, 1990; M. Bevier, pers. comm., 1990)	g, ag	b, m	(s, g)	—	ho, ca	gn	—	6	71-77	1.0	1.2-13.3	—	18.501	15.693	38.306	-0.2	1.58	8.6
G 6	(47 14/67 46) Mullin Stream Lake	(Irrinki, 1977b; Whalen, 1990; M. Bevier, pers. comm., 1990)	gd, g	b, m	(s, g, f)	—	ho, ca	gn	—	8	71-75	1.0	0.4-4.6	—	18.428	15.682	38.332	-0.9	1.39	8.5
G 7	(47 01/66 18) Fox Ridge	(Irrinki, 1972a; Whalen, 1990; M. Bevier, pers. comm., 1990)	gd, g	b, m	(s)	—	mi	gn, mc	—	11	70-78	1.0	0.5-7.9	0.703	18.397	15.699	38.348	-3.2	1.54	10.0
G 8	(46 52/66 45) South Renous River	(Crouse, 1977, 1981a; Irrinki, 1978; St. Peter, 1981; Fyfe and Pronk, 1985; Whalen, 1990; Bevier, 1988)	gd, g	b, m	(s)	—	ho, ca	gn	—	4	67-72	1.0	0.9-1.9	—	18.479	15.697	38.342	-1.9	1.49	8.7
G 9a	(46 50/66 30) Unnamed Ordovician granite	(Irrinki, 1980; M. Bevier, pers. comm., 1990)	g	b, m	(s)	—	ho	gn	—	3	69-73	1.0	0.4-3.1	—	—	—	—	—	—	
G 9b	(47 04/66 28) Unnamed Ordovician granite	(Fyfe, 1972a; Whalen, 1990)	gd	b	s	—	ho	gn	—	1	70	1.0	0.4	—	—	—	—	—	—	
G 9c	(47 01/66 28) Unnamed Ordovician granite	(Fyfe, 1972b)	g	b, m	l	—	ca	gn	—	1	74	1.1	1.8	—	—	—	—	—	—	
G 10	(46 57/66 32) Gibson; Benton	473 ± 11UZ	md, gd, g	h, b	(s)	im	ho, ca	m	Cu, Pb, Zn, Au	5	59-67	0.9-1.1	0.2-0.8	—	18.738	15.709	38.631	-3.4	1.38	8.2
G 11	(46 05/67 33; 46 02/67 36) Pabneau Falls	(Venugopal, 1978; 1981; M. Bevier, pers. comm., 1990)	g	b, (m)	(f)	if	ho	m	Mo, Be	4	71	1.0	1.1	—	18.276	15.612	38.089	-2.5	1.37	9.6
	(47 42/65 44)	(Skinner, 1974; Fyfe et al., 1981; Roddick and Bever, 1988)	g	b, (m)	(f)	if	ho	m	Mo, Be	4	71	1.0	1.1	—	18.276	15.612	38.089	-2.5	1.37	9.6

APPENDIX 1 (cont'd.)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
Z #	Pluton	Age	Lithology	Mafics	Access	Incl	Cont	Struct	Mineral	#An	SiO <sub>2</sub>	Al#	Rb/Sr	Sr <sub>i</sub>	Pb <sup>206</sup> /Pb <sup>204</sup>	Pb <sup>207</sup> /Pb <sup>204</sup>	T <sub>DM</sub> (Ga)	δ <sup>18</sup> O		
G 12	Mt. Elizabeth complex (47 2066 35)	418 ± 1UM 414±11-1UZ	ga, do, md, mz, gd, sy, g, ag	h, b, (p, o)	(s, f)	im, if	ho	m, c, 1	Cu, Ni	58	42.77	0.7-1.2	<0.1-26	—	18.462	15.677	36.331	-6.1- +2.2	1.05- 1.53	6.2±8.8
G 13	Miramichi (47 1466 22)	—	g	b, (m)	(s, f)	—	ho	m	—	4	71	1.0	2.0-3.0	—	—	—	-2.0	1.62	8.1	
G 14	North Pole Stream suite (47 0166 31)	417 ± 1UZ	do, to, gd, g	b, (m, h, p)	(s, f, c)	im, s	ho	m, c, p	—	38	53.77	0.8-1.1	0.1-31	—	18.539	15.665	36.250	-3.0	1.38	8.2
G 15	Redstone Mountain suite (46 4967 57)	409 ± 11RW	ga, g	b, (h, p)	(s, f)	im	ho	m, c	—	8	47.76	0.6-1.0	0.1-2.5	0.706	18.708	15.684	36.420	-1.8	1.30	8.6
G 16	North Dunganvan River (46 5266 41)	382K	ga, do, gd, to, g	b, (m, h)	(s)	—	ho	m, c	—	7	53.77	0.8-1.1	0.1-3.7	—	—	—	—	—	—	—
G 17	Lost Lake suite (46 3867 00)	408 ± 7KM 402 ± 4RM	to, gd, g	b, m	(s, g)	if	ho	f	Be	9	61.73	1.0	0.2-2.0	0.703	18.336	15.660	38.263	-1.1	1.24	5.6
G 18	Burnhill suite (46 3766 53)	380A	g	b, (m)	f	—	ho, me	m, p	W, Mo, Be, Sn, F, Cu, Zn	8	71.76	1.0	0.9-7.7	0.705	18.337	15.667	38.297	-1.2	1.44	9.2
G 19	Beadle Mountain (46 3967 07)	—	gd	b, m	c	s	ho	m	—	1	64	2.0	1.8	—	—	—	—	—	—	—
G 20	Juniper Barrren (45 3367 11)	433 ± 4RM	gd, g	b, h	s	—	ca	m	Mo	2	67	1.0	1.1	—	18.348	15.665	38.247	-2.0	1.39	8.0
G 21	Bogan Brook (46 3167 11)	—	to, gd	b, m	c, g	s	ho	m	—	2	67	1.0-1.5	0.9	—	—	—	—	—	—	—
G 22	Nashwaak (46 2867 03)	422 ± 4RM	g	b, m	(f)	—	ho	m	W, Cu	4	72.77	1.1	2.3-6.9	—	18.340	15.696	38.350	-3.4	1.57	9.6
G 23	Hartfield (46 0267 18)	415 ± 1US	do, to, gd	b, h	s, (g)	i	ho	f	—	4	56.68	0.9	0.3-0.7	—	18.349	15.658	38.224	-1.7	1.33	7.8
G 24	Shiff Lake (45 4567 40)	409 ± 2UZ	to, gd, g	b, m	—	s	ho	m, f	—	16	63.73	1.0-1.8	0.3-4.7	0.708	18.330	15.674	38.304	-3.9	1.48	10.0
G 25	Hawkshaw (45 5067 16)	411 ± 1US	g	b, m	(s, g, f, t)	i, s	ho	m, mc	Be, Mo	14	67.71	1.0	0.6-1.4	0.705	18.329	15.658	38.229	-2.5	1.37	9.6
G 26	Allendale (45 5267 16)	402 ± 1UM	g	b, m	(c)	—	ho	m	—	4	71	1.1	1.5-5.2	—	18.369	15.672	38.270	-1.6	1.35	9.5
G 27	Lake George Sb Deposit (45 5167 01)	411-417KB	g	b, h	s	—	ho	m, p	Sb	1	69	1.0	0.6	—	—	—	—	—	—	—
G 28	Tower Hill, Pleasant Ridge (45 1767 14; 45 2267 00)	422 ± 15RW	g	m, b	tp	—	ho	m	U	3	73.76	1.1	2.5-5438	0.737	18.312	15.628	38.196	-0.4	1.18	9.2
G 29	Beech Hill (45 2366 53)	349 ± 11RW	g	b	—	—	ho	m, p	—	1	75	1.0	6.9	0.715	—	—	—	—	—	—
A 1	Erandale (45 4465 47)	364KB	mg, gd, g	b, h, (p)	s	—	ho	m	Cu	4	66	0.9	0.4	—	18.371	15.645	38.241	+1.2	0.94	8.1
A 2	Weisford and Jake Lee Mountain complexes (45 2766 15; 45 1466 39)	422 ± 3UZ	sy, g, ag	h, p, (b)	(f)	im, if	ho	m, c, p	—	8	66.75	0.8-1.2	1.0-64	0.709	—	—	—	—	—	8.6
A 3	Mount Douglas (45 2166 26)	366 ± 1UZ	g	b, (m)	f, (s)	—	ho	m, p	Sn, U, Au	11	73.77	1.0	1.6-47	0.708	18.446	15.646	38.268	+1.7	1.02	7.5
A 4	Utopia (45 1466 19)	430 ± 3UZ	g	b, (h, m)	f	if	ho	m	—	8	73.76	1.0	4.7-47	0.705	18.265	15.615	38.050	+2.0	1.09	9.0
A 5	Magagadavic (45 1866 50)	396 ± 1UZ	md, gd, g	b, h	s, (f)	—	ho	m, mc	—	5	62.75	0.9	0.2-5.2	0.707	18.441	15.642	36.239	+1.5	0.94	8.2
A 6	Bocabeac complex (45 1267 21)	403 ± 20RW	ga, gd, g	b, h, (p)	(s)	im, if	ho	m, c, l	Cu, Ni	8	47.75	0.7-1.0	<0.1-14.9	0.707	—	—	—	+3.8	1.01	5.4-9.0

## APPENDIX 2

### Granite sample locations and descriptions

Listed below in order of pluton code number ("Code") are locations of geochemical samples by NTS sheet ("Map"), easting ("East"), and northing ("North"). Also given is a batholith or suite name, a pluton, phase or unit name and a sample description. Unit letters (e.g. "Ogp") refer to map units on GSC Map 1751A.

Key to abbreviations used in sample descriptions:

vfg = very fine grained	dk = dark
fg = fine grained	amph = amphibole
mg = medium grained	bt = biotite
cg = coarse grained	chl = chlorite
vcg = very coarse grained	ep = epidote
eq = equigranular	feld = feldspar
porph = porphyritic	Kfld = K-feldspar
diss = disseminated	musc = muscovite
amygd = amygdaloidal	neph = nepheline
fol = foliated	ol = olivine
incl = inclusions	plag = plagioclase
metased = metasedimentary	pz = pyroxene
pheno = phenocrysts	py = pyrite
alt = alteration	qtz = quartz
miar = miarolitic	

APPENDIX 2 (cont'd.)

WX#	Code	Map	East	North	Batholith/Suite	Pluton, Phase or Unit	Sample Description
MG-23	H	1 22H/4	8550	3205	McGerrigle	hybrid suite	cg eq amph-bt-px monzodiorite, grades to cg gabbro
MG-29	H	1 22H/4	8430	3345	McGerrigle	hybrid suite	fg eq bt-px-amph monzonite, small mafic incl-rich
MG-44	H	1 22A/13	8450	2980	McGerrigle	hybrid suite	cg red amph-bt Qtz monzonite
MG-28	H	1 22H/4	8610	3220	McGerrigle	granite suite	mg eq red bt granite
MG-60	H	1 22B/16	1910	2840	McGerrigle	granite suite	cg red seriate bt-amph granite
MG-46	H	1 22A/13	8310	2375	McGerrigle	granite suite	mg plag porph bt-amph granite
MG-16	H	1 22H/4	8480	3350	McGerrigle	dyke suite	mg miaskitic neph syenite
MG-94	H	1 22A/13	8180	3080	McGerrigle	dyke suite	fg grey feld porph peralkaline neph syenite dyke
MG-102	H	2 22A/14	1760	2685	Murdochville	dyke suite	grey Qtz-feld porphyry, diss sulphides
MG-103	H	2 22A/13	1640	2720	Murdochville		cg brown Qtz-feld bt-amph porphyry
MG-104	H	2 22A/13	1520	2665	Murdochville		Qtz-feld porphyry, 2829', level-465 road (W-side pit)
MG-105	H	2 22A/13	1550	2540	Murdochville		Qtz-feld porphyry, M1 conveyor level
MG-106	H	2 22A/13	1550	2540	Murdochville		Qtz-feld porphyry, 2502', level or drift
MG-107	H	2 22A/13	1550	2540	Murdochville		Qtz-feld porphyry, ore dyke in open pit
MG-108	H	2 22A/13	1560	2665	Murdochville		Qtz-feld porphyry, central plug in open pit
MG-109	H	2 22A/13	1565	2740	Murdochville		Qtz-feld porphyry, north dyke in open pit
MG-110	H	3 22A/13	0100	1330	Mt. Brown		fg brown dacitic intrusive rock
MG-111	H	3 22A/13	0195	1385	Mt. Brown		fg brown dacitic intrusive rock
MG-112	H	3 22A/13	0190	1370	Mt. Brown		fg brown plag (2-4mm) dacite porphyry
MG-32	H	4 22B/16	1280	1425	Mt. Hog's Back		fg pink bt-plag porphyry
MG-74	H	4 22B/16	1560	1620	Mt. Hog's Back		fg-mg reddish plag-bt porphyry
MG-75	H	4 22B/16	1420	1480	Mt. Hog's Back		beige plag-bt porphyry
MG-76	H	4 22B/16	1305	1490	Mt. Hog's Back		beige plag-bt porphyry
MG-80	H	4 22B/16	0025	1200	Mt. Chauve		beige plag-bt porphyry
MG-81	H	4 22B/16	0040	1085	Mt. Chauve		beige plag-Qtz-bt porphyry
MG-82	H	4 22B/16	0550	1500	Mt. Chauve		beige plag-Qtz-bt porphyry
MG-77	H	5 22B/16	1805	1125	Mt. Vallieres		reddish feld porphyry
MG-78	H	5 22B/16	1880	1375	Mt. Vallieres		grey fol red Kfd porph rhyolite dyke
MG-79	H	5 22B/16	1765	1340	Mt. Vallieres		scarlet Kfld porph syenite
MG-100	H	5 22B/16	1770	1070	Mt. Vallieres		mg-cg eq scarlet amph-bt granite
MG-101	H	5 22B/16	1770	1070	Mt. Vallieres		fg red amp-bt-px Qtz syenite
NB-69	D	1 210/15	547	018	Mt Squaw Cap Stocks	dyke	brown feld-amph (2-4mm) rhyolite porphyry
NB-70	D	1 210/15	560	047	Mt Squaw Cap Stocks	dyke	vfg eq brown mior aplite dyke
NB-71	D	1 210/15	581	051	Mt Squaw Cap Stocks	Mt Squaw Cap	grey feld-bt (1-3mm) porphyry
NB-72	D	1 210/15	563	072	Mt Squaw Cap Stocks	Slate Mountain	vfg brown plag porph rhyolite, rare mafic incl
NB-55	D	2 210/15	727	176	Mt Squaw Cap Stocks	Mount Sugar Loaf	greenish feld-px rhyolite porphyry
NB-56	D	2 210/15	730	175	Mt Squaw Cap Stocks	Mount Sugar Loaf	green feld-amph-px rhyolite porphyry
NB-57	D	2 210/15	720	173	Mt Squaw Cap Stocks	Mount Sugar Loaf	green feld-amph-px rhyolite porphyry
NB-51	D	3 210/16	010	012	Charlo Stocks	Benjamin River Complex	mg grey amph-px Qtz monzodiorite, chl alt, fg incl
NB-58	D	3 210/16	082	085	Charlo Stocks	Benjamin River Complex	mg-cg eq px-amph-bt leuco-gabbro
NB-59	D	3 210/16	078	076	Charlo Stocks	Benjamin River Complex	fg-mg dk red amph-px Qtz diorite
NB-60	D	3 210/16	078	076	Charlo Stocks	Benjamin River Complex	mg scarlet red amph-bt granite
NB-61	D	3 210/16	053	077	Charlo Stocks	Benjamin River Complex	brown feld-amph (2-5mm) dacite porphyry
NB-62	D	3 210/16	018	007	Charlo Stocks	Benjamin River Complex	mg scarlet amph-bt Qtz monzonite
NB-63	D	3 210/16	059	081	Charlo Stocks	Benjamin River Complex	vfg scarlet mlar red amph granite

APPENDIX 2 (cont'd.)

WX#	Code	Map	East	North	Batholith/Suite	Pluton, Phase or Unit	Sample Description
NB-64	D	3	210/16	021	Charlo Stocks	Benjamin River Complex	mg eq px leuco-gabbrogranite, chl alt
NB-65	D	3	210/16	019	Charlo Stocks	Benjamin River Complex	mg scarlet amph-bt granite
NB-66	D	3	210/16	021	Charlo Stocks	Benjamin River Complex	vcg px gabbrogranite, chl alt
NB-67	D	3	210/16	012	Charlo Stocks	Benjamin River Complex	mg grey amph-bt qtz monzonite, fg mafic incl
NB-48	D	4	210/16	910	Charlo Stocks		fg brown plag-amph porph granite
NB-49	D	4	210/16	900	Charlo Stocks		mg red px-amph qtz monzodiorite
NB-50	D	4	210/16	894	Charlo Stocks		mg eq grey px-amph monzonite
NB-68	D	4	210/16	909	Charlo Stocks		beige plag-amph dacite porphyry, highly fractured
NB-52	D	5	21P/13	774		Anitouri Lake	mg-cg eq red bt-amph granite
NB-53	D	5	21P/13	774		Anitouri Lake	mg-cg eq red bt granite
NB-47	D	6	21P/12	834		Nicholas Denys	mg eq bt granodiorite
NB-228	G	1	210/8	151	Ordovician Suite	Heath Steele	mg fol bt-musc granite, chl alt
NB-229	G	1	210/1	160	Ordovician Suite	Heath Steele	mg fol bt-musc granite, chl alt
NB-104	G	2	210/8	8941	Ordovician Suite	Popple Depot (Ogp)	mg eq fol red bt-musc granite
NB-270	G	2	210/7	8778	Ordovician Suite	Popple Depot (Ogp)	fg eq fol pink bt-musc granite
NB-271	G	2	210/7	8843	Ordovician Suite	Popple Depot (Ogp)	fg eq fol pink bt granite
NB-79	G	3	210/7	8189	Ordovician Suite	Meridian Brook (Ogm)	slightly fol amph-bt diorite, mafic clots and incl
NB-82	G	3	210/7	8212	Ordovician Suite	Meridian Brook (Ogm)	fg slightly fol small feld porph bt aplite
NB-83	G	3	210/7	7484	Ordovician Suite	Meridian Brook (Ogm)	strongly fol red bt-musc granite
NB-84	G	3	210/7	8229	Ordovician Suite	Meridian Brook (Ogm)	cg fol Kfld porph bt-musc granite, some mafic incl
NB-97	G	3	210/1	9036	Ordovician Suite	Meridian Brook (Ogm)	mg fol grey bt-musc granite
NB-98	G	3	210/1	9067	Ordovician Suite	Meridian Brook (Ogm)	mg fol reddish bt granodiorite, small mafic incl
NB-246	G	3	210/8	9056	Ordovician Suite	Meridian Brook (Ogm)	fg-mg fol feld augen bt-musc granodiorite
NB-248	G	3	210/7	8252	Ordovician Suite	Meridian Brook (Ogm)?	fol grey bt granodiorite
NB-258	G	3	210/7	8375	Ordovician Suite	Meridian Brook (Ogm)?	strongly fol feld porph bt granite
NB-282	G	3	210/7	7179	Ordovician Suite	Meridian Brook (Ogm)	cg eq fol orange bt-musc granite
NB-249	G	4	210/7	8015	Ordovician Suite	Sweat Hill (Ogs)	vcg Kfld porph bt-musc granite
NB-274	G	4	210/2	6449	Ordovician Suite	Sweat Hill (Ogs)	beige qtz-feld porph bt-musc granite
NB-275	G	4	210/2	6162	Ordovician Suite	Sweat Hill (Ogs)	vcg fol feld porph bt-musc granite
NB-276	G	4	210/2	6176	Ordovician Suite	Sweat Hill (Ogs)	mg-cg fol feld-qtz porph bt-musc granite
NB-277	G	4	210/2	6162	Ordovician Suite	Sweat Hill (Ogs)	vcg fol feld porph bt-musc granite
NB-290	G	4	210/1	7697	Ordovician Suite	Sweat Hill (Ogs)	strongly fol feld augen bt-musc granite
NB-278	G	5	210/2	6502	Ordovician Suite	Serpentine River (Oge)	mg-cg eq fol pink bt-musc granite
NB-279	G	5	210/2	6510	Ordovician Suite	Serpentine River (Oge)	mg-cg eq fol pink bt-musc granite
NB-311	G	5	210/2	6800	Ordovician Suite	Serpentine Lake (Oge)	fg strongly fol bt granite
NB-312	G	5	210/2	6525	Ordovician Suite	Serpentine Lake (Oge)	mg eq pink slightly fol bt granite
NB-280	G	5	210/2	6477	Ordovician Suite	Serpentine Lake (Oge)	cg-vcg fol grey bt-musc granite
NB-281	G	5	210/2	6370	Ordovician Suite	Serpentine River (Ogeb)	cg-vcg fol pink bt-musc granite
NB-111	G	6	210/1	9370	Ordovician Suite	Mullin Stream Lake (Ogu)	cg strongly fol grey bt-musc granodiorite
NB-230	G	6	210/1	1526	Ordovician Suite	Mullin Stream Lake (Ogu)	mg-cg fol pink bt-musc granodiorite
NB-231	G	6	210/1	1635	Ordovician Suite	Mullin Stream Lake (Ogu)	mg fol bt-musc granodiorite
NB-232	G	6	210/1	1458	Ordovician Suite	Mullin Stream Lake (Ogu)	mg eq fol pink bt granite
NB-233	G	6	210/1	1037	Ordovician Suite	Mullin Stream Lake (Ogu)	mg pk fol bt-musc granite
NB-267	G	6	210/1	9403	Ordovician Suite	Mullin Stream Lake (Ogu)	cg strongly fol augen feld bt-musc granite
NB-268	G	6	210/1	9835	Ordovician Suite	Mullin Stream Lake (Ogu)	mg-cg strongly fol pink bt-musc granite
NB-269	G	6	210/1	536	Ordovician Suite	Mullin Stream Lake (Ogu)?	fol pink bt-musc granite

APPENDIX 2 (cont'd.)

WX#	Code	Map	East North	Batholith/Suite	Pluton, Phase or Unit	Sample Description
NB-130	G	7	21J/15	Ordovician Suite	Fox Ridge (Ogf)?	fg-mg banded pink bt-musc granodiorite
NB-133	G	7	21J/15	Ordovician Suite	Fox Ridge (Ogf)?	fg-mg strongly fol pink bt-musc granite
NB-134	G	7	21J/15	Ordovician Suite	Fox Ridge (Ogf)	cg fol scarlet feld porph bt-musc granite
NB-135	G	7	21J/15	Ordovician Suite	Fox Ridge (Ogf)	fg-mg bt-musc granite gneiss, rare feld augens
NB-148	G	7	21J/15	Ordovician Suite	Fox Ridge (Ogf)	vcg fol scarlet Kfld porph (2-5cm) bt-musc granite
NB-151	G	7	21J/10	Ordovician Suite	Fox Ridge (Ogf)	vcg fol feld porph (2-5cm) bt granodiorite
NB-163	G	7	21J/15	Ordovician Suite	Fox Ridge (Ogf)	strongly fol scarlet musc gneiss
NB-164	G	7	21J/10	Ordovician Suite	Fox Ridge (Ogf)	bt-musc granite gneiss, cut by granodiorite
NB-315	G	7	21O/2	Ordovician Suite	Fox Ridge (Ogf)	strongly fol feld augen bt-musc granite
NB-322	G	7	21O/2	Ordovician Suite	Fox Ridge (Ogf)	strongly fol feld augen bt-musc granite
NB-323	G	7	21O/2	Ordovician Suite	Fox Ridge (Ogf)	vcg feld porph bt granite
NB-125	G	8	21J/15	Ordovician Suite	South Renous River?	mg-cg strongly fol bt-musc granite
NB-126	G	8	21J/15	Ordovician Suite	South Renous River	cg fol bt-musc granodiorite
NB-140	G	8	21J/15	Ordovician Suite	South Renous River	mg fol feld porph bt-musc granite
NB-141	G	8	21J/15	Ordovician Suite	South Renous River	fol feld porph bt-musc granite
NB-306	G	9a	21O/1	Ordovician Suite	unnamed (Og)	cg eq bt granite, banded portions
NB-324	G	9a	21O/1	Ordovician Suite	unnamed (Og)	cg grey strongly fol bt-musc granite
NB-317	G	9b	21O/1	Ordovician Suite	unnamed (Og)	fg strongly fol bt granodiorite
NB-175	G	9c	21J/15	Ordovician Suite	unnamed (Og)	moderately fol pink bt-musc granite
NB-39	G	10	21J/4	Ordovician Suite	Benton	mg-cg amph-bt qtz monzonite, chl+ep alt, mafic incl
NB-40	G	10	21J/4	Ordovician Suite	Benton	mg amph-bt qtz monzonite, chl+ep alt, mafic incl
NB-41	G	10	21J/4	Ordovician Suite	Benton	mg amph-bt qtz monzonite, ep+chl alt
NB-42	G	10	21J/4	Ordovician Suite	Gibson	scarlet mg amph-bt granite, chl+ep alt and veins
NB-43	G	10	21J/4	Ordovician Suite	Gibson	cg eq amph-bt granodiorite
NB-44	G	11	21P/12	Ordovician Suite	Papineau Falls	cg eq amph-bt granodiorite, prominent qtz eyes
NB-45	G	11	21P/12	Ordovician Suite	Papineau Falls	cg semi-porph (Kfld) bt granite
NB-46	G	11	21P/12	Ordovician Suite	Papineau Falls	cg Kfld porph bt granite
NB-54	G	11	21P/12	Ordovician Suite	Papineau Falls	cg Kfld porph bt granite
NB-73	G	12	21O/8	Mt Elizabeth Complex	Papineau Falls	mg Kfld porph (1-3cm) bt granite
NB-74	G	12	21O/8	Mt Elizabeth Complex	granite (SEpg)	mg eq bt granite
NB-79	G	12	21O/8	Mt Elizabeth Complex	granite (SEpg)	mg eq bt-musc granodiorite
NB-80	G	12	21O/8	Mt Elizabeth Complex	granite (SEpg)	mg eq white bt granite
NB-81	G	12	21O/8	Mt Elizabeth Complex	granite (SEpg)	mg eq pink bt granodiorite
NB-93	G	12	21O/7	Mt Elizabeth Complex	granite (SEpg)	mg-cg bt granite
NB-94	G	12	21O/7	Mt Elizabeth Complex	granite (SEpg)	mg eq bt granite, cuts cg eq bt granite
NB-95	G	12	21O/7	Mt Elizabeth Complex	granite (SEpg)	mg eq white bt granite
NB-240	G	12	21O/7	Mt Elizabeth Complex	granite (SEpg)	cg eq bt granite
NB-250	G	12	21O/7	Mt Elizabeth Complex	granite (SEpg)	fg eq grey bt granite
NB-257	G	12	21O/7	Mt Elizabeth Complex	granite (SEpg)	fg Kfld porph bt-amph granodiorite
NB-325	G	12	21O/7	Mt Elizabeth Complex	granite (SEpg)	mg eq bt granite
NB-75	G	12	21O/7	Mt Elizabeth Complex	Mafic Suite (SEmd)	vfg dk bt-rich intrusive, felsic volcanic incl
NB-77	G	12	21O/7	Mt Elizabeth Complex	Mafic Suite (SEmd)	vfg px-bt gabbro, incl in granodiorite
NB-91	G	12	21O/7	Mt Elizabeth Complex	Mafic Suite (SEmd)	cg black px-amph-ol-bt gabbro
NB-96	G	12	21O/8	Mt Elizabeth Complex	Mafic Suite (SEmd)	vfg amph-bt basaltic rock, incl in mg granite
NB-99	G	12	21O/7	Mt Elizabeth Complex	Mafic Suite (SEmd)	cg eq amph-px-bt gabbro, plus play-bt pegmatite
NB-105	G	12	21O/7	Mt Elizabeth Complex	Mafic Suite (SEmp)	mg-cg banded ol-px-amph troctolite
NB-238	G	12	21O/7	Mt Elizabeth Complex	Mafic Suite (SEmd)	cg amph gabbro

APPENDIX 2 (cont'd.)

WX#	Code	Map	East North	Batholith/Suite	Pluton, Phase or Unit	Sample Description
NB-239	G 12	210/7	8081 4916	Mt Elizabeth Complex	Mafic Suite (SEmd)	mg eq amph-bt leuco-gabbro
NB-241	G 12	210/7	8875 3959	Mt Elizabeth Complex	Mafic Suite (SEmd)	fg-mg grey amph-bt Qtz diorite
NB-243	G 12	210/8	8951 3791	Mt Elizabeth Complex	Mafic Suite (SEmd)	cg amph-px leuco-gabbro, amph veins
NB-244	G 12	210/8	8976 3758	Mt Elizabeth Complex	Mafic Suite (SEmd)	fg-mg black amph-px meli-gabbro
NB-247	G 12	210/7	8182 4028	Mt Elizabeth Complex	Mafic Suite (SEmd)	plag porph amph-px-bt diabase
NB-251	G 12	210/7	8487 5460	Mt Elizabeth Complex	Mafic Suite (SEmd)	mg eq grey amph-px-bt gabbro
NB-252	G 12	210/7	8532 5429	Mt Elizabeth Complex	Mafic Suite (SEmd)	cg eq grey px-amph-bt Qtz gabbro
NB-253	G 12	210/7	8643 5378	Mt Elizabeth Complex	Mafic Suite (SEMP)	cg eq layered ol-px leuco-troctolite
NB-256	G 12	210/7	8784 4982	Mt Elizabeth Complex	Mafic Suite (SEMP)	cg eq ol-amph-px leuco-troctolite
NB-88	G 12	210/7	8277 4326	Mt Elizabeth Complex	Alkaline Suite (SEah)	mg amph-bt Qtz monzonite, mafic and felsic zones
NB-100	G 12	210/7	747 454	Mt Elizabeth Complex	Alkaline Suite (SEah)	mg eq amph-px-bt Qtz diorite
NB-242	G 12	210/8	8934 3839	Mt Elizabeth Complex	Alkaline Suite (SEah)	fg hybrid bt-amph Qtz monzodiorite
NB-255	G 12	210/7	8544 4781	Mt Elizabeth Complex	Alkaline Suite (SEah)	fg-mg bt-musc granodiorite, metased incl-rich
NB-89	G 12	210/7	8320 4367	Mt Elizabeth Complex	Alkaline Suite (SEag)	mg grey amph-bt Qtz monzodiorite, mafic incl-rich
NB-108	G 12	210/7	8294 5176	Mt Elizabeth Complex	Alkaline Suite (SEag)	cg red amph-bt-px Qtz monzonite
NB-235	G 12	210/7	8320 4367	Mt Elizabeth Complex	Alkaline Suite (SEag)	cg amph Qtz monzonite
NB-76	G 12	210/7	851 464	Mt Elizabeth Complex	Alkaline Suite (SEas)	cg eq greenish px-ol-amph syenite
NB-92	G 12	210/7	8328 4222	Mt Elizabeth Complex	Alkaline Suite (SEas)	mg red bt-amph syenite
NB-245	G 12	210/7	8588 4625	Mt Elizabeth Complex	Alkaline Suite (SEas)	cg eq px-ol-amph syenite
NB-265	G 12	210/7	8398 5196	Mt Elizabeth Complex	Alkaline Suite (SEas)	cg eq amph-px-ol Qtz syenite
NB-273	G 12	210/7	8506 4654	Mt Elizabeth Complex	Alkaline Suite (SEas)	cg eq amph-px-ol Qtz syenite
NB-86	G 12	210/7	8394 4401	Mt Elizabeth Complex	Alkaline Suite (SEaa)	cg eq greenish px-ol-amph syenite
NB-87	G 12	210/7	8303 4283	Mt Elizabeth Complex	Alkaline Suite (SEaa)	scarlet vfg spherulitic (2-4mm) amph aplite
NB-103	G 12	210/7	7969 5038	Mt Elizabeth Complex	Alkaline Suite (SEaa)	vfg scarlet amph aplite, irregular mafic zones
NB-234	G 12	210/7	8284 4306	Mt Elizabeth Complex	Alkaline Suite (SEaa)	fg brown bt-amph aplite
NB-78	G 12	210/7	8211 4250	Mt Elizabeth Complex	Alkaline Suite (SEag)?	brown flow-banded rhyolite dyke
NB-85	G 12	210/7	8203 4141	Mt Elizabeth Complex	Alkaline Suite (SEag)?	fg pink bt granite
NB-90	G 12	210/7	8320 4367	Mt Elizabeth Complex	Alkaline Suite (SEag)	mg grey bt granite
NB-101	G 12	210/7	747 455	Mt Elizabeth Complex	Alkaline Suite (SEag)	mg dk pink amph-bt granite
NB-102	G 12	210/7	760 467	Mt Elizabeth Complex	Alkaline Suite (SEag)	mg red bt-amph granite
NB-107	G 12	210/7	8294 5176	Mt Elizabeth Complex	Alkaline Suite (SEag)	mg eq scarlet miar bt-amph granite
NB-236	G 12	210/7	8216 4572	Mt Elizabeth Complex	Alkaline Suite (SEag)	mg beige amph-px granite
NB-237	G 12	210/7	8378 4808	Mt Elizabeth Complex	Alkaline Suite (SEag)	cg eq white bt granite
NB-254	G 12	210/7	8544 4781	Mt Elizabeth Complex	Alkaline Suite (SEag)	fg-mg eq pink bt granite
NB-259	G 12	210/7	7568 4464	Mt Elizabeth Complex	Alkaline Suite (SEag)	cg eq red bt-amph alkali granite
NB-262	G 12	210/7	8136 4786	Mt Elizabeth Complex	Alkaline Suite (SEag)	cg eq reddish fol red bt granite
NB-283	G 12	210/7	6917 4193	Mt Elizabeth Complex	Alkaline Suite (SEag)?	cg eq slightly fol red bt granite
NB-284	G 12	210/7	6917 4193	Mt Elizabeth Complex	Alkaline Suite (SEag)	mg eq reddish granophyric bt-amph granite
NB-285	G 12	210/7	6836 4056	Mt Elizabeth Complex	Alkaline Suite (SEag)	mg eq reddish granophyric bt-amph granite
NB-291	G 12	210/7	7939 5034	Mt Elizabeth Complex	Alkaline Suite (SEag)	mg eq scarlet px-bt granite
NB-115	G 13	210/1	977 351	Miramichi (SM)	Miramichi (SM)	mg-cg slightly KfId porph bt granite
NB-116	G 13	210/1	974 355	Miramichi (SM)	Miramichi (SM)	mg pink KfId porph (1-2cm) bt granite
NB-117	G 13	210/8	976 363	Miramichi (SM)	Miramichi (SM)	mg pink KfId porph (1-2cm) bt granite
NB-326	G 13	210/1	9965 3390	Miramichi (SM)	Miramichi (SM)	mg-cg pink seriate bt-musc granite
NB-119	G 14	21J/15	884 530	North Pole Stream Suite	Mafic Suite (SNd)	mg eq amph-bt Qtz diorite
NB-142	G 14	21J/15	880 043	North Pole Stream Suite	Mafic Suite (SNd)	fg-mg grey amph-bt Qtz diorite, tonalite veins

APPENDIX 2 (cont'd.)

WX#	Code	Map	East	North	Batholith/Suite	Pluton, Phase or Unit	Sample Description
NB-143	G 14	21J/15	879	049	North Pole Stream Suite	Mafic Suite (Snd)	mg grey bt-amph Qtz diorite
NB-308	G 14	21O/2	8315	1003	North Pole Stream Suite	Mafic Suite (Snd)	mg eq amph-bt Qtz diorite
NB-310	G 14	21O/2	8275	1024	North Pole Stream Suite	Mafic Suite (Snd)	fg eq amph-bt Qtz diorite
NB-109	G 14	21O/1	9899	2581	North Pole Stream Suite	granodiorite (SNGd)	eq grey bt granodiorite
NB-112	G 14	21O/1	0306	2083	North Pole Stream Suite	granodiorite (SNGd)	cg plag porph bt granodiorite, metased incl-rich
NB-113	G 14	21O/1	9472	2544	North Pole Stream Suite	granodiorite (SNGd)	mg-cg bt-rich granite
NB-149	G 14	21J/15	716	024	North Pole Stream Suite?	granodiorite (SNGd)	cg eq bt tonalite, fg metased incl
NB-266	G 14	21O/1	9975	2363	North Pole Stream Suite	granodiorite (SNGd)	cg eq bt-musc granodiorite, metased incl-rich
NB-300	G 14	21O/2	6285	0735	North Pole Stream Suite?	granodiorite (SNGd)	mg eq bt-musc granite, metased incl-rich
NB-318	G 14	21J/15	7692	0598	North Pole Stream Suite?	granodiorite (SNGd)	cg eq grey bt tonalite, metased incl-rich
NB-319	G 14	21O/2	7013	0803	North Pole Stream Suite?	granodiorite (SNGd)	mg-cg eq grey bt tonalite, metased incl-rich
NB-114	G 14	21O/1	9451	2582	North Pole Stream Suite	granite (SNG)	cg seriate bt granite
NB-118	G 14	21O/2	793	149	North Pole Stream Suite	granite (SNG)	cg Kfld porph bt granite, rare bt-rich incl
NB-121	G 14	21O/2	818	115	North Pole Stream Suite	granite (SNG)	cg Kfld porph bt granodiorite
NB-123	G 14	21O/2	897	102	North Pole Stream Suite	granite (SNG)	cg Kfld porph bt granodiorite, metased incl
NB-139	G 14	21J/15	888	064	North Pole Stream Suite	granite (SNG)	mg-cg seriate bt granite
NB-289	G 14	21O/2	9792	2672	North Pole Stream Suite	granite (SNG)	mg-cg eq grey bt granodiorite
NB-301	G 14	21O/2	6690	1015	North Pole Stream Suite	granite (SNG)	vcg pink Kfld porph bt granite
NB-316	G 14	21O/1	9170	0940	North Pole Stream Suite	granite (SNG)	cg eq bt granite
NB-106	G 14	21O/1	9728	3074	North Pole Stream Suite	granite (SNG)	fg Qtz-feld-bt porphyry
NB-110	G 14	21O/1	9899	2581	North Pole Stream Suite	granite (SNG)	fg white bt granite dyke
NB-120	G 14	21J/15	882	770	North Pole Stream Suite	granite (SNG)	grey fg-mg subporph (feld) bt granite
NB-302	G 14	21O/2	6093	1237	North Pole Stream Suite	granite (SNG)	fg-mg eq to porph pink bt-musc granite dyke
NB-307	G 14	21J/15	8810	0770	North Pole Stream Suite	granite (SNG)	mg eq pink bt-musc granite
NB-309	G 14	21O/2	8050	1340	North Pole Stream Suite	granite (SNG)	grey Qtz-feld-bt granite porphyry
NB-313	G 14	21O/2	6830	1315	North Pole Stream Suite?	granite (SNG?)	mg seriate bt granite, chl veins
NB-124	G 14	21O/2	741	162	North Pole Stream Suite	granite (SNG)	fg-mg white bt-musc granodiorite, pegmatitic clots
NB-132	G 14	21O/2	684	116	North Pole Stream Suite	granite (SNG)	fg-mg grey bt-musc granite
NB-145	G 14	21O/2	619	088	North Pole Stream Suite	granite (SNG)	fg-mg white Kfld porph bt granite
NB-146	G 14	21O/2	613	091	North Pole Stream Suite	granite (SNG)	fg eq grey bt-musc granite
NB-314	G 14	21O/2	7035	1205	North Pole Stream Suite?	granite (SNG)	fg eq grey bt-musc granite, weathered
NB-136	G 14	21J/15	660	030	North Pole Stream Suite?	Squaw Lake	mg eq white bt-musc granite, rare bt clots
NB-137	G 14	21J/15	660	050	North Pole Stream Suite?	Squaw Lake	mg eq white Kfld (2-3cm) porph bt-amph granodiorite
NB-320	G 14	21J/15	6935	0535	North Pole Stream Suite?	Squaw Lake	mg eq white bt-musc granite
NB-321	G 14	21J/15	6773	0532	North Pole Stream Suite?	Squaw Lake	mg eq grey bt-musc granite
NB-131	G 15	21O/2	544	142	Redstone Mountain Suite	gabbro (SRG)	fg plag porph diabase, diss py
NB-303	G 15	21O/2	5530	1750	Redstone Mountain Suite	gabbro (SRd)	mg eq ophitic amph-px gabbro, ep+chl veins
NB-304	G 15	21O/2	5810	1640	Redstone Mountain Suite	gabbro (SRd)	fg amph-px diabase
NB-138	G 15	21J/15	559	043	Redstone Mountain Suite	granite (SRG)	cg seriate bt granite, ep veins
NB-144	G 15	21J/15	601	929	Redstone Mountain Suite	granite (SRG)	mg red bt-amph granite
NB-147	G 15	21J/15	548	044	Redstone Mountain Suite?	granite (SRG)	mg scarlet granophyric bt granite
NB-152	G 15	21J/15	584	869	Redstone Mountain Suite	granite (SRG)	mg eq bt granite
NB-305	G 15	21O/2	5450	0915	Redstone Mountain Suite	granite (SRG)	mg eq scarlet bt granite, ep veins
NB-127	G 16	21J/15	782	884		North Dunganarvan River	mg pink subporph (Kfld) bt granite
NB-128	G 16	21J/15	780	887		North Dunganarvan River	mg black amph-bt Qtz diorite

APPENDIX 2 (cont'd.)

WX#	Code	Map	East	North	Batholith/Suite	Pluton, Phase or Unit	Sample Description
NB-129	G 16	21J/15	767	899		North Dungarvan River	fg-mg white bt granodiorite
NB-154	G 16	21J/15	769	880		North Dungarvan River	mg-cg grey bt-musc tonalite, metased incl-rich
NB-155	G 16	21J/15	768	884		North Dungarvan River	mg-cg eq bt-amph tonalite, minor metased incl
NB-156	G 16	21J/15	769	882		North Dungarvan River	cg amph-bt qtz gabbro, metased incl
NB-292	G 16	21J/15	7694	9184		North Dungarvan River	fg eq grey bt-musc granite
NB-150	G 17	21J/10	564	732		Lost Lake	mg fol grey bt-musc tonalite
NB-153	G 17	21J/15	644	849		Lost Lake	fg-mg eq fol bt granodiorite (?) dyke
NB-157	G 17	21J/10	654	785		Lost Lake	mg eq fol bt granodiorite
NB-159	G 17	21J/10	604	752		Lost Lake	fg-mg eq bt granodiorite
NB-160	G 17	21J/10	543	725		Lost Lake	mg eq pink musc-bt granodiorite
NB-161	G 17	21J/11	468	750		Lost Lake	cg eq (larger Kfld) bt-musc granodiorite
NB-162	G 17	21J/10	535	707		Lost Lake	mg eq fol bt-musc granite
NB-165	G 17	21J/11	512	767		Lost Lake	fg-mg bt granodiorite
NB-167	G 17	21J/10	545	708		Lost Lake	mg eq slightly fol bt-musc granodiorite
NB-226	G 18	21J/15	881	807	Burnthill Brook Suite	Dungarvan	mg pink feld-qtz porph bt granite
NB-293	G 18	21J/10	8307	7129	Burnthill Brook Suite	Dungarvan	fg-mg qtz-feld porph bt granite
NB-294	G 18	21J/10	8138	7377	Burnthill Brook Suite	Dungarvan	mg eq to porph bt-musc granodiorite
NB-295	G 18	21J/10	8044	7468	Burnthill Brook Suite	Dungarvan	mg pink crowded porph bt granite
NB-296	G 18	21J/10	8213	7282	Burnthill Brook Suite	Dungarvan	mg eq to porph white bt granodiorite
NB-158	G 18	21J/10	658	769	Burnthill Brook Suite	Burnthill	mg-cg Kfld-plag porph bt granite
NB-224	G 18	21J/10	809	633	Burnthill Brook Suite	Trout Lake	mg pink feld-qtz porph bt granite
NB-225	G 18	21J/10	807	633	Burnthill Brook Suite	Trout Lake	mg pink feld-qtz porph bt granite
NB-166	G 19	21J/11	441	702		Beadle Mountain	mg grey bt-musc granite, metased and qtz incl
NB-168	G 20	21J/11	407	527		Juniper Barren	mg-cg eq pink bt-amph granodiorite, rare incl
NB-170	G 20	21J/11	390	531		Juniper Barren	mg eq pink bt-amph granite, some bt-rich incl
NB-169	G 21	21J/11	409	529		Bogan Brook	fg grey bt-musc tonalite, metased incl-rich
NB-171	G 21	21J/11	390	524		Bogan Brook	fg-mg eq bt granodiorite, some bt schist incl
NB-172	G 22	21J/11	501	559		Nashwaak	fg eq cream musc-bt granite
NB-173	G 22	21J/11	497	570		Nashwaak	mg eq white bt-musc granodiorite
NB-174	G 22	21J/6	401	421		Nashwaak	mg-cg eq pink bt-musc granite
NB-227	G 22	21J/6	4887	4325		Nashwaak	cg eq pink musc-bt granite
NB-1	G 23	21G/14	277	903	Pokiok Batholith	Hartfield	cg slightly fol bt granodiorite, rare fg mafic incl
NB-7	G 23	21G/14	298	912	Pokiok Batholith	Hartfield	cg eq bt-amph tonalite
NB-14	G 23	21J/3	314	979	Pokiok Batholith	Hartfield	cg fol bt-amph tonalite
NB-15	G 23	21J/3	461	147	Pokiok Batholith	Hartfield	mg-cg slightly fol bt-amph tonalite, ep+chl veins
NB-8	G 24	21G/13	962	688	Pokiok Batholith	Skiff Lake	fg white bt-musc granite, bt-rich incl
NB-9	G 24	21G/13	962	688	Pokiok Batholith	Skiff Lake	cg white bt-musc qtz-rich granodiorite, metased incl
NB-12	G 24	21G/13	142	719	Pokiok Batholith	Skiff Lake	cg seriate white bt granodiorite
NB-13	G 24	21G/13	092	671	Pokiok Batholith	Skiff Lake	banded fg-mg eq pink bt-musc granite
NB-22	G 24	21G/14	195	707	Pokiok Batholith	Skiff Lake	cg eq bt-musc granodiorite
NB-23	G 24	21G/14	192	695	Pokiok Batholith	Skiff Lake	cg eq bt-musc tonalite
NB-26	G 24	21G/11	184	592	Pokiok Batholith	Skiff Lake	cg white Kfld porph (2-4cm) bt-musc qtz monzonite
NB-27	G 24	21G/13	083	673	Pokiok Batholith	Skiff Lake	fg-mg seriate bt granodiorite
NB-28	G 24	21G/12	062	664	Pokiok Batholith	Skiff Lake	mg eq musc-bt granite
NB-29	G 24	21G/12	082	649	Pokiok Batholith	Skiff Lake	cg seriate bt-musc granite
NB-30	G 24	21G/12	034	640	Pokiok Batholith	Skiff Lake	mg-cg eq musc-bt granite, chl veins

APPENDIX 2 (cont'd.)

WX#	Code	Map	East	North	Batholith/Suite	Pluton, Phase or Unit	Sample Description
NB-31	G 24	21G/11	182	655	Pokiok Batholith	Skiff Lake	cg eq bt-musc granodiorite, rare Kfld pheno and incl
NB-34	G 24	21G/12	156	613	Pokiok Batholith	Skiff Lake	mg Kfld porph (2-4cm) bt granite
NB-35	G 24	21G/12	147	618	Pokiok Batholith	Skiff Lake	mg-cg eq bt granite
NB-36	G 24	21G/12	147	618	Pokiok Batholith	Skiff Lake	fg-mg bt granodiorite
NB-37	G 24	21G/12	145	640	Pokiok Batholith	Skiff Lake	fg bt granodiorite
NB-2	G 25	21G/14	313	898	Pokiok Batholith	Hawkshaw	cg Kfld porph (2-3cm) bt granite, fg igneous incl
NB-3	G 25	21G/14	360	935	Pokiok Batholith	Hawkshaw	mg Kfld porph (2-4cm) bt granodiorite
NB-4	G 25	21G/14	364	913	Pokiok Batholith	Hawkshaw	cg Kfld porph (2-5cm) bt granite
NB-5	G 25	21G/14	368	922	Pokiok Batholith	Hawkshaw	mg Kfld porph (2-5cm) bt granite, fg mafic incl
NB-6	G 25	21G/15	563	951	Pokiok Batholith	Hawkshaw	mg Kfld porph bt granite
NB-10	G 25	21G/14	274	807	Pokiok Batholith	Hawkshaw	mg pink Kfld porph bt granite
NB-11	G 25	21G/14	285	808	Pokiok Batholith	Hawkshaw	mg pink Kfld porph bt granite
NB-17	G 25	21J/3	370	966	Pokiok Batholith	Hawkshaw	mg grey Kfld porph bt-musc granite
NB-20	G 25	21J/3	496	981	Pokiok Batholith	Hawkshaw	mg-cg grey minor Kfld porph (2-4cm) bt-musc granite
NB-21	G 25	21J/3	530	142	Pokiok Batholith	Hawkshaw	cg Kfld porph (2-4cm) bt granite
NB-24	G 25	21G/11	333	546	Pokiok Batholith	Hawkshaw	cg Kfld porph (2-5cm) bt granite
NB-25	G 25	21G/11	315	594	Pokiok Batholith	Hawkshaw	cg Kfld porph bt granite
NB-32	G 25	21G/11	233	640	Pokiok Batholith	Hawkshaw	mg Kfld porph (2-4cm) bt-musc granodiorite
NB-33	G 25	21G/11	260	614	Pokiok Batholith	Hawkshaw	mg Kfld porph (2-4cm) bt-musc granite
NB-16	G 26	21J/6	518	238	Pokiok Batholith	Allandale	mg eq dk pink bt-musc granite, ep+chl veins
NB-18	G 26	21G/14	393	943	Pokiok Batholith	Allandale	mg eq white bt-musc granodiorite
NB-19	G 26	21G/14	468	909	Pokiok Batholith	Allandale	mg eq pink musc-bt granite, minor molybdenite
NB-38	G 26	21G/14	344	799	Pokiok Batholith	Allandale	mg-cg seriate bt-musc granite
NB-327	G 27	21H/14	5275	7875	Pokiok Batholith	Lake George Sb Mine	mg white feld porph bt-amph granite
NB-187	G 28	21G/7	576	279		Pleasant Ridge	mg cream eq musc granite
NB-213	G 28	21G/5	405	186		Tower Hill	mg eq white musc-bt granite
NB-214	G 28	21G/5	405	186		Tower Hill	mg eq white musc-bt granite
NB-188	G 29	21G/7	641	304		Beech Hill	fg beige feld-qtz-bt porph granite
NB-206	A 1	21G/9	283	538	St George Batholith	Hampstead	mg eq pink bt-amph granite
NB-207	A 1	21G/9	285	535	St George Batholith	Hampstead	mg eq pink bt-amph granodiorite
NB-208	A 1	21G/9	290	532	St George Batholith	Hampstead	mg eq pink bt-amph qtz monzonite
NB-209	A 1	21G/9	295	518	St George Batholith	Hampstead	mg eq pink bt-amph granodiorite
NB-210	A 2	21G/9	248	429	St George Batholith	Welsford Complex	mg eq grey bt qtz syenite
NB-211	A 2	21G/8	162	395	St George Batholith	Welsford Complex	fg-mg pink feld porph amph-bt granite
NB-212	A 2	21G/8	222	421	St George Batholith	Welsford Complex	fg pink amph-bt-px qtz monzonite
NB-221	A 2	21G/8	114	351	St George Batholith	Welsford Complex	cg eq beige amph-px granite
NB-222	A 2	21G/8	114	351	St George Batholith	Welsford Complex	mg-cg eq beige amph-px alkali granite
NB-223	A 2	21G/8	094	361	St George Batholith	Welsford Complex	mg-cg eq beige amph-px syenite
NB-191	A 2	21G/2	834	092	St George Batholith	Jake Lee Mountain	mg eq granophyric amph-px alkali granite, miar
NB-192	A 2	21G/2	841	094	St George Batholith	Jake Lee Mountain	fg-mg granophyric amph alkali granite
NB-193	A 3	21G/7	759	136	St George Batholith	Mount Douglas	fg pink feld(1-2cm)-qtz-bt granite porphyry, miar
NB-194	A 3	21G/7	807	165	St George Batholith	Mount Douglas	fg white feld porph (1-2cm) bt granite
NB-198	A 3	21G/1	976	128	St George Batholith	Mount Douglas	mg Kfld porph granite
NB-197	A 3	21G/8	966	153	St George Batholith	Mount Douglas	mg-cg seriate bt granite, rapakivi feld
NB-200	A 3	21G/7	924	201	St George Batholith	Mount Douglas	mg-cg scarlet bt-musc granite
NB-201	A 3	21G/7	840	229	St George Batholith	Mount Douglas	fg-mg pink feld-qtz porph bt granite

APPENDIX 2 (cont'd.)

WX#	Code	Map	East North	Batholith/Suite	Pluton, Phase or Unit	Sample Description
NB-216	A	3 21G/7	884	197 St George Batholith	Mount Douglas	mg-cg seriate red bt granite
NB-217	A	3 21G/7	958	242 St George Batholith	Mount Douglas	mg-cg seriate bt granite
NB-218	A	3 21G/8	067	376 St George Batholith	Mount Douglas	fg-mg pink feld-qtz porph bt granite
NB-219	A	3 21G/8	067	376 St George Batholith	Mount Douglas	cg seriate bt granite
NB-220	A	3 21G/8	028	396 St George Batholith	Mount Douglas	mg-cg pink seriate bt granite
NB-179	A	4 21G/2	745	073 St George Batholith	Utopia	mg-cg eq beige bt granite
NB-180	A	4 21G/2	744	075 St George Batholith	Utopia	mg-cg eq beige bt granite
NB-181	A	4 21G/2	695	107 St George Batholith	Utopia	mg-cg eq beige bt granite
NB-182	A	4 21G/2	697	039 St George Batholith	Utopia	mg-cg eq beige bt granite
NB-183	A	4 21G/2	702	036 St George Batholith	Utopia	mg-cg eq scarlet bt granite
NB-184	A	4 21G/2	686	066 St George Batholith	Utopia	cg eq beige bt granite
NB-185	A	4 21G/2	680	089 St George Batholith	Utopia	cg eq cream bt-musc granite, rapakivi feld
NB-189	A	4 21G/2	617	089 St George Batholith	Utopia	mg-cg eq pink bt granite
NB-186	A	5 21G/7	681	210 St George Batholith	Magaguadavic	mg-cg eq beige bt-amph granite
NB-190	A	5 21G/7	747	265 St George Batholith	Magaguadavic	mg Kfld porph bt-amph qtz monzodiorite, eptchl alt
NB-195	A	5 21G/7	767	199 St George Batholith	Magaguadavic	cg Kfld porph (2-5cm) bt-amph granodiorite
NB-196	A	5 21G/7	748	264 St George Batholith	Magaguadavic	vfg Kfld porph bt-amph granite, rapakivi feld
NB-199	A	5 21G/7	931	194 St George Batholith	Magaguadavic	cg Kfld porph (2-4cm) bt granite
NB-178	A	6 21G/3	436	033 St George Batholith	Bocabec Complex	mg-cg eq black amph-bt-px gabbroonorite
NB-204	A	6 21G/3	465	036 St George Batholith	Bocabec Complex	cg eq px-amph-bt gabbroonorite
NB-203	A	6 21G/3	464	044 St George Batholith	Bocabec Complex	fg-mg amph-bt-px granodiorite
NB-215	A	6 21G/3	519	064 St George Batholith	Bocabec Complex	fg eq grey bt granodiorite
NB-205	A	6 21G/3	466	027 St George Batholith	Bocabec Complex	mg eq amph-bt granite, fg hybrid incl-rich
NB-176	A	6 21G/3	419	041 St George Batholith	Bocabec Complex	cg eq beige bt granite
NB-177	A	6 21G/3	439	038 St George Batholith	Bocabec Complex	cg eq beige bt granite
NB-202	A	6 21G/3	464	060 St George Batholith	Bocabec Complex	mg eq pink bt-amph granite
NB-261	G	210/7	7519	4662 Silurian Volcanic	Sm	basalt, chl+ep alt
NB-272	G	210/7	8115	6255 Silurian Volcanic	Sm	vfg andesitic volcanic
NB-286	G	210/7	7281	4471 Silurian Volcanic	Sm	vesicular basalt, ep+chl+carbonate alt
NB-288	G	210/7	7479	4706 Silurian Volcanic	Sm	vesicular basalt, ep+chl+carbonate alt
NB-298	G	210/7	7504	4745 Silurian Volcanic	Sm	plag porph (1-2mm) basalt, ep+chl alt
NB-299	G	210/7	7576	4812 Silurian Volcanic	Sm	vfg grey andesitic volcanic
NB-260	G	210/7	7471	4601 Silurian Volcanic	Sf	vfg brown felsic volcanic, minor felsic incl
NB-263	G	210/7	8029	4841 Silurian Volcanic	Sf	vfg black banded felsic volcanic
NB-264	G	210/7	8036	4812 Silurian Volcanic	Sf	vfg red banded felsic volcanic
NB-287	G	210/7	7479	4706 Silurian Volcanic	Sf	vfg scarlet feld porph felsic volcanic
NB-297	G	210/7	7519	4719 Silurian Volcanic	Sf	vfg banded feld porph (1-3mm) felsic volcanic

### APPENDIX 3

#### Granite modal and petrographic data

Listed below are modal and petrographic data for analyzed samples. Samples are listed in the same order as Appendix 2, beginning with the Humber Zone and ending with the Avalon Zone.

For coarse- to fine medium-grained samples, modal data was obtained by a combination of points counts on a 17 x 12 cm rock slab, stained using the methods of Norman (1974), and a regular thin section. Percentages of quartz, plagioclase, K-feldspar, and mafics were obtained from the slab, whereas proportions of mafic minerals and percentages of accessory phases were obtained from the thin section. For Gaspésie samples, 2000 points were counted on a slab and

1000 points on a thin section; whereas for New Brunswick samples, 1000 points were counted on both slab and thin section. For fine grained samples, 1000 points were counted on a stained thin section only. Values are given in volume per cent and trace quantities (i.e. <.1%) are indicated by "tr". For some deformed granites, in which the primary mafic mineralogy was not preserved, point counts were carried out on stained slabs only. No point counts were carried out on altered samples, most porphyries, very fine grained samples or strongly foliated samples. For these samples, the mineralogy of the sample is given by the presence of "X"s opposite the minerals present.

APPENDIX 3 (cont'd.)

Pluton Code WXMG or NB#	H1 23	H1 29	H1 44	H1 28	H1 60	H1 46	H1 16	H1 94	H2 102	H2 103	H2 104	H2 105	H2 106
Quartz	1.8	-	8.8	33.9	30.9	27.2	-	-	X	8.0	X	X	X
Plagioclase	54.1	42.7	33.6	24.3	27.3	40.3	tr	X	X	30.8	X	X	X
K-feldspar	15.0	20.3	46.5	40.8	37.4	25.4	78.3	X	X	1.9	X	X	X
Mafics	-	-	-	-	-	-	-	-	-	-	-	-	-
Olivine	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyroxene	3.4	8.4	tr	-	-	-	3.0	X	-	-	-	-	-
Amphibole	10.7	0.7	6.7	-	1.6	2.3	-	-	-	0.5	-	-	-
Biotite	6.9	23.1	1.6	0.5	2.4	4.0	4.6	X	-	5.1	X	-	-
Muscovite	-	-	-	-	-	-	-	-	-	-	-	-	-
Opaques	5.6	2.4	2.7	0.3	0.3	0.9	0.8	X	X	0.7	X	X	X
Titanite	0.9	0.9	0.1	-	0.1	-	1.9	X	-	0.3	X	-	-
Allanite	0.1	-	-	0.1	tr	tr	-	-	-	-	-	-	-
Apatite	1.5	1.4	tr	tr	0.1	tr	tr	X	X	0.1	X	X	X
Zircon	tr	0.1	0.1	tr	-	tr	2.2	X	X	-	X	X	X
Fluorite	tr	-	-	-	-	-	-	-	-	-	-	-	-
Aenigmatite	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordierite	-	-	-	-	-	-	-	-	-	-	-	-	-
Silliminite	-	-	-	-	-	-	-	-	-	-	-	-	-
Garnet	-	-	-	-	-	-	-	-	-	-	-	-	-
Tourmaline	-	-	-	-	-	-	-	-	-	-	-	-	-
Topaz	-	-	-	-	-	-	-	-	-	-	-	-	-
Epidote	-	-	-	-	-	-	-	-	-	-	X	-	-
Chlorite	-	-	-	-	-	-	-	-	X	-	-	-	-
Carbonate	-	-	-	-	-	-	-	-	X	-	X	X	X
Matrix	-	-	-	-	-	-	-	-	X	52.7	X	X	X
Pluton Code WXMG or NB#	H2 107	H2 108	H2 109	H3 110	H3 111	H3 112	H4 32	H4 74	H4 75	H4 76	H4 80	H4 81	H4 82
Quartz	X	X	X	X	-	X	X	X	X	X	X	X	X
Plagioclase	X	X	X	X	X	X	X	X	X	X	X	X	X
K-feldspar	X	X	X	-	-	X	X	X	X	X	X	X	X
Mafics	-	-	-	-	-	-	-	-	-	-	-	-	-
Olivine	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyroxene	-	-	-	-	X	-	-	-	-	-	-	-	-
Amphibole	-	-	X	-	-	-	X	-	X	-	-	-	-
Biotite	X	X	X	-	X	-	X	X	X	X	X	X	X
Muscovite	-	-	-	-	-	-	-	-	-	-	-	-	-
Opaques	X	X	X	X	X	X	X	X	X	X	X	X	X
Titanite	-	X	X	X	-	-	X	X	X	-	-	-	-
Allanite	-	-	-	-	-	-	X	-	-	X	X	X	-
Apatite	X	X	X	X	X	X	X	X	X	X	X	X	X
Zircon	X	X	X	X	-	-	X	X	X	X	X	X	X
Fluorite	-	-	-	-	-	-	-	-	-	-	-	-	-
Aenigmatite	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordierite	-	-	-	-	-	-	-	-	-	-	-	-	-
Silliminite	-	-	-	-	-	-	-	-	-	-	-	-	-
Garnet	-	-	-	-	-	-	-	-	-	-	-	-	-
Tourmaline	-	-	-	-	-	-	-	-	-	-	-	-	-
Topaz	-	-	-	-	-	-	-	-	-	-	-	-	-
Epidote	-	-	-	X	X	X	X	X	X	X	X	X	X
Chlorite	-	-	X	X	X	X	X	X	X	X	X	X	X
Carbonate	X	X	X	X	-	X	-	-	-	X	-	-	X
Matrix	X	X	X	X	X	X	X	X	X	X	X	X	X
Pluton Code WXMG or NB#	H5 77	H5 78	H5 79	H5 100	H5 101	D1 69	D1 70	D1 71	D1 72	D2 55	D2 56	D2 57	D3 51
Quartz	X	X	X	20.6	X	X	X	X	X	X	X	X	7.4
Plagioclase	X	X	X	7.7	X	X	X	X	X	X	X	X	61.6
K-feldspar	X	X	X	66.1	X	X	X	X	X	X	X	X	18.9
Mafics	-	-	-	-	-	-	-	-	-	-	-	-	11.9
Olivine	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyroxene	-	-	-	-	X	-	-	-	-	X	-	X	2.2
Amphibole	-	-	-	1.7	X	X	-	-	-	-	X	X	2.9
Biotite	-	-	X	0.2	X	-	-	X	X	-	-	-	4.0
Muscovite	-	-	-	-	-	-	-	-	-	-	-	-	-
Opaques	X	X	X	3.0	X	X	-	X	X	X	X	X	2.7
Titanite	-	-	-	0.5	X	-	-	-	-	-	X	-	0.1
Allanite	-	-	-	-	-	-	-	-	-	-	-	-	-
Apatite	X	X	X	0.1	X	X	-	-	-	-	-	-	-
Zircon	-	-	X	0.1	X	-	-	-	X	-	-	-	0.1
Fluorite	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX 3 (cont'd.)

Pluton Code WXMG or NB#	H5 77	H5 78	H5 79	H5 100	H5 101	D1 69	D1 70	D1 71	D1 72	D2 55	D2 56	D2 57	D3 51
Aenigmatite	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordierite	-	-	-	-	-	-	-	-	-	-	-	-	-
Silliminite	-	-	-	-	-	-	-	-	-	-	-	-	-
Garnet	-	-	-	-	-	-	-	-	-	-	-	-	-
Tourmaline	-	-	-	-	-	-	-	-	-	-	-	-	-
Topaz	-	-	-	-	-	-	-	-	-	-	-	-	-
Epidote	X	X	X	-	X	-	-	-	-	-	-	-	-
Chlorite	X	X	X	-	-	X	X	-	X	X	X	X	-
Carbonate	X	X	X	-	X	X	X	-	X	X	X	X	-
Matrix	-	-	-	-	-	X	X	-	-	X	X	X	-
Pluton Code WXMG or NB#	D3 58	D3 59	D3 60	D3 61	D3 62	D3 63	D3 64	D3 65	D3 66	D3 67	D4 48	D4 49	D4 50
Quartz	-	5.2	25.9	X	17.1	X	-	23.1	-	15.4	X	8.4	3.6
Plagioclase	72.6	59.9	25.4	X	46.0	X	66.5	43.8	54.8	43.8	X	39.9	41.5
K-feldspar	2.6	5.9	42.0	X	25.8	X	-	28.1	-	27.9	X	19.0	30.9
Mafics	24.1	28.1	6.5	-	10.5	-	33.5	4.6	44.5	12.9	-	32.1	23.4
Olivine	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyroxene	11.4	7.1	-	-	-	-	30.4	-	37.5	-	-	X	14.8
Amphibole	2.7	15.9	4.9	X	X	X	0.2	X	0.5	7.5	X	X	4.8
Biotite	6.4	tr	0.3	-	X	-	-	X	-	3.8	-	-	-
Muscovite	-	-	-	-	-	-	-	-	-	-	-	-	-
Opagues	3.5	5.1	1.3	X	2.1	X	2.9	1.1	6.5	1.6	X	3.4	3.8
Titanite	-	-	-	X	-	X	-	-	-	-	-	-	-
Allanite	-	-	-	-	-	X	-	tr	-	tr	-	-	tr
Apatite	0.7	0.8	tr	-	0.6	X	tr	0.2	0.6	tr	-	0.4	0.5
Zircon	tr	0.1	0.2	-	tr	-	-	0.2	0.1	tr	-	0.2	tr
Fluorite	-	-	tr	-	-	-	-	-	-	-	-	-	-
Aenigmatite	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordierite	-	-	-	-	-	-	-	-	-	-	-	-	-
Silliminite	-	-	-	-	-	-	-	-	-	-	-	-	-
Garnet	-	-	-	-	-	-	-	-	-	-	-	-	-
Tourmaline	-	-	-	-	-	-	-	-	-	-	-	-	-
Topaz	-	-	-	-	-	-	-	-	-	-	-	-	-
Epidote	-	-	-	X	X	-	-	-	-	-	-	X	-
Chlorite	-	-	-	X	X	X	-	-	-	-	X	X	-
Carbonate	-	-	-	X	-	-	-	-	-	-	X	-	-
Matrix	-	-	-	-	-	-	-	-	-	-	-	-	-
Pluton Code WXMG or NB#	D4 68	D5 52	D5 53	D6 47	G1 228	G1 229	G2 104	G2 270	G2 271	G3 79	G3 82	G3 83	G3 84
Quartz	X	34.6	32.9	26.5	X	X	X	X	X	X	X	35.1	X
Plagioclase	X	21.2	23.0	52.8	X	X	X	X	X	X	X	24.8	X
K-feldspar	X	39.7	40.1	6.5	X	X	X	X	X	X	X	33.4	X
Mafics	-	4.5	4.0	14.0	-	-	-	-	-	-	-	6.7	-
Olivine	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyroxene	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphibole	X	0.1	-	-	-	-	-	-	-	X	-	-	-
Biotite	X	4.3	3.9	13.9	X	X	X	X	X	X	X	X	X
Muscovite	-	-	-	-	X	X	X	X	-	-	-	X	X
Opagues	X	0.1	0.1	0.2	X	X	X	X	X	X	X	X	X
Titanite	-	-	-	-	-	-	-	-	-	X	-	X	X
Allanite	-	tr	tr	-	-	-	-	-	-	-	-	-	-
Apatite	-	tr	tr	0.1	-	X	-	-	-	X	X	-	X
Zircon	-	tr	tr	0.1	X	-	X	X	X	X	X	X	X
Fluorite	-	tr	0.1	-	X	-	-	X	-	-	-	-	-
Aenigmatite	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordierite	-	-	-	-	-	-	-	-	-	-	-	-	-
Silliminite	-	-	-	-	-	-	-	-	-	-	-	-	-
Garnet	-	-	-	-	-	-	-	-	-	-	-	X	-
Tourmaline	-	-	-	-	-	-	-	-	-	-	-	-	-
Topaz	-	-	-	-	-	-	-	-	-	-	-	-	-
Epidote	-	-	-	-	-	-	-	-	-	-	-	X	X
Chlorite	-	-	-	-	-	-	X	X	-	-	-	X	X
Carbonate	X	-	-	-	X	X	-	-	-	-	-	-	-
Matrix	X	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX 3 (cont'd.)

Pluton Code WXMG or NB#	G3 97	G3 98	G3 246	G3 248	G3 258	G3 282	G4 249	G4 274	G4 275	G4 276	G4 277	G4 290	G5 278
Quartz	X	X	X	X	X	X	33.7	26.0	37.6	33.1	22.9	X	47.5
Plagioclase	X	X	X	X	X	X	20.8	25.4	16.4	22.4	36.5	X	1.3
K-feldspar	X	X	X	X	X	X	34.9	38.4	31.0	35.9	28.5	X	47.1
Mafics	-	-	-	-	-	-	10.6	10.2	15.0	8.6	12.1	-	4.0
Olivine	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyroxene	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphibole	-	-	-	-	-	-	-	-	-	-	-	-	-
Biotite	X	X	X	X	X	X	X	X	X	X	X	X	X
Muscovite	X	-	X	-	-	X	X	X	X	X	X	X	X
Opauques	X	X	X	X	X	X	X	X	X	X	X	X	X
Titanite	-	X	-	X	-	-	-	-	X	-	X	X	-
Allanite	X	-	X	-	X	-	-	X	-	-	-	-	-
Apatite	-	-	X	-	X	X	-	X	-	-	X	X	-
Zircon	X	X	X	X	X	X	-	X	X	X	X	X	X
Fluorite	-	-	-	-	-	-	-	-	-	-	-	-	X
Aenigmatite	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordierite	-	-	-	-	-	-	-	-	-	-	-	-	-
Silliminite	-	-	-	-	-	-	-	-	-	-	-	-	-
Garnet	-	-	-	-	-	X	X	X	X	X	X	-	X
Tourmaline	-	-	-	-	-	-	-	-	-	-	-	-	-
Topaz	-	-	-	-	-	-	-	-	-	-	-	-	-
Epidote	X	X	X	X	-	X	X	X	X	X	-	X	-
Chlorite	-	-	-	-	-	-	-	X	-	X	-	-	-
Carbonate	-	-	-	-	-	-	-	-	-	-	-	-	-
Matrix	-	-	-	-	-	-	-	-	-	-	-	-	-
Pluton Code WXMG or NB#	G5 279	G5 311	G5 312	G5 280	G5 281	G6 111	G6 230	G6 231	G6 232	G6 233	G6 267	G6 268	G6 269
Quartz	39.6	X	X	35.4	25.6	X	X	X	30.0	21.7	X	X	X
Plagioclase	6.0	X	X	14.8	24.9	X	X	X	39.1	20.9	X	X	X
K-feldspar	51.7	X	X	41.0	35.7	X	X	X	23.7	52.9	X	X	X
Mafics	2.7	X	-	8.8	13.8	-	-	-	7.2	4.5	-	-	-
Olivine	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyroxene	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphibole	-	-	-	-	-	-	-	-	-	-	-	-	-
Biotite	X	X	X	X	X	X	X	X	7.2	X	X	X	X
Muscovite	X	X	X	X	X	X	X	X	-	X	X	X	X
Opauques	X	X	X	X	X	X	X	X	tr	X	X	X	X
Titanite	X	-	X	X	X	-	X	X	-	X	-	X	-
Allanite	-	X	X	-	-	-	-	X	-	X	-	X	-
Apatite	-	X	X	-	X	X	-	X	tr	-	X	-	-
Zircon	X	X	X	X	X	-	-	X	-	X	X	X	X
Fluorite	X	-	-	-	-	-	-	-	-	-	-	-	X
Aenigmatite	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordierite	-	-	-	-	-	-	-	-	-	-	-	-	-
Silliminite	-	-	-	-	-	-	-	-	-	-	-	-	-
Garnet	X	-	-	-	-	X	X	-	-	-	-	-	X
Tourmaline	-	-	-	-	-	-	-	-	-	-	-	-	-
Topaz	-	-	-	-	-	-	-	-	-	-	-	-	-
Epidote	X	-	X	X	X	-	X	X	-	X	X	X	X
Chlorite	-	-	-	-	-	-	-	-	-	X	-	-	-
Carbonate	-	-	-	-	X	-	-	X	-	-	-	-	-
Matrix	-	-	-	-	-	-	-	-	-	-	-	-	-
Pluton Code WXMG or NB#	G7 130	G7 133	G7 134	G7 135	G7 148	G7 151	G7 163	G7 164	G7 315	G7 322	G7 323	G8 125	G8 126
Quartz	27.2	X	30.4	33.7	29.6	21.5	X	36.3	X	X	30.0	27.0	23.5
Plagioclase	46.8	X	35.5	37.9	19.6	41.8	X	27.2	X	X	28.0	26.6	47.2
K-feldspar	21.6	X	27.8	23.4	45.5	14.4	X	24.9	X	X	30.1	36.2	16.2
Mafics	4.4	-	6.4	5.0	5.2	22.3	-	11.6	X	X	11.2	10.2	13.2
Olivine	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyroxene	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphibole	-	-	-	-	-	-	-	-	-	-	-	-	-
Biotite	X	X	X	X	X	X	-	X	X	X	10.7	X	X
Muscovite	X	X	X	X	X	-	X	X	X	X	tr	X	X
Opauques	X	X	X	X	X	X	X	X	X	X	0.6	X	X
Titanite	-	X	X	-	-	-	X	-	-	-	-	-	X
Allanite	-	-	-	-	-	-	X	-	-	-	-	-	-
Apatite	X	-	X	X	-	X	-	X	X	X	0.5	X	X
Zircon	X	X	X	X	X	X	X	X	X	X	0.1	X	X
Fluorite	-	-	X	-	-	-	-	-	-	-	-	-	-

APPENDIX 3 (cont'd.)

Pluton Code WXMG or NB#	G7 130	G7 133	G7 134	G7 135	G7 148	G7 151	G7 163	G7 164	G7 315	G7 322	G7 323	G8 125	G8 126
Aenigmatite	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordierite	-	-	-	-	-	-	-	-	-	-	-	-	-
Silliminite	-	-	-	-	-	-	-	-	-	-	-	-	-
Garnet	-	-	-	-	-	-	-	-	-	-	-	-	-
Tourmaline	-	-	-	-	-	-	-	-	-	-	-	-	-
Topaz	-	-	-	-	-	-	-	-	-	-	-	-	-
Epidote	-	-	X	-	X	X	X	X	-	-	-	-	-
Chlorite	-	-	X	-	-	-	X	X	-	-	-	-	-
Carbonate	-	-	-	X	-	-	-	-	-	-	-	-	-
Matrix	-	-	-	-	-	-	-	-	-	-	-	-	-
Pluton Code WXMG or NB#	G8 140	G8 141	G9a 306	G9a 324	G9b 317	G9c 175	G10 39	G10 40	G10 41	G10 42	G10 43	G11 44	G11 45
Quartz	20.4	38.0	31.4	X	X	41.0	16.5	12.5	21.1	29.0	25.1	31.1	31.2
Plagioclase	37.7	16.3	22.1	X	X	24.0	36.2	45.9	32.6	44.9	44.0	31.7	31.8
K-feldspar	25.4	34.2	38.4	X	X	22.7	32.5	18.0	35.7	7.4	8.9	29.9	28.0
Mafics	16.5	11.6	8.1	-	-	11.1	14.6	22.9	10.6	18.5	21.9	7.4	9.0
Olivine	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyroxene	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphibole	-	-	-	-	-	-	X	19.5	X	X	X	-	-
Biotite	X	X	7.5	X	X	8.4	X	-	X	X	X	7.3	8.4
Muscovite	X	X	tr	X	-	3.3	-	-	-	-	-	-	0.1
Opagues	X	X	0.6	X	X	0.3	2.7	3.4	1.6	0.5	X	0.1	0.4
Titanite	X	-	-	-	X	-	X	-	-	-	X	-	-
Allanite	-	-	-	-	X	-	-	-	-	-	-	-	-
Apatite	X	X	0.1	X	X	0.2	0.2	0.8	tr	0.2	X	tr	tr
Zircon	X	X	tr	X	X	0.1	tr	tr	tr	tr	X	tr	tr
Fluorite	-	-	-	-	-	0.1	-	-	-	-	-	tr	-
Aenigmatite	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordierite	-	-	-	-	-	-	tr	-	-	-	-	-	-
Silliminite	-	-	-	-	-	-	-	-	-	-	-	-	-
Garnet	-	-	-	-	-	-	-	-	-	-	-	-	-
Tourmaline	-	-	-	-	-	-	-	-	-	-	-	-	-
Topaz	-	-	-	-	-	-	-	-	-	-	-	-	-
Epidote	X	X	-	X	-	-	X	-	X	X	X	-	-
Chlorite	-	-	-	-	-	-	X	-	X	X	X	-	-
Carbonate	-	-	-	-	-	-	-	-	-	-	-	-	-
Matrix	-	-	-	-	-	-	-	-	-	-	-	-	-
Pluton Code WXMG or NB#	G11 46	G11 54	G12 73	G12 74	G12 80	G12 81	G12 93	G12 94	G12 95	G12 240	G12 250	G12 257	G12 325
Quartz	31.5	28.5	29.7	32.8	32.3	30.4	30.5	35.8	25.7	31.6	32.7	22.8	28.0
Plagioclase	34.5	37.5	34.8	41.7	29.2	43.8	33.0	17.3	36.3	25.1	32.0	45.1	33.0
K-feldspar	25.8	25.8	29.4	17.8	34.3	21.9	32.2	39.7	31.0	40.7	30.5	22.6	29.2
Mafics	7.7	7.8	5.7	7.7	4.0	4.0	4.3	7.0	6.8	2.7	4.7	9.4	9.5
Olivine	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyroxene	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphibole	-	-	-	-	-	-	-	-	-	-	-	0.7	-
Biotite	7.0	7.2	5.5	7.2	4.0	3.8	4.3	6.7	6.8	2.3	4.7	8.5	9.4
Muscovite	0.4	0.2	0.2	0.5	tr	0.1	tr	-	-	0.1	-	-	0.0
Opagues	0.3	0.4	tr	tr	tr	tr	tr	0.3	tr	0.3	tr	0.2	0.1
Titanite	-	-	-	-	-	-	-	-	-	-	-	-	-
Allanite	-	-	-	-	-	-	-	tr	-	-	0.1	-	-
Apatite	0.2	0.4	0.2	tr	tr	tr	tr	0.2	0.2	tr	tr	0.1	0.2
Zircon	0.2	0.1	0.2	tr	0.2	tr	tr	tr	tr	tr	tr	tr	tr
Fluorite	-	-	tr	-	-	-	-	-	-	-	-	-	-
Aenigmatite	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordierite	-	-	-	-	-	-	-	-	-	-	-	-	-
Silliminite	-	-	-	-	-	-	-	-	-	-	-	-	-
Garnet	-	-	-	-	-	-	-	-	-	-	-	-	-
Tourmaline	-	-	-	-	-	-	-	-	-	-	-	-	-
Topaz	-	-	-	-	-	-	-	-	-	-	-	-	-
Epidote	-	-	-	-	-	-	-	-	-	-	-	-	-
Chlorite	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbonate	-	-	-	-	-	-	-	-	-	-	-	-	-
Matrix	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX 3 (cont'd.)

Pluton Code WXMG or NB#	G12 75	G12 77	G12 91	G12 96	G12 99	G12 105	G12 238	G12 239	G12 241	G12 243	G12 244	G12 247	G12 251
Quartz	X	-	-	X	2.6	-	2.8	2.6	5.8	-	-	-	4.3
Plagioclase	X	60.4	28.5	X	51.4	63.8	60.8	64.3	47.8	70.3	33.9	47.7	52.0
K-feldspar	X	0.6	-	-	0.4	-	-	-	3.0	-	-	-	-
Mafics	-	38.6	71.5	-	44.5	36.2	33.9	31.6	42.9	29.7	66.1	52.2	43.6
Olivine	-	-	12.5	-	-	32.4	-	-	-	-	-	-	-
Pyroxene	-	28.5	26.0	-	2.1	2.0	0.4	tr	0.2	7.8	1.8	17.1	15.1
Amphibole	-	-	26.0	X	26.9	0.6	29.2	17.1	37.6	17.4	63.1	25.1	18.0
Biotite	X	7.0	5.8	X	12.5	0.4	0.1	10.1	4.6	3.5	0.2	7.5	8.0
Muscovite	X	-	-	-	-	-	-	-	-	-	-	-	-
Opagues	X	3.1	1.2	X	3.0	0.6	4.2	4.5	0.5	1.0	1.0	2.4	2.5
Titanite	-	-	-	-	-	-	0.8	-	0.4	-	-	-	-
Allanite	-	-	-	-	-	-	-	-	-	-	-	-	-
Apatite	X	0.4	-	X	0.9	-	1.7	1.5	0.2	tr	-	-	0.1
Zircon	X	-	-	-	0.2	-	tr	tr	tr	tr	-	0.1	-
Fluorite	-	-	-	-	-	-	-	-	-	-	-	-	-
Aenigmatite	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordierite	X	-	-	-	-	-	-	-	-	-	-	-	-
Silliminite	-	-	-	-	-	-	-	-	-	-	-	-	-
Garnet	-	-	-	-	-	-	-	-	-	-	-	-	-
Tourmaline	-	-	-	-	-	-	-	-	-	-	-	-	-
Topaz	-	-	-	-	-	-	-	-	-	-	-	-	-
Epidote	-	-	-	-	-	-	-	-	-	-	-	-	-
Chlorite	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbonate	X	-	-	-	-	-	-	-	-	-	-	-	-
Matrix	-	-	-	-	-	-	-	-	-	-	-	-	-

Pluton Code WXMG or NB#	G12 252	G12 253	G12 256	G12 88	G12 100	G12 242	G12 255	G12 89	G12 108	G12 0	G12 76	G12 92	G12 245
Quartz	10.9	-	-	11.0	3.9	15.0	24.3	5.5	9.1	16.7	2.7	15.0	4.8
Plagioclase	56.9	72.3	69.9	43.2	56.1	48.8	43.1	56.6	26.7	31.1	30.1	13.3	23.4
K-feldspar	0.1	-	-	27.7	2.2	24.5	9.0	24.5	39.5	42.8	61.4	68.7	68.5
Mafics	31.5	27.7	30.1	17.5	37.6	11.3	23.4	12.4	24.1	9.2	5.4	2.8	2.9
Olivine	-	23.9	27.4	-	-	-	-	-	-	-	1.3	-	0.9
Pyroxene	16.1	3.0	0.7	-	10.1	0.1	-	0.1	0.5	tr	2.1	-	1.5
Amphibole	8.0	0.2	2.0	11.9	14.4	3.2	-	7.2	14.7	7.1	1.6	0.1	0.4
Biotite	6.8	0.4	-	3.8	9.8	7.9	21.6	2.0	7.4	tr	-	1.7	-
Muscovite	-	-	-	-	-	-	1.5	-	-	-	-	-	-
Opagues	0.6	0.3	0.1	1.8	3.3	0.1	0.2	3.2	1.5	2.1	0.4	1.0	0.1
Titanite	-	-	-	-	-	0.2	-	0.3	-	0.1	-	0.2	-
Allanite	-	-	-	tr	-	0.1	-	-	-	-	-	tr	-
Apatite	0.6	-	tr	0.4	0.3	tr	0.1	0.8	0.5	0.1	0.1	tr	0.1
Zircon	-	-	-	0.1	-	0.1	tr	tr	0.1	tr	0.2	tr	0.3
Fluorite	-	-	-	-	-	-	-	-	-	-	-	-	-
Aenigmatite	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordierite	-	-	-	-	-	-	0.2	-	-	-	-	-	-
Silliminite	-	-	-	-	-	-	0.1	-	-	-	-	-	-
Garnet	-	-	-	-	-	-	-	-	-	-	-	-	-
Tourmaline	-	-	-	-	-	-	-	-	-	-	-	-	-
Topaz	-	-	-	-	-	-	-	-	-	-	-	-	-
Epidote	-	-	-	-	-	-	-	-	-	-	-	-	-
Chlorite	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbonate	-	-	-	-	-	-	-	-	-	-	-	-	-
Matrix	-	-	-	-	-	-	-	-	-	-	-	-	-

Pluton Code WXMG or NB#	G12 265	G12 273	G12 86	G12 87	G12 103	G12 234	G12 78	G12 85	G12 90	G12 101	G12 102	G12 107	G12 236
Quartz	17.7	1.4	X	X	X	X	24.2	19.7	24.8	25.8	27.6	26.3	20.4
Plagioclase	7.8	25.6	X	X	X	X	28.5	39.7	19.6	24.6	0.2	8.0	31.4
K-feldspar	70.7	64.9	X	X	X	X	45.0	35.0	53.0	45.8	69.7	60.9	40.1
Mafics	3.6	7.9	-	-	-	-	2.1	5.4	1.8	3.7	2.3	4.6	7.9
Olivine	0.6	1.4	-	-	-	-	-	-	-	-	-	-	-
Pyroxene	1.1	4.0	-	-	-	-	-	-	-	-	-	-	0.4
Amphibole	1.3	1.6	X	X	X	-	-	-	0.9	0.1	-	-	6.1
Biotite	0.5	-	-	-	X	X	1.3	5.0	0.5	2.7	1.5	4.4	tr
Muscovite	-	-	-	-	-	-	-	-	-	-	-	-	-
Opagues	0.1	1.0	X	X	X	-	0.8	0.4	0.4	0.9	0.8	0.2	1.5
Titanite	-	-	X	X	-	X	tr	-	0.8	-	-	-	0.1
Allanite	tr	-	-	X	-	-	0.1	-	tr	0.1	-	0.2	-
Apatite	tr	0.1	-	X	-	X	-	tr	tr	tr	-	-	tr
Zircon	0.1	0.2	-	-	X	X	tr	0.1	tr	0.1	tr	tr	0.1
Fluorite	0.1	-	-	-	-	-	-	-	-	-	0.2	-	-

APPENDIX 3 (cont'd.)

Pluton Code WXMG or NB#	G12 265	G12 273	G12 86	G12 87	G12 103	G12 234	G12 78	G12 85	G12 90	G12 101	G12 102	G12 107	G12 236
Aenigmatite	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordierite	-	-	-	-	-	-	-	-	-	-	-	-	-
Silliminite	-	-	-	-	-	-	-	-	-	-	-	-	-
Garnet	-	-	-	-	-	-	-	-	-	-	-	-	-
Tourmaline	-	-	-	-	-	-	-	-	-	-	-	-	-
Topaz	-	-	-	-	-	-	-	-	-	-	-	-	-
Epidote	-	-	X	-	-	-	-	-	-	-	-	-	-
Chlorite	-	-	-	-	-	X	-	-	-	-	-	-	-
Carbonate	-	-	-	-	-	-	-	-	-	-	-	-	-
Matrix	-	-	-	-	-	X	-	-	-	-	-	-	-
Pluton Code WXMG or NB#	G12 237	G12 254	G12 259	G12 262	G12 283								
Quartz	26.4	29.5	27.0	39.0	27.0								
Plagioclase	18.6	27.1	25.3	4.1	10.3								
K-feldspar	48.9	34.3	43.8	53.0	49.5								
Mafics	6.0	8.9	3.8	3.4	13.2								
Olivine	-	-	-	-	-								
Pyroxene	-	-	-	-	-								
Amphibole	3.3	-	-	0.5	-								
Biotite	2.2	8.4	3.1	2.3	X								
Muscovite	-	-	-	-	-								
Opagues	0.5	0.6	0.7	0.6	X								
Titanite	-	-	tr	0.2	-								
Allanite	tr	0.1	0.1	0.1	-								
Apatite	0.1	tr	tr	tr	X								
Zircon	tr	0.1	0.1	0.2	X								
Fluorite	-	-	-	-	-								
Aenigmatite	-	-	-	-	-								
Cordierite	-	-	-	-	-								
Silliminite	-	-	-	-	-								
Garnet	-	-	-	-	-								
Tourmaline	-	-	-	-	-								
Topaz	-	-	-	-	-								
Epidote	-	-	-	-	-								
Chlorite	-	-	-	-	-								
Carbonate	-	-	-	-	-								
Matrix	-	-	-	-	-								
Pluton Code WXNB#	G12 284	G12 285	G12 291	G13 115	G13 116	G13 117	G13 326	G14 119	G14 142	G14 143	G14 308	G14 310	G14 109
Quartz	37.8	38.8	22.8	26.3	27.0	30.3	30.0	6.5	5.7	6.1	5.4	5.3	24.9
Plagioclase	9.0	13.1	31.3	33.7	39.0	35.3	31.2	56.2	57.5	64.2	47.7	53.8	44.7
Kfeldspar	51.1	44.6	40.4	31.1	25.3	25.3	31.0	1.3	1.7	1.6	4.6	1.1	11.5
Mafics	1.5	3.2	5.5	8.9	8.5	9.1	7.5	35.6	34.1	26.1	41.0	40.5	18.4
Olivine	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyroxene	-	-	3.1	-	-	-	-	-	-	-	tr	tr	-
Amphibole	tr	0.5	-	-	-	-	-	30.2	19.6	11.4	33.3	2.6	-
Biotite	1.2	2.3	0.6	8.8	8.5	8.8	6.3	5.1	13.6	14.5	7.2	1.0	17.9
Muscovite	-	-	-	-	-	tr	1.2	-	-	-	-	-	-
Opagues	0.3	0.3	1.6	tr	tr	tr	tr	0.1	0.8	0.2	0.5	2.3	0.5
Sphene	0.1	-	tr	tr	-	-	-	tr	0.5	1.4	0.8	0.9	-
Allanite	0.1	0.1	-	tr	-	tr	-	-	-	-	0.0	-	-
Apatite	-	tr	0.1	tr	tr	-	0.2	0.3	0.6	0.6	0.1	0.4	0.2
Zircon	0.1	tr	tr	tr	0.1	tr	tr	tr	-	-	-	tr	0.3
Fluorite	0.2	0.2	-	-	-	-	tr	-	-	-	-	-	-
Aenigmatite	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordierite	-	-	-	-	-	-	-	-	-	-	-	-	-
Silliminite	-	-	-	-	-	-	-	-	-	-	-	-	-
Garnet	-	-	-	-	-	-	-	-	-	-	-	-	-
Tourmaline	-	-	-	-	-	-	-	-	-	-	-	-	-
Topaz	-	-	-	-	-	-	-	-	-	-	-	-	-
Epidote	-	-	0.1	0.1	-	0.3	-	0.2	-	-	0.3	-	-
Chlorite	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbonate	-	-	-	-	-	-	-	-	-	-	-	-	-
Matrix	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX 3 (cont'd.)

Pluton Code WXNB#	G14 112	G14 113	G14 149	G14 266	G14 300	G14 318	G14 319	G14 114	G14 118	G14 121	G14 123	G14 139	G14 289
Quartz	29.9	25.0	18.2	21.2	25.4	25.8	15.3	28.6	28.9	24.8	27.3	31.8	31.0
Plagioclase	37.5	39.7	56.5	38.3	44.1	47.9	56.3	34.8	36.1	53.5	42.2	29.2	42.8
Kfeldspar	14.9	22.9	0.9	20.3	18.3	6.5	tr	25.9	25.6	9.2	19.9	32.0	17.4
Mafics	17.1	11.9	23.9	19.4	11.3	19.3	27.8	10.7	9.2	12.3	10.1	7.0	8.3
Olivine	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyroxene	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphibole	-	-	-	-	-	-	0.1	-	-	-	tr	-	-
Biotite	16.8	11.9	22.3	18.6	7.2	18.3	24.4	10.7	8.6	11.1	9.3	7.0	7.9
Muscovite	-	-	tr	0.5	3.5	0.8	-	-	-	-	-	-	-
Opagues	0.3	tr	1.3	0.4	0.7	0.3	3.4	tr	0.6	1.2	0.8	tr	0.4
Sphene	-	-	0.1	-	-	-	-	-	-	tr	0.4	-	-
Allanite	-	0.3	0.2	-	-	-	-	-	tr	0.1	-	-	-
Apatite	0.6	0.1	0.2	0.6	0.5	0.4	0.4	tr	0.1	0.1	0.1	tr	0.1
Zircon	tr	tr	-	tr	0.2	tr	tr	tr	0.1	tr	0.1	tr	0.4
Fluorite	-	-	-	0.2	tr	-	-	-	-	-	-	-	-
Aenigmatite	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordierite	-	-	-	-	-	-	-	-	-	-	-	-	-
Silliminite	-	-	-	-	-	-	-	-	-	-	-	-	-
Garnet	-	-	-	-	-	-	-	-	-	-	-	-	-
Tourmaline	-	-	-	-	-	-	-	-	-	-	-	-	-
Topaz	-	-	-	-	-	-	-	-	-	-	-	-	-
Epidote	-	-	0.3	-	0.1	-	0.1	-	-	-	-	-	-
Chlorite	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbonate	-	-	-	-	-	-	-	-	-	-	-	-	-
Matrix	-	-	-	-	-	-	-	-	-	-	-	-	-
Pluton Code WXNB#	G14 301	G14 316	G14 106	G14 110	G14 120	G14 302	G14 307	G14 309	G14 313	G14 122	G14 124	G14 132	G14 145
Quartz	32.5	25.3	18.9	28.5	27.1	28.8	31.4	X	29.4	23.7	28.2	23.7	26.7
Plagioclase	35.6	45.4	8.1	27.3	30.4	39.9	33.4	X	32.0	55.9	28.6	39.5	27.6
Kfeldspar	21.2	15.1	22.3	42.8	30.6	22.2	33.0	X	27.9	8.9	36.4	25.3	34.0
Mafics	10.0	13.1	1.0	1.4	11.6	8.8	2.2	-	10.6	11.5	5.5	11.1	11.6
Olivine	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyroxene	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphibole	-	-	-	-	-	-	-	-	-	-	-	-	-
Biotite	9.0	12.2	1.0	1.4	10.8	7.4	1.4	X	10.6	7.6	4.3	11.1	8.7
Muscovite	-	-	-	-	0.3	1.2	0.6	X	-	3.9	1.1	-	2.7
Opagues	1.1	1.0	tr	tr	0.5	0.2	0.2	X	tr	tr	0.1	tr	0.1
Sphene	0.2	0.2	-	-	-	-	-	-	-	-	-	-	-
Allanite	tr	0.3	tr	-	-	-	-	X	tr	-	-	tr	-
Apatite	0.4	0.3	-	tr	0.1	0.3	-	X	tr	0.1	tr	0.4	0.1
Zircon	tr	0.1	tr	tr	0.1	tr	0.1	X	tr	-	tr	tr	-
Fluorite	-	-	-	-	-	-	-	-	-	-	-	-	-
Aenigmatite	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordierite	-	-	-	-	-	-	-	-	-	-	1.3	-	-
Silliminite	-	-	-	-	-	-	-	-	-	-	-	-	-
Garnet	-	-	-	-	-	-	-	-	-	-	-	-	-
Tourmaline	-	-	-	-	-	-	-	-	-	-	-	-	-
Topaz	-	-	-	-	-	-	-	-	-	-	-	-	-
Epidote	-	0.1	-	-	-	0.1	-	-	0.1	-	-	-	-
Chlorite	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbonate	-	-	-	-	-	-	-	-	-	-	-	-	-
Matrix	-	-	49.6	-	-	-	-	-	-	-	-	-	-
Pluton Code WXNB#	G14 146	G14 314	G14 136	G14 137	G14 320	G14 321	G15 131	G15 303	G15 304	G15 138	G15 144	G15 147	G15 152
Quartz	23.7	28.8	32.8	27.6	27.2	29.4	X	-	-	26.5	24.2	25.9	28.0
Plagioclase	29.7	30.4	22.9	45.6	32.5	28.7	X	X	X	37.6	28.9	9.5	24.6
Kfeldspar	34.8	35.2	34.6	16.7	32.1	32.6	-	-	-	25.0	42.4	61.5	39.8
Mafics	7.5	5.6	8.8	9.9	7.9	9.3	-	-	-	10.5	4.5	2.7	7.3
Olivine	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyroxene	-	-	-	-	-	-	-	X	X	-	-	-	-
Amphibole	-	-	-	0.4	-	-	X	X	X	-	0.1	-	-
Biotite	6.7	4.9	5.9	9.5	5.5	6.9	-	-	X	10.1	4.0	1.1	7.1
Muscovite	4.9	0.7	2.6	-	2.3	2.3	-	-	-	-	-	-	-
Opagues	0.1	tr	0.4	tr	0.1	0.1	X	X	X	0.4	0.3	1.0	0.2
Sphene	-	-	-	0.1	-	-	X	-	-	tr	tr	0.3	-
Allanite	-	-	-	0.1	-	-	-	-	-	0.1	tr	tr	-
Apatite	0.1	-	0.2	0.1	0.2	tr	-	X	X	0.3	tr	-	0.1
Zircon	tr	tr	tr	-	tr	tr	-	-	-	tr	-	0.1	0.1
Fluorite	tr	-	-	-	-	-	-	-	-	-	tr	-	0.2

APPENDIX 3 (cont'd.)

Pluton Code WXNB#	G14 146	G14 314	G14 136	G14 137	G14 320	G14 321	G15 131	G15 303	G15 304	G15 138	G15 144	G15 147	G15 152
Aenigmatite	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordierite	-	-	0.7	-	-	-	-	-	-	-	-	-	-
Silliminite	-	-	-	-	-	-	-	-	-	-	-	-	-
Garnet	-	-	-	-	-	-	-	-	-	-	-	-	-
Tourmaline	-	-	-	-	-	-	-	-	-	-	-	-	-
Topaz	-	-	-	-	-	-	-	-	-	-	-	-	-
Epidote	-	-	-	-	0.1	0.1	X	X	X	-	0.1	0.6	-
Chlorite	-	-	-	-	-	-	X	X	X	-	-	-	-
Carbonate	-	-	-	-	-	-	X	-	-	-	-	-	-
Matrix	-	-	-	-	-	-	-	-	-	-	-	-	-
Pluton Code WXNB#	G15 305	G16 127	G16 128	G16 129	G16 154	G16 155	G16 156	G16 292	G17 150	G17 153	G17 157	G17 159	G17 160
Quartz	34.7	34.6	4.0	23.7	32.5	14.0	5.8	26.5	20.6	X	X	21.9	34.0
Plagioclase	22.8	35.2	48.5	53.9	45.8	50.8	46.3	36.4	56.9	X	X	53.1	38.6
Kfeldspar	38.2	24.5	0.2	13.7	1.7	-	-	29.2	2.2	X	X	16.3	17.3
Mafics	4.1	5.7	46.9	8.5	19.8	34.6	47.7	7.7	20.1	-	-	8.4	5.0
Olivine	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyroxene	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphibole	-	-	19.9	-	-	10.2	23.6	-	-	-	-	-	-
Biotite	3.6	5.7	19.9	7.7	17.6	23.2	23.4	6.3	18.4	X	X	8.3	3.0
Muscovite	-	tr	-	0.1	1.5	-	-	1.4	0.5	-	-	tr	6.8
Opagues	0.5	tr	7.0	0.4	0.7	1.2	0.8	tr	0.7	X	X	0.1	tr
Sphene	0.2	-	0.1	0.1	-	-	-	-	-	X	-	-	-
Allanite	tr	-	-	tr	-	tr	-	-	-	-	-	-	-
Apatite	tr	tr	0.3	0.1	0.1	0.6	0.1	0.1	0.2	X	X	0.3	-
Zircon	0.1	-	tr	-	tr	tr	0.1	tr	tr	X	X	tr	tr
Fluorite	-	-	-	-	-	-	-	-	-	-	-	-	-
Aenigmatite	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordierite	-	-	-	-	-	-	-	-	-	-	-	-	-
Silliminite	-	-	-	-	-	-	-	-	-	-	-	-	-
Garnet	-	-	-	-	-	-	-	-	-	-	-	-	0.2
Tourmaline	-	-	-	-	-	-	-	-	-	-	-	-	-
Topaz	-	-	-	-	-	-	-	-	-	-	-	-	-
Epidote	tr	-	-	0.3	-	-	-	-	0.5	X	X	-	0.1
Chlorite	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbonate	-	-	-	-	-	-	-	-	-	-	-	-	-
Matrix	-	-	-	-	-	-	-	-	-	-	-	-	-
Pluton Code WXNB#	G17 161	G17 162	G17 165	G17 167	G18 226	G18 293	G18 294	G18 295	G18 296	G18 158	G18 224	G18 225	G19 166
Quartz	31.5	31.9	31.1	24.7	30.1	31.1	25.0	20.4	37.5	34.4	34.5	36.0	17.6
Plagioclase	42.5	33.2	43.4	49.5	35.3	23.5	29.4	32.6	23.7	21.1	30.9	25.6	1.8
Kfeldspar	4.7	23.0	21.3	12.6	25.6	39.3	36.7	41.1	32.7	34.1	29.0	31.7	33.1
Mafics	21.3	8.5	4.2	13.0	8.8	6.0	8.9	5.9	6.1	10.1	5.5	6.5	38.5
Olivine	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyroxene	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphibole	-	-	-	-	-	-	-	-	-	-	-	-	-
Biotite	18.5	8.5	3.8	10.3	8.6	6.0	6.6	5.6	5.9	9.5	5.3	6.3	21.9
Muscovite	1.7	3.1	0.3	1.6	-	-	2.3	-	0.1	-	0.2	0.1	15.7
Opagues	0.8	0.1	0.0	0.1	0.2	tr	tr	0.3	0.1	0.5	tr	0.1	0.9
Sphene	-	-	-	0.1	-	-	-	-	-	-	-	-	-
Allanite	-	-	-	-	0.1	-	-	-	-	tr	-	-	-
Apatite	0.1	0.1	0.1	0.1	tr	0.1	tr	0.1	tr	tr	tr	0.2	0.1
Zircon	tr	0.1	tr	tr	tr	tr	tr	tr	0.1	0.2	tr	tr	tr
Fluorite	-	-	-	-	-	-	tr	tr	tr	-	tr	0.1	-
Aenigmatite	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordierite	-	-	-	-	-	-	-	-	-	-	-	-	6.9
Silliminite	-	-	-	-	-	-	-	-	-	-	-	-	1.9
Garnet	-	-	-	-	-	-	-	-	-	-	-	-	-
Tourmaline	-	-	-	-	-	-	-	-	-	-	-	-	-
Topaz	-	-	-	-	-	-	-	-	-	-	-	-	-
Epidote	0.3	-	0.0	1.0	-	-	-	-	-	-	-	-	-
Chlorite	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbonate	-	-	-	-	-	-	-	-	-	-	-	-	-
Matrix	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX 3 (cont'd.)

Pluton Code WXNB#	G20 168	G20 170	G21 169	G21 171	G22 172	G22 173	G22 174	G22 227	G23 1	G23 7	G23 14	G23 15	G24 8
Quartz	28.4	25.7	39.2	25.6	31.6	27.5	37.8	33.7	26.7	21.8	18.0	5.4	52.0
Plagioclase	45.0	36.2	31.4	39.5	28.5	38.5	19.7	30.2	50.0	52.5	51.0	47.7	12.0
Kfeldspar	9.0	20.6	1.2	19.3	30.9	17.8	37.9	25.6	11.3	5.6	3.5	-	3.6
Mafics	16.2	16.6	19.2	15.4	6.3	10.9	4.7	9.8	10.6	18.9	25.9	45.0	23.6
Olivine	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyroxene	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphibole	0.5	tr	-	-	-	-	-	-	tr	4.6	3.2	14.8	-
Biotite	15.3	15.7	19.4	15.0	4.0	10.7	4.3	5.2	10.5	14.2	22.6	28.3	15.4
Muscovite	-	-	7.5	0.1	5.0	5.5	0.4	4.7	-	-	-	-	7.8
Opagues	0.5	0.7	0.2	0.4	tr	tr	tr	tr	-	0.1	0.1	1.9	0.4
Sphene	0.4	0.6	-	-	-	-	-	-	0.8	0.7	0.5	1.5	-
Allanite	tr	0.1	-	-	-	-	-	-	0.1	-	0.2	-	-
Apatite	0.8	0.1	tr	0.2	tr	tr	tr	-	0.3	0.3	0.8	0.4	0.1
Zircon	0.1	0.1	0.1	tr	tr	0.1	tr	0.1	tr	0.2	0.1	tr	tr
Fluorite	-	-	-	-	-	-	-	4.6	-	-	-	-	-
Aenigmatite	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordierite	-	-	1.0	-	-	-	-	-	-	-	-	-	8.6
Silliminite	-	-	0.1	-	-	-	-	-	-	-	-	-	-
Garnet	-	-	-	-	-	-	-	-	0.1	-	-	-	-
Tourmaline	-	-	tr	-	-	-	-	-	-	-	-	-	-
Topaz	-	-	-	-	-	-	-	0.6	-	-	-	-	-
Epidote	-	0.2	-	tr	-	-	-	-	0.1	-	-	-	-
Chlorite	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbonate	-	-	-	-	-	-	-	-	-	-	-	-	-
Matrix	-	-	-	-	-	-	-	-	-	-	-	-	-
Pluton Code WXNB#	G24 9	G24 12	G24 13	G24 22	G24 23	G24 26	G24 27	G24 28	G24 29	G24 30	G24 31	G24 34	G24 35
Quartz	49.7	32.0	33.0	30.1	31.3	16.1	19.7	36.9	36.1	32.1	28.0	28.8	30.9
Plagioclase	21.9	42.1	31.9	39.3	42.3	35.7	50.4	28.2	30.0	29.9	38.7	43.9	32.5
Kfeldspar	9.3	6.9	26.0	8.3	1.8	35.3	20.7	28.4	23.3	28.6	11.6	14.2	27.3
Mafics	18.9	18.9	9.1	21.9	23.7	12.6	9.2	6.4	10.2	9.2	20.9	12.9	9.3
Olivine	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyroxene	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphibole	-	-	-	-	-	-	-	-	-	-	-	-	-
Biotite	10.0	18.8	4.8	21.3	23.5	11.8	9.1	3.0	6.5	3.8	19.7	12.6	7.8
Muscovite	8.9	0.1	4.3	0.4	tr	0.7	0.1	3.4	3.6	5.4	0.9	0.1	1.1
Opagues	0.1	tr	tr	0.2	0.1	0.2	tr	tr	0.1	tr	0.3	0.2	0.1
Sphene	-	-	-	-	-	-	-	-	-	-	-	-	-
Allanite	-	-	-	-	-	-	-	-	-	-	-	-	-
Apatite	-	0.1	tr	0.5	0.7	0.1	tr	0.1	0.4	0.2	0.6	0.1	tr
Zircon	tr	tr	tr	tr	0.2	0.1	tr	tr	tr	tr	0.2	tr	tr
Fluorite	-	-	-	-	-	-	tr	-	-	-	-	-	-
Aenigmatite	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordierite	0.1	-	-	-	-	-	-	-	-	-	-	-	-
Silliminite	-	-	-	-	-	-	-	-	-	-	-	-	-
Garnet	-	tr	-	-	-	-	-	-	-	-	-	-	-
Tourmaline	-	-	-	-	-	-	-	-	-	-	-	-	-
Topaz	-	-	-	-	-	-	-	-	-	-	-	-	-
Epidote	-	-	-	-	-	-	-	-	-	-	-	-	0.3
Chlorite	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbonate	-	-	-	-	-	-	-	-	-	-	-	-	-
Matrix	-	-	-	-	-	-	-	-	-	-	-	-	-
Pluton Code WXNB#	G24 36	G24 37	G25 2	G25 3	G25 4	G25 5	G25 6	G25 10	G25 11	G25 17	G25 20	G25 21	G25 24
Quartz	30.2	22.4	24.0	30.5	24.7	27.5	29.7	30.3	30.2	27.8	27.9	25.0	29.2
Plagioclase	45.1	52.9	34.1	44.5	38.8	38.3	34.8	37.1	36.0	33.9	34.8	32.9	37.0
Kfeldspar	12.1	9.1	25.6	16.6	25.9	22.6	23.2	20.7	22.8	28.9	26.8	32.0	24.4
Mafics	12.3	15.5	15.9	7.3	10.6	11.2	11.8	11.4	10.9	9.0	10.4	9.8	9.2
Olivine	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyroxene	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphibole	-	-	-	-	-	-	-	-	-	-	-	-	-
Biotite	10.9	15.0	15.4	6.4	9.2	10.8	10.3	11.1	10.2	7.6	9.9	9.3	8.4
Muscovite	1.2	0.3	-	-	-	-	0.7	-	tr	1.3	0.6	0.1	0.1
Opagues	0.1	0.2	0.5	0.9	1.4	0.4	0.7	0.3	0.4	0.3	tr	0.3	0.7
Sphene	-	-	-	0.3	-	0.3	-	0.3	-	-	-	-	-
Allanite	-	-	-	0.2	-	-	-	-	-	-	-	-	-
Apatite	0.1	0.1	0.5	0.3	tr	tr	0.4	0.1	0.1	0.3	tr	0.1	0.1
Zircon	0.2	tr	tr	0.1	tr	0.1	-	tr	0.1	tr	0.1	0.2	0.1
Fluorite	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX 3 (cont'd.)

Pluton Code WXNB#	G24 36	G24 37	G25 2	G25 3	G25 4	G25 5	G25 6	G25 10	G25 11	G25 17	G25 20	G25 21	G25 24
Aenigmatite	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordierite	-	-	-	-	-	-	-	-	-	-	-	-	-
Silliminite	-	-	-	-	-	-	-	-	-	-	-	-	-
Garnet	-	-	-	0.1	-	-	0.1	-	-	-	-	-	-
Tourmaline	-	-	-	-	-	-	-	-	0.2	-	-	-	-
Topaz	-	-	-	-	-	-	-	-	-	-	-	-	-
Epidote	0.1	-	-	0.1	-	-	-	-	0.1	-	-	-	-
Chlorite	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbonate	-	-	-	-	-	-	-	-	-	-	-	-	-
Matrix	-	-	-	-	-	-	-	-	-	-	-	-	-
Pluton Code WXNB#	G25 25	G25 32	G25 33	G26 16	G26 18	G26 19	G26 38	G27 327	G28 187	G28 213	G28 214	G29 188	A1 206
Quartz	31.5	27.7	29.4	35.5	29.9	39.9	33.9	X	34.9	30.7	30.0	15.6	18.4
Plagioclase	33.5	40.5	33.8	35.2	41.9	21.4	29.8	X	30.4	32.2	32.3	11.5	35.4
Kfeldspar	24.4	19.6	26.2	24.0	19.5	30.7	27.5	X	27.6	29.8	32.3	16.2	31.2
Mafics	10.3	11.4	10.4	3.8	5.5	2.6	7.7	X	5.5	7.3	5.4	2.5	14.4
Olivine	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyroxene	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphibole	-	-	-	-	-	-	-	X	-	-	-	-	3.3
Biotite	9.8	9.5	7.8	3.8	5.5	2.0	6.8	X	-	2.7	2.1	2.5	9.8
Muscovite	0.1	1.8	2.4	1.3	3.2	5.6	1.0	-	5.5	4.6	3.3	-	-
Opagues	0.4	0.1	0.2	tr	tr	0.1	tr	X	tr	tr	-	tr	1.3
Sphene	0.1	tr	-	-	-	-	-	X	-	-	-	-	0.5
Allanite	-	-	-	-	-	-	-	X	-	-	-	-	-
Apatite	0.3	0.7	0.2	0.2	tr	0.2	0.4	X	-	-	-	tr	0.1
Zircon	tr	0.1	tr	tr	tr	-	0.2	X	tr	tr	-	tr	0.1
Fluorite	tr	-	-	-	-	-	-	-	0.4	-	-	tr	-
Aenigmatite	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordierite	-	-	-	-	-	-	0.4	-	-	-	-	-	-
Silliminite	-	-	-	-	-	-	-	-	-	-	-	-	-
Garnet	-	-	-	-	-	-	-	-	-	-	-	-	-
Tourmaline	-	-	-	-	-	-	-	-	-	-	-	-	-
Topaz	-	-	-	-	-	-	-	-	1.2	0.1	tr	-	-
Epidote	-	-	-	-	-	-	-	-	-	-	-	-	-
Chlorite	-	-	-	-	-	-	-	X	-	-	-	-	-
Carbonate	-	-	-	-	-	-	-	X	-	-	-	-	-
Matrix	-	-	-	-	-	-	-	-	-	-	-	54.2	-
Pluton Code WXNB#	A1 207	A1 208	A1 209	A2 210	A2 211	A2 212	A2 221	A2 222	A2 223	A2 191	A2 192	A3 193	A3 194
Quartz	22.7	14.1	17.2	10.1	25.6	X	31.5	30.5	2.9	29.0	28.9	16.3	27.7
Plagioclase	45.4	42.6	49.8	19.6	18.7	X	35.1	-	18.9	2.6	-	11.2	35.8
Kfeldspar	18.3	27.0	19.7	57.3	47.4	X	26.0	62.1	65.8	60.3	64.6	21.5	31.0
Mafics	12.8	15.6	12.8	13.0	8.0	-	7.2	7.3	11.8	8.1	6.5	2.4	5.5
Olivine	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyroxene	0.2	0.1	-	-	-	X	0.7	2.1	3.2	0.4	-	-	-
Amphibole	2.9	5.2	3.6	-	6.3	X	6.2	3.4	7.5	7.7	6.1	-	-
Biotite	8.7	9.2	8.0	12.0	0.8	X	-	-	-	-	-	1.6	5.2
Muscovite	-	-	-	-	-	-	-	-	-	-	-	tr	0.1
Opagues	1.0	1.2	1.1	1.0	0.8	X	0.3	tr	1.1	-	0.4	0.8	0.2
Sphene	0.5	0.7	0.2	-	-	-	-	-	-	tr	-	tr	-
Allanite	-	-	-	-	tr	-	tr	tr	-	-	-	-	-
Apatite	0.4	tr	0.1	-	0.1	X	tr	-	0.5	-	-	tr	tr
Zircon	tr	tr	0.2	0.1	0.2	X	0.1	0.1	tr	tr	tr	tr	tr
Fluorite	-	-	-	-	-	-	0.1	-	-	-	tr	tr	tr
Aenigmatite	-	-	-	-	-	-	-	1.8	-	-	-	-	-
Cordierite	-	-	-	-	-	-	-	-	-	-	-	-	-
Silliminite	-	-	-	-	-	-	-	-	-	-	-	-	-
Garnet	-	-	-	-	-	-	-	-	-	-	-	-	-
Tourmaline	-	-	-	-	-	-	-	-	-	-	-	-	-
Topaz	-	-	-	-	-	-	-	-	-	-	-	-	-
Epidote	-	-	-	-	-	-	-	-	-	-	-	-	-
Chlorite	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbonate	-	-	-	-	-	-	-	-	-	-	-	-	-
Matrix	-	-	-	-	-	-	-	-	-	-	-	48.5	-

APPENDIX 3 (cont'd.)

Pluton Code WXNB#	A3 197	A3 198	A3 200	A3 201	A3 216	A3 217	A3 218	A3 219	A3 220	A4 179	A4 180	A4 181	A4 182
Quartz	35.2	29.6	37.7	35.7	35.4	36.2	34.6	36.4	26.1	34.6	34.8	28.1	31.9
Plagioclase	16.8	16.8	14.8	11.5	20.3	18.1	15.6	13.5	19.4	18.1	16.3	22.9	17.0
Kfeldspar	42.7	48.3	44.2	49.9	41.5	41.6	44.7	46.9	46.0	41.9	44.5	42.6	46.0
Mafics	5.4	4.0	3.1	2.9	2.7	3.7	4.7	3.2	8.2	4.8	4.2	6.4	4.5
Olivine	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyroxene	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphibole	-	-	-	-	-	-	-	-	-	-	-	tr	-
Biotite	4.2	3.7	2.4	2.7	2.7	2.7	4.7	3.1	7.9	4.8	3.6	5.4	4.5
Muscovite	-	tr	0.7	-	-	-	-	-	-	-	-	-	-
Opagues	1.2	0.3	tr	0.2	tr	0.9	tr	0.1	0.3	tr	0.6	1.0	tr
Sphene	tr	1.1	-	-	-	-	-	-	tr	-	-	tr	-
Allanite	tr	tr	-	tr	-	-	-	tr	-	0.2	0.2	-	-
Apatite	tr	0.1	tr	tr	-	-	-	tr	0.3	-	-	-	tr
Zircon	tr	tr	0.2	tr	-	tr	0.2	tr	tr	0.2	tr	tr	0.2
Fluorite	tr	-	tr	tr	tr	0.4	0.2	tr	0.1	0.2	tr	tr	0.4
Aenigmatite	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordierite	-	-	-	-	-	-	-	-	-	-	-	-	-
Silliminite	-	-	-	-	-	-	-	-	-	-	-	-	-
Garnet	-	-	-	-	-	-	-	-	-	-	-	-	-
Tourmaline	-	-	-	-	-	-	-	-	-	-	-	-	-
Topaz	-	-	-	-	-	-	-	-	-	-	-	-	-
Epidote	-	-	-	-	-	-	-	-	-	-	-	-	-
Chlorite	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbonate	-	-	-	-	-	-	-	-	-	-	-	-	-
Matrix	-	-	-	-	-	-	-	-	-	-	-	-	-

Pluton Code WXNB#	A4 183	A4 184	A4 185	A4 189	A5 186	A5 190	A5 195	A5 196	A5 199	A6 178	A6 204	A6 203	A6 215
Quartz	27.9	30.4	30.7	25.6	26.0	9.3	28.8	27.6	31.1	2.7	-	17.1	30.1
Plagioclase	24.0	20.6	24.2	20.6	37.6	47.7	43.2	38.7	18.5	55.5	44.9	44.8	42.8
Kfeldspar	40.6	43.3	37.4	49.8	28.4	10.1	19.2	21.8	44.8	-	-	17.3	20.1
Mafics	7.3	5.5	7.5	3.9	7.2	32.1	7.8	11.3	5.3	41.2	54.5	20.5	7.0
Olivine	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyroxene	-	-	-	-	-	-	-	-	-	3.9	38.7	0.4	-
Amphibole	-	-	-	-	tr	6.8	1.6	1.5	-	18.4	10.9	13.0	-
Biotite	7.3	4.4	6.5	3.7	6.1	23.8	5.4	7.7	4.5	15.3	2.3	4.2	6.8
Muscovite	tr	-	0.6	-	-	-	-	-	-	-	-	-	-
Opagues	tr	1.1	0.4	0.1	1.1	0.9	0.8	0.6	0.8	3.6	2.7	2.9	0.2
Sphene	-	-	-	-	0.6	0.4	0.4	0.5	-	-	-	-	-
Allanite	-	tr	-	-	-	-	-	tr	-	-	-	tr	-
Apatite	-	-	tr	0.2	0.2	0.4	0.5	0.2	tr	0.6	0.5	0.3	tr
Zircon	tr	0.2	0.2	tr	tr	tr	0.1	tr	0.3	-	0.1	0.1	tr
Fluorite	0.2	tr	tr	tr	-	-	-	-	0.1	-	-	-	-
Aenigmatite	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordierite	-	-	-	-	-	-	-	-	-	-	-	-	-
Silliminite	-	-	-	-	-	-	-	-	-	-	-	-	-
Garnet	-	-	-	-	-	-	-	-	-	-	-	-	-
Tourmaline	-	-	-	-	-	-	-	-	-	-	-	-	-
Topaz	-	-	-	-	-	-	-	-	-	-	-	-	-
Epidote	-	-	-	-	-	0.6	-	1.5	-	-	-	-	-
Chlorite	-	-	-	-	-	-	-	-	-	-	-	-	-
Carbonate	-	-	-	-	-	-	-	-	-	-	-	-	-
Matrix	-	-	-	-	-	-	-	-	-	-	-	-	-

Pluton Code WXNB#	A6 205	A6 176	A6 177	A6 202	Sm 261	Sm 272	Sm 286	Sm 288	Sm 298	Sm 299	Sf 260	Sf 263	Sf 264
Quartz	25.5	33.3	33.2	25.4	-	-	-	-	X	-	X	X	X
Plagioclase	28.3	15.7	13.5	31.5	X	X	X	X	X	-	X	X	X
Kfeldspar	34.6	47.6	49.6	39.0	-	-	-	-	-	-	X	X	X
Mafics	11.0	3.4	3.3	4.1	-	-	-	-	-	-	-	-	-
Olivine	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyroxene	-	-	-	0.1	-	X	-	-	-	-	-	-	-
Amphibole	8.1	-	-	0.9	X	-	-	-	-	-	-	-	-
Biotite	1.4	3.3	3.3	2.6	-	-	-	-	-	-	X	X	X
Muscovite	-	-	tr	-	-	-	-	-	-	-	-	X	X
Opagues	1.4	0.1	tr	0.5	X	X	X	X	X	-	X	X	X
Sphene	0.4	-	-	-	-	-	-	-	-	-	-	-	-
Allanite	tr	tr	tr	-	-	-	-	-	-	-	-	-	-
Apatite	0.2	-	-	tr	-	-	-	-	-	-	-	X	-
Zircon	tr	tr	tr	tr	-	-	-	-	-	-	-	-	X
Fluorite	-	-	0.4	-	-	-	-	-	-	-	-	-	-

APPENDIX 3 (cont'd.)

Pluton Code WXNB#	A6 205	A6 176	A6 177	A6 202	Sm 261	Sm 272	Sm 286	Sm 288	Sm 298	Sm 299	Sf 260	Sf 263	Sf 264
Aenigmatite	-	-	-	-	-	-	-	-	-	-	-	-	-
Cordierite	-	-	-	-	-	-	-	-	-	-	-	-	-
Silliminite	-	-	-	-	-	-	-	-	-	-	-	-	-
Garnet	-	-	-	-	-	-	-	-	-	-	-	-	-
Tourmaline	-	-	-	-	-	-	-	-	-	-	-	-	-
Topaz	-	-	-	-	-	-	-	-	-	-	-	-	-
Epidote	-	-	-	-	-	-	X	X	X	-	X	-	-
Chlorite	-	-	-	-	X	X	X	X	X	-	X	-	-
Carbonate	-	-	-	-	-	-	X	-	X	-	-	-	-
Matrix	-	-	-	-	-	-	-	-	-	-	-	-	-
Pluton Code WXNB#	Sf 287	Sf 297											
Quartz	X	X											
Plagioclase	X	X											
Kfeldspar	X	X											
Mafics	-	-											
Olivine	-	-											
Pyroxene	-	-											
Amphibole	-	-											
Biotite	-	-											
Muscovite	-	-											
Opagues	X	X											
Sphene	-	-											
Allanite	-	-											
Apatite	-	X											
Zircon	X	-											
Fluorite	-	-											
Aenigmatite	-	-											
Cordierite	-	-											
Silliminite	-	-											
Garnet	-	-											
Tourmaline	-	-											
Topaz	-	-											
Epidote	-	X											
Chlorite	X	X											
Carbonate	-	-											
Matrix	-	-											

## APPENDIX 4

### Granite geochemical and isotopic data

Tabulated below are all the major element, trace element, and isotopic data collected during this study. Information on analytical methods and accuracy are given in Appendix 5. Analyses are listed by zone in the same order as Appendices 2 and 3, starting with the Humber Zone and ending with the Avalon Zone. The pluton code is given above each analysis, as in Figure 1. Major elements are in weight per cent; TTE is the total of the trace element values. Trace element analyses are in part per million, except Au, which is in parts per billion. An examination of precision data (see table of Appendix 5) indicates that results for some trace elements (e.g., Bi, Sn, Au) are of poor quality and should be treated with caution.

Below the trace element data are listed isotopic ratios or values:  $206/204 = {}^{206}\text{Pb}/{}^{204}\text{Pb}$ ;  $207/204 = {}^{207}\text{Pb}/{}^{204}\text{Pb}$ ;  $208/204 = {}^{208}\text{Pb}/{}^{204}\text{Pb}$ ; DO18 =  $\delta^{18}\text{O}$ ; E-Nd =  $\epsilon_{\text{Nd}}$ ; tDM =  $t_{\text{DM}}$  depleted mantle model age in Ga; E-400 =  $\epsilon_{\text{Nd}}$  at 400 Ma. Lead data for New Brunswick samples (WXNB prefix) from Ayuso and Bevier (1991) with proper sample number identification from Bevier (pers. comm. 1989). Other isotopic data are unpublished results of Whalen and co-workers.

APPENDIX 4 (cont'd.)

Pluton Unit MG or NB#	H1 2a 23	H1 2c-2e 29	H1 2c-2e 44	H1 3b 28	H1 3b 60	H1 3c 46	H1 4c 16	H1 4c 94	H2 102	H2 103	H2 104	H2 105
SiO <sub>2</sub>	55.00	59.20	65.50	76.10	74.80	71.10	60.80	59.90	68.40	70.50	68.90	67.10
TiO <sub>2</sub>	2.07	0.94	0.54	0.13	0.23	0.37	0.69	0.33	0.39	0.37	0.37	0.40
Al <sub>2</sub> O <sub>3</sub>	15.90	18.00	16.60	12.80	13.10	14.50	19.30	20.00	14.40	14.90	14.00	14.20
Fe <sub>2</sub> O <sub>3</sub>	2.99	1.51	0.96	0.19	0.12	0.78	1.65	2.31	0.54	0.93	0.01	0.13
FeO	5.36	3.48	2.00	0.50	1.00	1.50	1.39	1.40	0.96	0.99	0.87	1.15
MnO	0.17	0.17	0.09	0.02	0.03	0.05	0.17	0.26	0.07	0.04	0.02	0.03
MgO	2.86	1.48	0.57	0.10	0.33	0.62	0.54	0.12	0.88	0.83	0.78	0.96
CaO	5.24	2.58	1.44	0.58	1.14	1.99	1.30	0.81	3.23	2.10	3.94	4.03
Na <sub>2</sub> O	4.85	7.27	5.98	4.14	4.42	4.60	7.48	9.21	3.20	4.86	3.00	3.00
K <sub>2</sub> O	3.12	3.72	5.52	5.03	4.45	4.06	5.67	5.09	4.03	3.46	4.06	4.43
P <sub>2</sub> O <sub>5</sub>	0.87	0.44	0.14	0.03	0.05	0.10	0.14	0.04	0.12	0.12	0.12	0.14
LOI	-	-	-	-	-	-	-	-	-	-	-	-
H <sub>2</sub> O	0.60	0.45	0.16	0.09	0.25	0.21	0.63	0.29	1.32	0.42	0.85	0.96
CO <sub>2</sub>	0.12	0.14	0.07	0.07	0.24	0.07	0.10	0.03	2.50	0.18	2.52	2.82
TTE	0.36	0.33	0.30	0.09	0.14	0.15	0.29	0.32	0.38	0.24	0.32	0.29
Total	99.51	99.71	99.87	99.87	100.30	100.09	100.15	100.10	100.42	99.93	99.77	99.64
Trace Elements												
Rb	89	102	138	142	154	148	152	168	125	81	138	161
Cs	1.2	1.9	1.5	1.0	1.6	1.9	2.5	1.5	-	0.5	-	1.2
Ba	454	620	501	108	261	503	311	61	772	798	562	649
Sr	575	413	174	35	94	207	300	7	281	577	307	381
Ga	22	22	23	15	18	19	24	31	19	19	17	17
Li	21	-	-	9	-	17	85	28	-	-	-	-
Tl	-	-	-	-	-	-	-	-	-	-	-	-
Ta	4.84	6.78	6.53	3.35	5.38	4.51	10.80	16.20	-	1.91	-	1.54
Nb	69	104	97	23	42	36	202	306	17	17	16	17
Hf	8.8	12.4	13.1	3.9	5.1	6.7	14.6	26.6	-	4.3	-	4.2
Zr	405	626	498	118	159	206	845	1474	162	168	164	166
Y	50	33	65	10	39	39	32	49	14	12	14	15
Th	15.3	19.9	34.2	27.2	27.0	21.1	17.5	35.2	-	10.0	-	9.9
U	3.8	4.2	4.2	3.5	5.7	3.7	4.6	13.0	-	1.5	-	2.9
La	72	64	138	36	48	48	84	134	-	36	-	37
Ce	140	134	200	59	81	85	141	223	-	63	-	63
Pr	15.4	-	21.0	6.0	-	8.8	12.8	18.9	-	-	-	-
Nd	57.4	36.6	64.6	18.2	18.6	29.2	37.9	54.2	-	16.9	-	19.0
Sm	10.51	7.22	10.07	2.49	5.26	5.26	5.49	7.83	-	3.55	-	3.67
Eu	2.86	1.73	1.39	0.31	0.52	0.96	1.10	0.59	-	0.95	-	0.86
Gd	9.32	-	9.70	1.58	-	4.57	5.55	6.70	-	-	-	-
Tb	1.27	0.91	1.42	0.22	0.77	0.76	0.79	1.11	-	0.33	-	0.38
Dy	8.40	-	8.67	1.24	-	4.90	4.96	7.19	-	-	-	-
Ho	1.59	1.14	1.81	0.26	-	1.06	1.12	1.59	-	-	-	-
Er	4.58	-	5.24	0.75	-	3.01	3.22	4.70	-	-	-	-
Tm	0.68	0.15	0.79	0.12	-	0.46	0.52	0.77	-	-	-	-
Yb	4.32	3.23	5.40	0.87	3.30	3.27	3.69	5.77	-	1.11	-	0.93
Lu	0.59	0.51	0.80	0.09	0.70	0.46	0.61	0.96	-	0.18	-	0.21
Cr	5	4	5	1	<1	1	<1	2	8	7	13	17
Ni	10	7	8	7	9	10	8	7	15	14	13	17
Co	-	-	-	-	-	-	-	-	-	-	-	-
Sc	12.2	3.7	4.1	0.3	2.1	3.7	1.6	0.8	-	3.4	-	3.8
V	-	-	18	<1	-	18	20	-	-	-	-	-
Cu	24	9	4	1	2	7	4	4	1301	8	948	487
Pb	22	-	9	8	-	7	7	16	-	-	-	-
Zn	50	83	40	6	21	30	61	85	154	27	41	23
Mn	-	-	-	-	-	-	-	-	-	-	-	-
Bi	-	-	-	-	-	-	-	-	-	-	-	-
Cd	-	-	-	-	-	-	-	-	-	-	-	-
Sn	-	-	-	-	-	-	-	-	-	-	-	-
W	-	-	-	-	-	-	-	-	-	-	-	-
Mo	-	-	-	-	-	-	-	-	-	-	-	-
F	-	-	-	-	-	-	-	-	-	-	-	-
Cl	-	-	-	-	-	-	-	-	-	-	-	-
Br	-	-	-	-	-	-	-	-	-	-	-	-
B	-	-	-	-	-	-	-	-	-	-	-	-
Be	-	-	-	-	-	-	-	-	-	-	-	-
Au	-	-	-	-	-	-	-	-	-	-	-	-
Ge	-	-	-	-	-	-	-	-	-	-	-	-
As	-	-	-	1.1	0.6	-	-	-	-	0.4	-	1.2
Se	-	-	-	-	-	-	-	-	-	-	-	-
Sb	-	-	0.2	-	0.3	0.2	-	-	-	0.1	-	0.4
206/204	18.173	-	18.307	18.206	18.280	18.311	18.263	18.422	-	18.201	-	-
207/204	15.550	-	15.570	15.524	15.583	15.554	15.538	15.574	-	15.564	-	-
208/204	37.956	-	38.111	37.850	38.181	38.034	38.084	38.385	-	37.917	-	-
DO18	6.5	-	6.7	6.6	6.9	6.4	6.7	6.6	-	7.9	-	-
E-Nd	4.3	-	3.5	3.6	0.4	3.4	5.1	5.2	-	1.7	-	-
tDm	0.76	-	0.75	0.71	-	0.81	0.64	0.63	-	1.07	-	-
E-400	4.4	-	3.7	3.8	0.4	3.5	5.3	5.4	-	1.8	-	-

APPENDIX 4 (cont'd.)

Pluton Unit MG or NB#	H2 106	H2 107	H2 108	H2 109	H3 110	H3 111	H3 112	H4 32	H4 74	H4 75	H4 76	H4 80
SiO <sub>2</sub>	69.70	70.00	67.50	67.50	63.40	65.00	64.80	69.70	70.10	70.20	69.90	69.90
TiO <sub>2</sub>	0.38	0.38	0.46	0.49	0.84	0.75	0.74	0.28	0.28	0.27	0.28	0.34
Al <sub>2</sub> O <sub>3</sub>	14.20	14.40	14.60	15.40	15.00	15.40	15.40	15.70	15.50	15.40	15.50	15.30
Fe <sub>2</sub> O <sub>3</sub>	0.67	0.63	0.31	1.60	1.70	2.07	1.59	0.42	0.56	0.52	0.21	0.66
FeO	0.98	0.78	0.97	0.89	3.00	2.25	2.54	1.19	0.99	1.09	1.68	1.19
MnO	0.02	0.01	0.03	0.01	0.06	0.07	0.07	0.03	0.03	0.02	0.05	0.04
MgO	0.74	0.84	0.58	1.14	2.64	2.63	2.77	0.81	0.92	0.91	0.87	0.80
CaO	2.90	2.64	3.01	3.15	2.00	2.26	1.64	2.01	1.76	1.55	1.74	1.66
Na <sub>2</sub> O	4.28	3.55	3.36	4.78	5.55	4.61	5.55	5.74	5.72	5.76	5.65	5.77
K <sub>2</sub> O	3.26	4.05	5.48	3.41	2.75	2.64	2.73	2.60	2.67	2.99	2.66	2.88
P <sub>2</sub> O <sub>5</sub>	0.12	0.12	0.17	0.18	0.22	0.19	0.18	0.07	0.07	0.07	0.07	0.10
LOI	-	-	-	-	-	-	-	-	-	-	-	-
H <sub>2</sub> O	0.84	0.87	0.81	0.49	2.14	2.08	2.25	0.68	0.92	0.91	0.94	0.85
CO <sub>2</sub>	1.49	1.36	2.00	0.25	0.95	0.11	0.05	0.09	0.05	0.04	0.14	0.18
TTE	0.23	0.25	0.37	0.35	0.22	0.22	0.21	0.19	0.16	0.18	0.19	0.20
Total	99.81	99.88	99.65	99.64	100.47	100.28	100.51	99.51	99.73	99.91	99.88	99.86
Trace Elements												
Rb	96	108	105	71	67	71	73	67	71	67	78	65
Cs	-	-	1.7	0.8	0.4	0.5	-	0.5	-	-	0.4	0.3
Ba	627	723	1250	932	524	472	571	631	530	568	589	526
Sr	509	363	390	798	225	346	315	436	461	429	430	439
Ga	18	18	19	21	17	18	18	20	18	19	19	21
Li	-	-	-	15	27	-	-	35	-	-	-	-
Tl	-	-	-	-	-	-	-	-	-	-	-	-
Ta	-	-	1.82	1.49	1.50	1.54	-	1.44	-	-	1.13	1.31
Nb	21	18	21	19	21	21	22	9	9	9	8	11
Hf	-	-	5.8	4.5	6.1	6.4	-	3.6	-	-	3.6	4.5
Zr	162	157	194	224	281	274	286	134	140	133	142	182
Y	13	10	15	12	37	39	37	4	6	5	7	8
Th	-	-	15.9	9.1	7.5	8.9	-	5.6	-	-	5.4	6.1
U	-	-	2.5	2.5	1.8	1.8	-	1.7	-	-	1.7	1.4
La	-	-	47	51	27	40	-	20	-	-	22	34
Ce	-	-	103	97	59	72	-	35	-	-	37	52
Pr	-	-	-	9.7	6.9	-	-	3.7	-	-	-	-
Nd	-	-	48.4	33.1	27.6	34.4	-	13.2	-	-	11.8	18.0
Sm	-	-	5.60	5.16	5.64	6.68	-	2.32	-	-	2.50	3.66
Eu	-	-	1.33	1.20	1.36	1.32	-	0.45	-	-	0.63	0.83
Gd	-	-	-	4.10	5.55	-	-	1.77	-	-	-	-
Tb	-	-	0.50	0.51	0.88	0.79	-	0.22	-	-	0.20	0.29
Dy	-	-	-	2.70	5.34	-	-	1.18	-	-	-	-
Ho	-	-	-	0.50	1.11	-	-	0.21	-	-	-	-
Er	-	-	-	1.22	3.01	-	-	0.53	-	-	-	-
Tm	-	-	-	0.17	0.45	-	-	0.08	-	-	-	-
Yb	-	-	1.52	1.15	2.92	2.80	-	0.43	-	-	0.68	1.08
Lu	-	-	0.20	0.15	0.43	0.46	-	0.06	-	-	0.09	0.13
Cr	9	13	19	13	33	27	29	1	5	5	3	5
Ni	14	13	18	16	24	24	25	11	11	11	10	11
Co	-	-	-	-	-	-	-	-	-	-	-	-
Sc	-	-	4.7	3.8	9.8	9.2	-	2.8	-	-	2.8	3.1
V	-	-	-	38	98	-	-	21	-	-	-	-
Cu	241	86	535	133	6	32	44	6	2	5	9	24
Pb	-	-	-	5	1	-	-	6	-	-	-	-
Zn	27	13	22	10	56	75	57	22	22	20	32	32
Mn	-	-	-	-	-	-	-	-	-	-	-	-
Bi	-	-	-	-	-	-	-	-	-	-	-	-
Cd	-	-	-	-	-	-	-	-	-	-	-	-
Sn	-	-	-	-	-	-	-	-	-	-	-	-
W	-	-	-	-	-	-	-	-	-	-	-	-
Mo	-	-	-	-	-	-	-	-	-	-	-	-
F	-	-	-	-	-	-	-	-	-	-	-	-
Cl	-	-	-	-	-	-	-	-	-	-	-	-
Br	-	-	-	-	-	-	-	-	-	-	-	-
B	-	-	-	-	-	-	-	-	-	-	-	-
Be	-	-	-	-	-	-	-	-	-	-	-	-
Au	-	-	-	-	-	-	-	-	-	-	-	-
Ge	-	-	-	-	-	-	-	-	-	-	-	-
As	-	-	0.6	0.2	19.6	0.3	-	0.3	-	-	0.5	0.6
Se	-	-	-	-	-	-	-	-	-	-	-	-
Sb	-	-	0.5	0.1	1.5	0.1	-	0.1	-	-	0.2	0.1
206/204	-	-	-	18.133	-	-	-	-	-	-	-	-
207/204	-	-	-	15.546	-	-	-	-	-	-	-	-
208/204	-	-	-	37.868	-	-	-	-	-	-	-	-
DO18	-	-	-	8.2	13.7	-	-	8.1	-	-	-	-
E-Nd	-	-	-	3.0	2.5	-	-	4.2	-	-	-	-
tDm	-	-	-	0.79	0.97	-	-	0.73	-	-	-	-
E-400	-	-	-	3.1	2.6	-	-	4.4	-	-	-	-

APPENDIX 4 (cont'd.)

Pluton Unit MG or NB#	H4 81	H4 82	H5 77	H5 78	H5 79	H5 100	H5 101	D1 69	D1 70	D1 71	D1 72	D2 55
SiO <sub>2</sub>	70.00	69.10	64.20	63.20	68.30	69.10	61.50	65.25	55.70	69.70	64.00	64.50
TiO <sub>2</sub>	0.34	0.32	0.73	0.48	0.47	0.40	1.12	0.32	0.87	0.18	0.22	0.47
Al <sub>2</sub> O <sub>3</sub>	15.40	15.40	15.30	16.60	14.60	15.10	15.80	15.50	18.60	16.10	16.40	16.50
Fe <sub>2</sub> O <sub>3</sub>	0.33	0.42	1.90	0.80	2.22	0.62	0.50	1.03	2.23	1.60	1.46	1.60
FeO	1.58	1.78	2.24	1.82	0.79	0.89	1.28	1.05	4.60	1.40	2.70	1.30
MnO	0.05	0.05	0.08	0.05	0.05	0.03	0.03	0.03	0.11	0.13	0.13	0.05
MgO	0.67	1.10	1.75	1.75	1.00	0.56	2.37	1.43	2.70	0.29	0.36	1.58
CaO	1.89	1.23	1.14	3.23	0.79	1.01	5.10	2.95	2.23	1.43	3.42	4.57
Na <sub>2</sub> O	5.85	5.98	4.60	5.41	5.93	4.69	4.54	5.20	6.65	6.00	5.09	4.87
K <sub>2</sub> O	2.88	2.60	4.63	1.90	4.10	6.16	4.85	1.25	2.14	1.79	1.62	1.21
F <sub>2</sub> O <sub>5</sub>	0.10	0.09	0.26	0.13	0.09	0.07	0.43	0.10	0.23	0.11	0.18	0.15
LOI	-	-	-	-	-	-	-	5.73	3.47	1.39	4.16	3.39
H <sub>2</sub> O	0.85	1.13	1.51	2.14	0.60	0.42	0.82	-	-	-	-	-
CO <sub>2</sub>	0.10	0.22	1.11	2.01	0.73	0.21	0.96	-	-	-	-	-
TTE	0.20	0.18	0.27	0.15	0.28	0.33	0.42	0.15	0.23	0.17	0.14	0.15
Total	100.24	99.59	99.72	99.66	99.96	99.58	99.72	99.98	99.75	100.29	99.87	100.34
Trace Elements												
Rb	66	51	102	37	73	147	105	19	52	49	39	17
Cs	-	0.2	0.7	-	-	0.6	0.5	2.6	1.0	2.0	1.5	0.3
Ba	583	511	684	280	240	530	574	332	360	528	276	297
Sr	436	389	160	315	40	161	407	388	977	349	221	520
Ga	20	19	19	18	26	21	20	19	20	20	20	20
Li	-	-	-	-	-	9	-	48	86	40	18	14
Tl	-	-	-	-	-	-	-	2	2	<1	<1	<1
Ta	-	1.16	3.48	-	-	5.56	3.26	0.50	0.90	0.60	1.00	<0.04
Nb	10	9	51	8	107	75	52	4	9	9	11	6
Hf	-	3.8	10.4	-	-	14.6	13.3	3.2	3.8	4.8	7.0	3.1
Zr	174	156	489	151	835	520	581	132	202	199	304	158
Y	6	8	59	10	98	73	66	7	21	13	23	6
Th	-	5.1	12.6	-	-	19.4	10.5	3.6	3.0	5.5	5.0	2.8
U	-	1.1	7.7	-	-	4.9	3.7	1.2	1.4	2.0	1.9	1.1
La	-	2.6	64	-	-	73	77	18	16	24	27	19
Ce	-	45	117	-	-	143	146	33	33	43	49	33
Pr	-	-	-	-	-	14.9	-	-	-	-	-	-
Nd	-	15.1	44.0	-	-	52.5	56.7	12.5	15.0	16.0	20.0	12.0
Sm	-	2.94	7.87	-	-	9.70	11.64	2.09	3.19	2.46	3.49	1.77
Eu	-	0.72	1.87	-	-	1.06	2.46	0.80	1.24	1.04	1.28	0.81
Gd	-	-	-	-	-	9.49	-	-	-	-	-	-
Tb	-	0.26	1.20	-	-	1.56	1.53	0.25	0.50	0.40	0.60	0.30
Dy	-	-	-	-	-	10.12	-	-	-	-	-	-
Ho	-	-	-	-	-	2.18	-	-	-	-	-	-
Er	-	-	-	-	-	6.39	-	-	-	-	-	-
Tm	-	-	-	-	-	0.97	-	-	-	-	-	-
Yb	-	0.97	4.63	-	-	6.83	5.63	0.68	1.92	1.42	2.48	0.52
Lu	-	0.11	0.76	-	-	1.02	0.94	0.10	0.30	0.21	0.40	0.07
Cr	4	5	3	10	<1	<1	4	13	2	1	3	17
Ni	10	11	12	16	10	8	12	6	2	2	3	9
Co	-	-	-	-	-	-	-	5.3	17.0	2.4	3.2	8.9
Sc	-	3.5	7.4	-	-	4.3	10.9	4.9	7.9	1.0	1.3	5.7
V	-	-	-	-	-	8	-	39	103	4	7	51
Cu	15	10	6	10	6	6	5	2	4	2	6	14
Pb	-	-	-	-	-	6	-	2	4	16	8	8
Zn	40	20	42	36	3	14	10	16	76	73	84	49
Mn	-	-	-	-	-	-	-	220	870	1007	970	370
Bi	-	-	-	-	-	-	-	<0.1	0.2	0.4	0.2	0.4
Cd	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	-	-	-	-	-	-	-	0.8	<0.5	<0.5	9.0	<0.5
W	-	-	-	-	-	-	-	<0.5	<0.5	<0.5	<0.5	<0.5
Mo	-	-	-	-	-	-	-	1.0	<0.5	<0.5	2.0	<0.5
F	-	-	-	-	-	-	-	405	240	240	250	260
Cl	-	-	-	-	-	-	-	<25	<25	50	<25	<25
Br	-	-	-	-	-	-	-	<0.3	<0.3	0.8	<0.3	<0.3
B	-	-	-	-	-	-	-	40	80	50	50	10
Be	-	-	-	-	-	-	-	2.5	4.0	3.0	4.0	3.0
Au	-	-	-	-	-	-	-	1	<0.3	<0.3	<0.3	<0.3
Ge	-	-	-	-	-	-	-	<5	<5	<5	<5	<5
As	-	0.2	0.3	-	-	0.4	1.6	<0.2	0.5	2.0	<0.2	<0.2
Se	-	-	-	-	-	-	-	<0.4	0.8	<0.4	<0.4	<0.4
Sb	-	0.1	0.3	-	-	0.2	0.3	0.1	0.6	0.3	0.3	0.1
206/204	-	-	-	-	-	18.601	-	-	-	-	-	-
207/204	-	-	-	-	-	15.612	-	-	-	-	-	-
208/204	-	-	-	-	-	39.058	-	-	-	-	-	-
DO18	-	-	-	-	-	8.3	-	-	-	-	-	-
E-Nd	-	-	-	-	-	3.6	-	-	-	-	-	-
tDm	-	-	-	-	-	0.82	-	-	-	-	-	-
E-400	-	-	-	-	-	3.7	-	-	-	-	-	-

APPENDIX 4 (cont'd.)

Pluton Unit MG or NB#	D2 56	D2 57	D3 51	D3 58	D3 59	D3 60	D3 61	D3 62	D3 63	D3 64	D3 65	D3 66
SiO <sub>2</sub>	63.90	64.80	62.00	56.00	58.90	70.55	51.50	64.20	66.60	46.40	63.50	46.35
TiO <sub>2</sub>	0.49	0.46	0.84	1.26	1.57	0.27	2.64	0.74	0.57	1.98	0.79	3.52
Al <sub>2</sub> O <sub>3</sub>	16.60	16.55	16.50	17.70	14.70	14.35	14.30	15.90	15.45	20.85	16.00	16.10
Fe <sub>2</sub> O <sub>3</sub>	1.73	1.76	2.05	2.59	2.23	1.46	2.40	2.10	1.15	2.34	2.35	4.07
FeO	1.20	1.10	3.30	5.70	6.10	1.30	6.00	2.50	1.30	4.65	2.30	7.45
MnO	0.05	0.05	0.11	0.19	0.15	0.05	0.14	0.08	0.04	0.11	0.07	0.16
MgO	1.71	1.57	1.68	2.10	2.18	0.23	3.91	1.17	1.29	5.14	1.41	5.11
CaO	4.73	4.70	3.66	5.84	4.00	0.88	8.64	3.00	2.08	13.60	2.75	10.55
Na <sub>2</sub> O	4.83	4.90	4.89	5.08	6.10	5.94	5.61	4.37	7.06	2.20	4.54	2.93
K <sub>2</sub> O	1.16	1.12	2.94	1.57	1.53	3.81	0.42	3.60	2.28	0.41	3.65	0.68
P <sub>2</sub> O <sub>5</sub>	0.15	0.15	0.26	0.43	0.62	0.04	0.45	0.19	0.17	0.07	0.20	0.20
LOI	3.54	3.00	1.23	0.62	0.93	0.62	2.85	2.00	1.70	1.35	2.00	1.01
H <sub>2</sub> O	-	-	-	-	-	-	-	-	-	-	-	-
CO <sub>2</sub>	-	-	-	-	-	-	-	-	-	-	-	-
TTE	0.17	0.14	0.22	0.39	0.31	0.25	0.26	0.23	0.18	0.17	0.25	0.20
Total	100.26	100.30	99.68	99.47	99.31	99.73	99.12	100.09	99.87	99.26	99.82	98.33
Trace Elements												
Rb	16	15	79	46	29	97	5	99	36	8	101	17
Cs	0.8	0.4	1.2	1.0	<0.20	0.4	0.9	2.3	0.3	2.3	1.4	1.2
Ba	277	266	419	378	416	490	58	487	441	89	500	113
Sr	533	499	295	365	235	67	153	219	184	589	258	539
Ga	20	19	22	25	25	23	21	21	20	19	20	20
Li	26	22	14	36	76	10	24	60	8	8	86	36
Tl	<1	<1	6	<1	<1	<1	<1	<1	<1	<1	<1	<1
Ta	<0.04	0.50	1.30	<0.04	1.40	1.90	1.40	1.50	1.30	0.60	1.00	1.20
Nb	7	6	21	12	20	27	16	17	17	7	17	13
Hf	3.1	3.2	8.6	5.1	9.2	11.5	5.3	8.6	6.7	1.2	8.0	2.6
Zr	149	153	346	190	328	366	227	267	240	68	290	118
Y	6	6	34	41	65	60	42	33	37	10	34	17
Th	2.9	3.3	11.5	5.4	9.0	16.5	3.2	15.5	13.8	0.5	13.5	1.8
U	1.1	1.2	4.9	1.6	2.8	5.2	1.3	4.9	5.1	0.1	4.2	0.8
La	19	21	42	30	44	49	26	45	37	6	44	13
Ce	36	36	84	65	89	95	56	78	69	14	79	27
Pr	3.9	-	-	8.0	-	-	-	-	-	-	-	-
Nd	14.3	13.0	33.0	34.1	45.0	40.0	30.0	33.0	29.5	7.0	33.0	13.5
Sm	2.44	2.10	5.79	7.60	10.00	7.43	6.26	5.53	5.71	1.60	5.68	2.96
Eu	0.82	0.84	1.69	3.12	3.41	1.28	2.48	1.55	1.30	1.20	1.40	1.38
Gd	2.16	-	-	8.05	-	-	-	-	-	-	-	-
Tb	0.27	0.20	0.90	1.27	1.60	1.60	1.10	1.00	0.95	0.25	0.90	0.60
Dy	1.28	-	-	7.49	-	-	-	-	-	-	-	-
Ho	0.24	-	-	1.57	-	-	-	-	-	-	-	-
Er	0.59	-	-	4.09	-	-	-	-	-	-	-	-
Tm	0.07	-	-	0.55	-	-	-	-	-	-	-	-
Yb	0.48	0.55	3.48	3.65	5.89	6.07	3.55	3.47	3.73	0.82	3.30	1.62
Lu	0.06	0.08	0.52	0.53	0.89	0.92	0.53	0.49	0.58	0.12	0.49	0.23
Cr	32	18	8	1	<1	<1	2	5	1	146	4	2
Ni	10	8	5	3	2	1	4	4	2	43	3	7
Co	9.5	9.5	11.0	14.5	11.0	2.0	17.0	9.3	5.2	35.5	9.6	45.0
Sc	6.5	6.4	10.1	19.8	18.4	6.7	32.3	10.0	10.0	36.5	10.3	41.9
V	54	51	62	83	54	6	326	67	42	236	69	510
Cu	31	17	12	11	9	2	75	25	1	115	6	61
Pb	8	4	12	8	8	3	<1	16	<1	8	20	2
Zn	51	50	68	137	39	26	42	57	28	42	41	71
Mn	400	365	820	1471	1162	360	1084	640	305	820	550	1200
Bi	0.3	0.3	0.3	0.2	0.3	0.2	<0.1	0.4	0.9	0.4	1.4	0.4
Cd	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	7.0	<0.5	3.0	6.0	<0.5	0.8	2.0	<0.5	1.5	<0.5	6.0	0.8
W	<0.5	<0.5	1.5	1.0	<0.5	<0.5	<0.5	3.0	<0.5	<0.5	1.5	<0.5
Mo	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	2.0	<0.5	3.5	<0.5	1.5
F	380	190	560	480	1100	770	730	580	520	160	810	240
Cl	<25	<25	<25	1900	400	300	650	100	50	<25	<25	100
Br	<0.3	<0.3	<0.3	0.9	0.7	1.4	1.1	0.6	0.7	<0.3	<0.3	<0.3
B	10	<5	20	10	10	20	<5	30	15	10	20	10
Be	2.0	2.5	5.0	4.0	6.0	5.5	4.0	5.0	3.5	3.0	4.0	4.0
Au	<0.3	2	6	2	<0.3	2	<0.3	1	7	1	2	<0.3
Ge	<5	<5	<5	<5	<5	5	<5	<5	5	<5	<5	<5
As	<0.2	0.3	5.0	1.5	1.0	1.3	1.5	1.0	<0.2	3.3	1.0	4.5
Se	<0.4	0.9	<0.4	<0.4	<0.4	<0.4	3.8	<0.4	<0.4	0.6	2.0	0.6
Sb	0.1	0.1	0.6	0.2	0.2	0.1	0.6	0.3	0.1	0.7	0.4	0.8
206/204	18.293	-	-	18.410	-	-	-	-	-	-	-	-
207/204	15.589	-	-	15.578	-	-	-	-	-	-	-	-
208/204	38.005	-	-	38.073	-	-	-	-	-	-	-	-
DO18	9.6	-	-	6.6	-	-	-	-	-	-	-	-
E-Nd	4.5	-	-	4.5	-	-	-	-	-	-	-	-
tDm	0.71	-	-	0.84	-	-	-	-	-	-	-	-
E-400	4.7	-	-	4.7	-	-	-	-	-	-	-	-

APPENDIX 4 (cont'd.)

Pluton Unit MG or NB#	D3 67	D4 48	D4 49	D4 50	D4 68	D5 52	D5 53	D6 47	G1 228	G1 229	G2 104	G2 270
SiO <sub>2</sub>	64.60	66.60	59.80	59.55	67.00	74.45	74.95	68.95	76.05	75.80	75.10	76.60
TiO <sub>2</sub>	0.70	0.36	1.35	1.36	0.37	0.21	0.20	0.42	0.16	0.15	0.18	0.14
Al <sub>2</sub> O <sub>3</sub>	15.60	15.70	14.95	15.00	15.80	12.70	12.75	15.40	12.15	12.05	12.30	12.00
Fe <sub>2</sub> O <sub>3</sub>	1.77	1.28	2.11	2.45	1.22	0.53	0.43	1.11	0.42	0.49	1.06	0.86
FeO	2.60	1.00	5.75	5.55	1.00	1.00	1.00	1.40	0.70	0.50	0.80	0.30
MnO	0.07	0.04	0.20	0.16	0.05	0.04	0.04	0.03	0.01	0.01	0.01	0.02
MgO	1.14	1.01	2.23	1.94	1.04	0.24	0.22	0.93	0.27	0.22	0.30	0.10
CaO	2.96	3.12	3.00	4.77	3.42	0.87	0.81	3.00	0.48	0.30	0.14	0.20
Na <sub>2</sub> O	4.64	5.67	4.26	4.03	5.60	3.97	3.94	4.82	3.49	2.99	3.59	3.48
K <sub>2</sub> O	3.68	1.43	3.16	2.57	1.33	4.74	4.81	2.36	4.68	5.34	5.05	5.48
P <sub>2</sub> O <sub>5</sub>	0.18	0.10	0.35	0.36	0.10	0.05	0.05	0.11	0.03	0.03	0.03	0.02
LOI	0.93	2.70	1.28	0.54	2.93	0.47	0.51	0.78	0.89	0.85	0.54	0.54
H <sub>2</sub> O	-	-	-	-	-	-	-	-	-	-	-	-
CO <sub>2</sub>	-	-	-	-	-	-	-	-	-	-	-	-
TTE	0.28	0.13	0.29	0.30	0.14	0.21	0.22	0.21	0.24	0.22	0.18	0.27
Total	99.15	99.14	98.74	98.57	99.99	99.47	99.93	99.52	99.59	98.97	99.28	100.01
Trace Elements												
Rb	129	24	102	81	21	215	211	74	127	138	99	160
Cs	3.0	0.3	4.1	6.4	0.5	2.9	2.7	1.4	1.0	0.9	0.4	0.4
Ba	419	273	517	353	275	182	170	504	734	775	937	782
Sr	203	458	375	253	439	49	49	380	24	19	51	28
Ga	22	19	23	24	20	18	18	20	19	16	17	17
Li	46	26	28	12	34	70	54	14	6	8	<1	4
Tl	<1	<1	1	<1	<1	2	<1	<1	<1	<1	<1	<1
Ta	1.10	0.60	1.30	1.25	<0.04	1.90	1.60	0.80	1.70	1.65	1.30	1.60
Nb	18	4	23	24	4	20	19	8	26	26	22	25
Hf	7.6	3.1	8.4	9.6	3.0	5.7	5.6	3.3	6.0	5.7	7.4	6.0
Zr	282	135	338	341	135	137	146	127	153	135	224	166
Y	34	6	53	53	5	52	42	10	75	78	54	112
Th	15.0	3.4	9.6	11.3	3.4	25.3	27.5	8.8	22.3	22.3	16.5	18.5
U	3.5	1.3	2.5	3.1	1.3	7.9	5.8	3.9	5.2	5.0	4.1	4.5
La	38	18	46	42	17	36	45	26	56	73	48	84
Ce	77	29	92	92	29	82	85	52	122	125	95	143
Pr	8.5	-	-	11.1	-	9.4	-	5.4	14.2	-	-	19.7
Nd	31.1	11.0	42.0	45.8	11.0	34.6	33.0	19.2	56.6	57.5	41.0	77.7
Sm	6.19	1.82	8.29	9.83	1.84	7.57	6.04	3.08	12.11	11.25	7.82	16.40
Eu	1.31	0.73	2.31	2.57	0.76	0.34	0.44	0.78	0.93	1.18	1.26	1.40
Gd	6.13	-	-	10.08	-	7.16	-	2.62	12.06	-	-	16.94
Tb	0.96	0.20	1.50	1.59	0.20	1.26	1.00	0.33	2.10	2.00	1.60	2.79
Dy	5.89	-	-	9.89	-	7.93	-	1.87	13.10	-	-	17.47
Ho	1.24	-	-	2.09	-	1.73	-	0.37	2.77	-	-	3.58
Er	3.39	-	-	5.60	-	4.85	-	1.02	7.32	-	-	9.10
Tm	0.49	-	-	0.77	-	0.73	-	0.15	1.04	-	-	1.17
Yb	3.30	0.56	4.86	5.11	0.50	5.01	4.23	1.02	7.01	6.59	5.29	7.57
Lu	0.49	0.08	0.72	0.75	0.07	0.72	0.66	0.16	0.99	0.96	0.78	1.07
Cr	6	6	6	6	5	2	1	5	2	<1	1	<1
Ni	4	5	3	4	5	2	1	3	2	1	4	1
Co	9.1	6.2	14.0	15.3	6.0	1.7	1.7	4.6	1.3	1.1	1.3	1.5
Sc	9.0	4.6	19.9	21.5	4.6	4.6	4.1	4.6	14.5	13.9	17.3	14.8
V	57	40	121	106	43	11	13	42	3	3	5	<1
Cu	6	3	17	11	10	1	1	77	4	1	3	2
Pb	16	<1	9	12	8	12	9	9	10	13	4	8
Zn	39	36	118	101	40	22	21	20	18	9	5	12
Mn	560	300	1549	1278	360	320	310	240	105	85	60	150
Bi	<0.1	0.2	1.3	0.3	0.3	<0.1	0.3	0.6	0.6	0.3	2.0	0.6
Cd	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	<0.5	<0.5	1.5	7.0	<0.5	2.0	1.8	4.3	2.3	3.3	<0.5	2.0
W	1.5	<0.5	<0.5	1.3	<0.5	1.0	1.5	<0.5	1.3	<0.5	<0.5	1.0
Mo	<0.5	2.0	4.0	15.5	<0.5	<0.5	<0.5	1.0	<0.5	<0.5	<0.5	<0.5
F	670	210	690	965	280	1030	1200	620	880	685	100	900
Cl	600	<25	225	350	<25	<25	<25	<25	<25	<25	<25	<25
Br	1.0	<0.3	1.1	0.8	<0.3	<0.3	<0.3	<0.3	0.4	0.8	<0.3	<0.3
B	50	10	20	20	30	25	20	5	10	15	30	20
Be	4.0	3.0	5.0	5.5	3.0	5.5	6.5	3.5	5.0	4.0	5.0	6.0
Au	<0.3	<0.3	<0.3	<0.3	<0.3	2	1	<0.3	2	1	1	1
Ge	<5	<5	<5	<5	<5	5	<5	<5	<5	<5	<5	<5
As	6.5	<0.2	14.3	5.3	<0.2	1.0	<0.2	<0.2	0.8	2.3	<0.2	<0.2
Se	<0.4	<0.4	1.0	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	0.9	1.2	<0.4
Sb	0.9	0.2	1.8	0.5	<0.1	0.2	0.1	0.1	0.1	0.2	0.1	0.1
206/204	-	-	-	-	-	18.212	-	18.236	18.658	-	-	18.770
207/204	-	-	-	-	-	15.585	-	15.586	15.694	-	-	15.702
208/204	-	-	-	-	-	38.075	-	38.044	38.707	-	-	38.528
DO18	6.5	-	-	7.4	-	8.9	-	7.2	8.7	-	-	10.1
E-Nd	2.0	-	-	1.2	-	-1.6	-	0.1	-1.5	-	-	-4.0
tDm	0.96	-	-	1.12	-	1.38	-	1.03	1.44	-	-	1.72
E-400	2.2	-	-	1.4	-	-1.6	-	0.2	-2.1	-	-	-4.6

APPENDIX 4 (cont'd.)

Pluton Unit MG or NB#	G2 271	G3 79	G3 82	G3 83	G3 84	G3 97	G3 98	G3 246	G3 248	G3 258	G3 282	G4 249
SiO <sub>2</sub>	76.55	65.20	73.10	71.80	70.90	69.50	67.10	68.50	73.00	67.90	71.10	73.10
TiO <sub>2</sub>	0.13	0.74	0.18	0.29	0.32	0.44	0.51	0.50	0.30	0.60	0.31	0.32
Al <sub>2</sub> O <sub>3</sub>	12.10	15.65	13.80	14.20	14.30	14.80	15.20	15.20	13.90	15.30	14.10	13.50
Fe <sub>2</sub> O <sub>3</sub>	0.99	2.02	0.95	0.90	0.78	0.92	1.04	1.38	1.11	1.52	1.09	1.20
FeO	0.15	2.00	0.70	1.50	1.65	1.80	2.10	1.80	0.50	2.50	1.20	1.30
MnO	0.01	0.05	0.06	0.05	0.05	0.04	0.04	0.06	0.02	0.06	0.04	0.05
MgO	0.16	1.40	0.35	0.37	0.46	0.49	0.65	0.72	0.39	0.96	0.28	0.45
CaO	0.15	2.82	0.40	0.76	1.17	1.36	1.83	1.46	1.31	1.48	1.14	0.73
Na <sub>2</sub> O	3.34	4.77	3.78	3.73	3.54	3.72	3.76	3.77	3.65	3.73	3.49	2.97
K <sub>2</sub> O	5.49	3.63	5.48	5.15	5.54	5.58	5.66	5.63	5.18	4.87	5.23	4.93
P <sub>2</sub> O <sub>5</sub>	0.02	0.18	0.06	0.09	0.09	0.11	0.11	0.11	0.09	0.15	0.09	0.13
LOI	0.58	0.73	0.74	0.85	0.81	0.77	0.85	0.70	0.62	0.85	1.00	1.00
H <sub>2</sub> O	-	-	-	-	-	-	-	-	-	-	-	-
CO <sub>2</sub>	-	-	-	-	-	-	-	-	-	-	-	-
TTE	0.23	0.31	0.22	0.23	0.26	0.27	0.29	0.27	0.14	0.29	0.24	0.18
Total	99.89	99.51	99.82	99.93	99.87	99.80	99.14	100.09	100.21	100.22	99.31	99.86
Trace Elements												
Rb	173	103	148	162	201	190	211	204	216	141	192	242
Cs	1.0	1.0	0.7	1.0	2.7	1.7	3.0	2.5	5.4	2.4	1.6	9.7
Ba	773	712	722	630	660	689	551	604	364	722	623	239
Sr	30	241	51	64	91	113	113	80	69	143	74	42
Ga	18	21	17	18	18	20	20	19	16	20	17	16
Li	5	10	92	2	18	10	12	10	10	12	6	30
Tl	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	9
Ta	1.55	1.35	0.90	1.30	1.10	1.40	0.90	1.10	1.60	1.30	1.00	1.50
Nb	22	19	16	19	18	19	18	18	17	21	19	15
Hf	5.2	9.0	5.4	7.1	7.3	9.4	9.9	10.5	5.6	10.5	8.2	4.8
Zr	127	285	149	216	215	298	357	349	173	325	224	131
Y	78	49	64	82	69	66	53	54	34	55	60	38
Th	19.5	18.3	20.0	21.0	19.8	25.5	22.0	22.5	24.0	23.5	21.5	12.5
U	4.5	4.4	4.9	4.6	4.4	6.4	5.9	6.0	5.6	7.2	5.3	6.5
La	97	66	70	74	51	63	57	59	34	65	65	27
Ce	157	115	106	111	109	126	99	105	60	116	118	53
Pr	-	-	-	-	12.7	15.6	-	-	-	-	-	-
Nd	81.0	51.0	48.5	54.0	49.3	59.6	42.0	43.0	23.0	49.0	53.0	24.0
Sm	15.05	8.98	9.42	11.00	10.48	12.31	7.76	8.16	4.04	9.70	10.40	4.71
Eu	1.59	1.67	1.15	1.45	1.09	1.10	1.39	1.29	0.82	1.47	1.23	0.54
Gd	-	-	-	-	10.52	11.95	-	-	-	-	-	-
Tb	2.20	1.40	1.70	2.20	1.71	1.83	1.50	1.50	0.80	1.60	1.70	0.80
Dy	-	-	-	-	10.69	10.69	-	-	-	-	-	-
Ho	-	-	-	-	2.24	2.11	-	-	-	-	-	-
Er	-	-	-	-	6.12	5.32	-	-	-	-	-	-
Tm	-	-	-	-	0.83	0.73	-	-	-	-	-	-
Yb	6.65	4.55	5.41	6.20	5.44	4.68	4.55	4.70	2.69	5.23	5.34	3.26
Lu	0.96	0.66	0.77	0.88	0.78	0.64	0.67	0.69	0.45	0.74	0.76	0.50
Cr	<1	14	<1	3	4	7	7	4	8	13	3	13
Ni	2	8	2	2	2	2	3	4	4	4	3	5
Co	1.7	7.2	1.6	2.7	2.7	4.2	4.6	4.9	3.3	6.4	2.7	4.3
Sc	15.5	17.9	9.2	14.0	13.0	9.5	9.7	10.0	5.7	14.6	15.2	7.4
V	1	81	6	19	16	32	39	33	18	50	15	25
Cu	1	4	2	7	2	3	1	4	3	3	2	8
Pb	8	16	14	20	16	16	16	4	16	8	16	8
Zn	8	24	19	24	29	20	14	24	7	23	21	37
Mn	54	420	460	390	400	300	320	430	140	480	330	390
Bi	1.8	0.5	0.3	0.6	0.3	0.6	0.4	<0.1	0.2	<0.1	0.3	0.3
Cd	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	1.0	2.0	3.3	12.0	2.5	<0.5	<0.5	4.0	5.0	3.0	39.0	11.0
W	<0.5	0.8	0.5	<0.5	<0.5	<0.5	2.0	2.0	<0.5	3.5	1.5	3.0
Mo	<0.5	1.0	<0.5	<0.5	<0.5	<0.5	2.0	<0.5	<0.5	<0.5	<0.5	<0.5
F	630	1120	630	750	945	760	1200	970	260	730	730	800
Cl	<25	75	25	<25	<25	50	<25	<25	<25	350	<25	<25
Br	0.6	0.4	0.7	<0.3	<0.3	0.8	0.8	<0.3	1.2	<0.3	1.8	0.9
B	15	20	15	20	15	30	20	20	30	30	20	110
Be	4.5	5.0	4.0	6.0	5.0	5.0	6.0	7.0	5.0	8.0	5.0	5.0
Au	2	2	<0.3	2	2	<0.3	2	<0.3	3	2	11	3
Ge	<5	5	<5	<5	5	<5	10	<5	<5	<5	<5	<5
As	<0.2	0.3	0.3	0.5	0.5	1.0	0.5	<0.2	<0.2	1.0	2.0	3.5
Se	2.5	0.8	<0.4	1.1	1.8	<0.4	<0.4	<0.4	<0.4	<0.4	4.9	<0.4
Sb	0.1	0.1	0.3	0.2	0.6	0.3	0.1	0.1	0.2	0.6	0.4	0.6
206/204	-	-	-	-	18.491	18.618	-	-	-	-	-	-
207/204	-	-	-	-	15.696	15.677	-	-	-	-	-	-
208/204	-	-	-	-	38.398	38.467	-	-	-	-	-	-
DO18	-	-	-	-	8.8	8.2	-	-	-	-	-	-
E-Nd	-	-	-	-	-3.0	-2.9	-	-	-	-	-	-
tDm	-	-	-	-	1.60	1.52	-	-	-	-	-	-
E-400	-	-	-	-	-3.6	-3.6	-	-	-	-	-	-

APPENDIX 4 (cont'd.)

Pluton Unit MG or NB#	G4 274	G4 275	G4 276	G4 277	G4 290	G5 278	G5 279	G5 311	G5 312	G5 280	G5 281	G6 111
SiO <sub>2</sub>	72.10	71.30	72.80	70.30	71.40	76.50	77.00	75.00	75.40	73.70	70.75	72.20
TiO <sub>2</sub>	0.29	0.40	0.29	0.50	0.41	0.13	0.13	0.28	0.21	0.36	0.45	0.32
Al <sub>2</sub> O <sub>3</sub>	13.80	14.00	13.60	14.40	14.10	12.20	12.10	12.80	12.60	12.80	13.90	13.40
Fe <sub>2</sub> O <sub>3</sub>	1.05	1.05	0.68	0.89	0.83	0.64	0.42	0.69	0.67	0.68	0.95	0.39
FeO	1.50	1.80	1.40	2.50	1.20	0.50	0.70	0.80	0.50	1.10	1.60	1.95
MnO	0.06	0.07	0.06	0.07	0.03	0.04	0.04	0.03	0.02	0.03	0.05	0.05
MgO	0.35	0.63	0.40	0.86	0.69	0.05	0.04	0.31	0.28	0.36	0.49	0.37
CaO	0.80	1.06	0.78	1.07	0.77	0.38	0.40	0.81	0.44	0.96	1.37	0.82
Na <sub>2</sub> O	3.89	2.87	3.03	2.91	3.58	3.38	3.30	3.54	3.85	3.54	3.45	3.06
K <sub>2</sub> O	4.56	4.92	5.04	4.84	4.38	4.92	5.01	4.96	4.92	4.52	4.99	4.98
P <sub>2</sub> O <sub>5</sub>	0.08	0.14	0.12	0.14	0.12	0.04	0.04	0.06	0.04	0.08	0.10	0.18
LOI	1.00	1.31	1.16	1.39	1.39	1.00	0.70	0.47	0.70	1.08	1.20	0.97
H <sub>2</sub> O	-	-	-	-	-	-	-	-	-	-	-	-
CO <sub>2</sub>	-	-	-	-	-	-	-	-	-	-	-	-
TTE	0.24	0.22	0.18	0.24	0.21	0.21	0.19	0.17	0.16	0.23	0.24	0.24
Total	99.72	99.77	99.54	100.11	99.10	100.00	100.07	99.93	99.79	99.44	99.53	98.92
Trace Elements												
Rb	166	198	232	198	121	273	270	217	208	146	142	185
Cs	5.5	7.8	6.8	8.4	1.4	2.2	1.9	8.4	2.5	1.5	1.3	3.3
Ba	481	401	268	552	817	101	30	359	261	500	536	602
Sr	47	70	53	74	84	26	20	43	49	94	114	66
Ga	22	18	17	17	16	16	15	15	13	16	19	18
Li	26	2	28	42	14	8	4	-	-	18	9	12
Tl	<1	<1	<1	11	<1	<1	<1	<1	<1	<1	<1	<1
Ta	3.80	1.00	1.40	1.50	0.60	2.70	1.70	1.70	1.70	1.90	1.40	1.25
Nb	49	16	15	17	13	21	19	17	18	19	21	17
Hf	9.1	5.1	4.4	6.2	5.2	3.3	3.3	5.9	4.9	6.4	7.8	6.1
Zr	257	157	118	179	157	79	86	141	110	185	256	183
Y	101	42	42	43	36	60	74	45	62	44	47	45
Th	17.0	13.5	14.0	16.0	13.5	17.0	18.5	21.0	28.0	21.0	22.0	11.8
U	4.2	3.6	5.3	3.5	3.2	6.4	7.0	5.2	5.6	6.9	6.2	3.7
La	74	38	26	43	36	22	23	46	48	42	56	39
Ce	122	68	55	85	63	47	54	84	83	83	101	73
Pr	-	-	6.6	-	-	-	6.4	-	-	-	-	-
Nd	58.0	28.0	25.0	37.0	27.0	21.0	23.2	32.0	36.0	33.0	39.5	32.5
Sm	11.30	5.73	5.53	6.67	4.95	4.63	6.07	7.46	7.96	6.26	7.16	6.17
Eu	1.51	1.04	0.64	1.22	1.22	0.24	0.12	0.66	0.41	0.80	1.20	1.17
Gd	-	-	5.27	-	-	-	6.83	-	-	-	-	-
Tb	2.10	1.00	0.98	1.10	1.00	1.20	1.47	1.20	1.50	1.10	1.15	1.25
Dy	-	-	6.41	-	-	-	10.39	-	-	-	-	-
Ho	-	-	1.32	-	-	-	2.38	-	-	-	-	-
Er	-	-	3.51	-	-	-	6.72	-	-	-	-	-
Tm	-	-	0.49	-	-	-	0.98	-	-	-	-	-
Yb	7.23	3.40	3.21	3.63	3.03	5.67	6.56	4.60	6.51	4.40	4.32	4.06
Lu	1.07	0.51	0.45	0.53	0.42	0.88	0.91	0.72	1.01	0.68	0.66	0.58
Cr	7	16	12	16	17	1	4	5	6	7	9	12
Ni	3	5	3	7	6	2	1	2	2	3	4	3
Co	3.9	6.2	4.2	7.4	4.5	1.2	1.4	2.6	2.1	3.1	4.5	3.8
Sc	6.2	8.4	6.8	9.6	7.6	3.9	3.8	6.4	7.4	6.0	7.3	5.5
V	19	34	20	47	40	4	3	19	15	26	38	22
Cu	3	10	8	13	2	1	3	1	2	3	8	10
Pb	4	20	20	20	12	20	28	12	10	12	16	14
Zn	38	37	31	48	20	26	27	23	11	14	29	42
Mn	450	550	450	530	210	310	320	260	130	240	350	415
Bi	0.2	<0.1	0.3	0.3	0.3	0.3	0.2	0.4	0.1	<0.1	<0.1	<0.1
Cd	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	6.0	7.0	7.0	7.0	2.0	11.0	13.0	7.0	5.5	9.0	5.5	7.5
W	3.5	2.5	2.5	3.5	2.5	3.0	3.0	2.0	2.0	1.0	1.5	3.5
Mo	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.0	<0.5
F	800	940	680	900	570	1300	1100	610	550	850	885	995
Cl	<25	<25	50	<25	<25	<25	<25	<25	<25	100	<25	<25
Br	0.5	0.5	0.8	<0.3	<0.3	0.6	1.0	<0.3	<0.3	<0.3	1.0	0.3
B	30	30	40	30	30	20	20	30	20	20	15	20
Be	9.0	5.0	4.0	5.0	3.0	7.0	5.0	4.0	3.0	5.0	5.0	4.5
Au	<0.3	<0.3	2	3	<0.3	3	24	<0.3	<0.3	1	2	<0.3
Ge	<5	<5	<5	10	10	<5	10	<5	<5	<5	10	<5
As	1.0	1.0	1.5	2.5	<0.2	1.0	0.5	2.0	1.0	1.0	0.5	1.0
Se	3.1	<0.4	4.2	<0.4	1.8	1.9	5.3	<0.4	<0.4	<0.4	<0.4	10.0
Sb	0.3	0.2	0.3	0.4	0.1	0.1	0.1	0.8	0.2	0.1	0.2	0.5
206/204	-	-	18.353	-	-	-	18.501	-	-	-	-	-
207/204	-	-	15.675	-	-	-	15.693	-	-	-	-	-
208/204	-	-	38.232	-	-	-	38.306	-	-	-	-	-
DO18	-	-	9.8	-	-	-	8.6	-	-	-	-	-
E-Nd	-	-	-3.7	-	-	-	0.1	-	-	-	-	-
tDm	-	-	1.69	-	-	-	1.58	-	-	-	-	-
E-400	-	-	-4.3	-	-	-	-0.2	-	-	-	-	-

APPENDIX 4 (cont'd.)

Pluton Unit MG or NB#	G6 230	G6 231	G6 232	G6 233	G6 267	G6 268	G6 269	G7 130	G7 133	G7 134	G7 135	G7 148
SiO <sub>2</sub>	73.70	70.80	70.55	75.00	72.40	74.80	72.20	77.60	74.05	72.40	69.90	73.00
TiO <sub>2</sub>	0.17	0.40	0.41	0.17	0.32	0.18	0.21	0.16	0.20	0.42	0.54	0.40
Al <sub>2</sub> O <sub>3</sub>	13.50	13.60	13.85	12.40	13.70	12.60	13.90	11.80	13.00	13.10	14.60	13.15
Fe <sub>2</sub> O <sub>3</sub>	0.60	1.13	1.33	0.95	1.01	0.92	1.02	0.39	0.84	1.03	1.28	0.94
FeO	0.85	1.90	1.60	0.50	1.50	0.50	1.30	0.30	0.65	1.30	1.00	1.25
MnO	0.04	0.06	0.07	0.02	0.03	0.02	0.08	0.02	0.03	0.07	0.02	0.05
MgO	0.20	0.55	0.69	0.05	0.42	0.10	0.07	0.16	0.12	0.62	0.86	0.59
CaO	0.37	2.09	2.11	0.66	0.88	0.52	0.40	0.56	0.57	1.37	1.98	1.39
Na <sub>2</sub> O	3.99	4.63	3.25	3.46	3.25	3.66	4.69	4.34	3.64	3.09	5.56	3.33
K <sub>2</sub> O	4.81	2.18	4.06	5.16	4.89	5.26	4.93	3.43	5.55	4.83	2.20	4.63
P <sub>2</sub> O <sub>5</sub>	0.06	0.09	0.09	0.02	0.18	0.03	0.03	0.05	0.03	0.10	0.20	0.10
LOI	0.85	2.16	1.23	0.70	1.08	0.47	0.85	0.62	0.39	0.85	0.70	0.73
H <sub>2</sub> O	-	-	-	-	-	-	-	-	-	-	-	-
CO <sub>2</sub>	-	-	-	-	-	-	-	-	-	-	-	-
TTE	0.18	0.21	0.21	0.25	0.23	0.24	0.21	0.09	0.11	0.22	0.24	0.19
Total	99.31	99.80	99.45	99.34	99.90	99.30	99.89	99.52	99.20	99.39	99.07	99.75
Trace Elements												
Rb	142	79	129	181	163	157	112	171	204	184	87	206
Cs	0.6	1.5	2.6	1.6	1.9	1.2	1.3	2.9	1.8	6.4	3.2	8.0
Ba	671	555	721	467	608	500	667	65	196	454	450	344
Sr	52	213	144	39	71	41	35	58	26	85	192	72
Ga	15	18	16	22	19	20	26	13	16	15	18	13
Li	6	6	7	8	10	6	4	12	6	14	6	40
Tl	<1	<1	<1	<1	<1	<1	7	<1	<1	8	3	<1
Ta	1.00	1.30	0.60	2.20	1.30	1.90	4.00	1.60	1.20	0.70	2.00	1.75
Nb	12	11	12	28	17	30	57	18	18	15	23	16
Hf	4.4	7.2	6.0	7.2	5.6	7.0	12.5	3.2	6.8	5.3	6.3	5.5
Zr	106	177	193	161	186	180	364	75	161	157	227	148
Y	53	44	36	77	46	88	83	49	45	45	34	46
Th	12.3	17.0	13.5	24.5	12.5	23.5	19.0	15.5	26.8	17.0	15.0	17.3
U	3.4	4.9	3.0	5.1	4.1	4.5	4.7	5.3	4.3	3.2	3.3	6.9
La	43	44	51	65	39	82	83	21	69	31	52	37
Ce	65	83	75	130	76	137	147	42	119	66	89	72
Pr	-	-	-	15.4	-	-	-	-	-	7.6	-	-
Nd	32.0	37.0	32.0	57.3	33.0	57.0	63.0	20.0	46.0	29.0	33.0	29.5
Sm	6.87	7.44	5.99	12.01	6.45	11.20	12.60	3.97	7.94	6.05	6.31	5.67
Eu	0.87	1.39	1.08	0.94	1.29	1.07	2.07	0.26	0.68	0.84	1.33	0.99
Gd	-	-	-	12.72	-	-	-	-	-	6.14	-	-
Tb	1.45	1.30	0.90	1.87	1.30	1.90	2.20	1.10	1.65	1.06	1.10	1.20
Dy	-	-	-	12.45	-	-	-	-	-	7.22	-	-
Ho	-	-	-	2.45	-	-	-	-	-	1.56	-	-
Er	-	-	-	7.15	-	-	-	-	-	4.21	-	-
Tm	-	-	-	1.05	-	-	-	-	-	0.60	-	-
Yb	3.96	4.71	3.21	6.73	4.03	6.56	7.24	5.43	4.37	4.01	3.28	4.66
Lu	0.56	0.73	0.48	0.98	0.58	0.98	0.98	0.85	0.63	0.58	0.48	0.70
Cr	1	<1	9	2	4	<1	3	20	3	21	6	11
Ni	2	<1	3	1	3	1	1	1	1	4	4	4
Co	1.3	4.5	4.9	1.1	3.9	1.4	1.6	1.4	1.8	5.5	5.6	6.1
Sc	5.3	14.5	10.5	5.8	5.4	5.8	2.5	6.2	4.8	8.6	9.7	9.2
V	9	34	38	4	21	5	4	8	5	39	46	33
Cu	6	6	3	4	5	1	5	2	3	13	2	9
Pb	8	16	8	8	4	8	8	20	16	24	12	16
Zn	27	37	44	31	12	13	194	3	18	41	5	26
Mn	310	490	530	170	210	150	630	140	265	520	130	380
Bi	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.6	<0.1	0.3	0.3
Cd	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	1.5	<0.5	<0.5	7.0	2.0	<0.5	23.0	6.0	5.8	<0.5	16.0	4.5
W	1.3	<0.5	1.0	3.0	2.0	0.5	1.5	1.0	<0.5	0.5	0.5	1.0
Mo	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	3.0	<0.5	<0.5	<0.5	<0.5	0.5
F	480	640	520	1100	980	980	130	280	90	870	1000	690
Cl	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Br	<0.3	<0.3	0.8	0.6	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
B	15	30	25	20	20	20	20	30	10	30	30	25
Be	3.5	5.0	3.5	6.0	6.0	7.0	9.0	4.0	4.0	3.0	5.0	4.5
Au	1	2	<0.3	<0.3	6	6	6	2	2	4	<0.3	7
Ge	<5	10	<5	10	<5	<5	10	<5	<5	<5	<5	<5
As	1.8	6.0	4.5	<0.2	1.5	<0.2	1.0	<0.2	<0.2	1.5	0.5	0.8
Se	3.2	<0.4	<0.4	2.0	<0.4	15.0	5.5	1.1	<0.4	<0.4	<0.4	<0.4
Sb	0.1	0.2	0.2	0.2	0.1	1.1	0.6	0.2	<0.1	0.4	0.1	0.3
206/204	-	-	-	18.428	-	-	-	-	-	18.397	-	-
207/204	-	-	-	15.682	-	-	-	-	-	15.699	-	-
208/204	-	-	-	38.332	-	-	-	-	-	38.348	-	-
DC18	-	-	-	8.5	-	-	-	-	-	10.0	-	-
E-Nd	-	-	-	-0.4	-	-	-	-	-	-2.8	-	-
tDm	-	-	-	1.39	-	-	-	-	-	1.54	-	-
E-400	-	-	-	-0.9	-	-	-	-	-	-3.2	-	-

APPENDIX 4 (cont'd.)

Pluton Unit MG or NB#	G7 151	G7 163	G7 164	G7 315	G7 322	G7 323	G8 125	G8 126	G8 140	G8 141	G9a 306	G9a 324
SiO <sub>2</sub>	70.45	75.20	71.90	73.00	73.00	72.20	69.50	67.20	71.45	72.20	73.00	72.60
TiO <sub>2</sub>	0.62	0.20	0.49	0.38	0.40	0.44	0.59	0.63	0.53	0.44	0.36	0.42
Al <sub>2</sub> O <sub>3</sub>	13.80	12.25	13.70	13.40	13.50	13.60	13.70	15.10	13.85	13.10	13.60	14.00
Fe <sub>2</sub> O <sub>3</sub>	0.86	0.84	0.95	0.97	0.72	0.93	1.24	1.65	1.26	1.20	0.49	0.39
FeO	2.55	0.50	1.90	1.30	1.60	1.50	2.10	1.90	1.65	1.30	1.50	1.80
MnO	0.07	0.03	0.05	0.05	0.05	0.04	0.06	0.08	0.08	0.09	0.03	0.03
MgO	1.01	0.13	0.59	0.49	0.51	0.76	0.87	0.93	0.70	0.63	0.47	0.59
CaO	2.11	0.61	1.56	1.27	1.35	1.58	1.66	2.73	1.83	1.61	1.01	1.51
Na <sub>2</sub> O	3.12	3.36	3.94	3.43	3.29	3.15	3.27	4.21	3.74	3.43	3.31	4.70
K <sub>2</sub> O	4.00	5.21	3.59	4.40	4.34	4.69	4.63	3.40	4.06	4.25	5.11	2.58
P <sub>2</sub> O <sub>5</sub>	0.13	0.03	0.15	0.14	0.17	0.14	0.14	0.15	0.12	0.11	0.11	0.14
LOI	0.62	0.70	1.08	0.62	0.70	0.62	0.54	0.93	0.74	0.62	0.70	0.77
H <sub>2</sub> O	-	-	-	-	-	-	-	-	-	-	-	-
CO <sub>2</sub>	-	-	-	-	-	-	-	-	-	-	-	-
TTE	0.22	0.14	0.17	0.23	0.23	0.16	0.21	0.24	0.23	0.19	0.23	0.13
Total	99.57	99.21	100.07	99.67	99.86	99.81	98.51	99.15	100.24	99.16	99.93	99.66
Trace Elements												
Rb	171	178	155	167	164	184	185	135	153	158	208	108
Cs	8.7	1.1	3.7	6.9	9.2	7.1	9.5	7.7	6.9	4.1	6.1	12.4
Ba	468	305	277	626	719	649	453	547	566	370	570	529
Sr	96	35	69	97	113	113	115	157	101	82	68	121
Ga	14	17	19	16	16	15	16	18	16	14	16	15
Li	84	4	20	-	-	-	25	34	54	28	-	-
Tl	2	<1	5	<1	<1	<1	<1	<1	<1	<1	<1	<1
Ta	1.25	1.25	2.40	1.20	2.10	1.50	1.10	1.50	1.70	1.20	1.30	2.00
Nb	16	22	21	16	17	13	17	21	20	17	16	16
Hf	6.5	6.0	7.6	5.8	6.4	6.3	6.1	8.2	7.8	5.5	5.9	4.4
Zr	171	163	203	174	180	153	197	246	232	179	176	185
Y	43	33	26	40	40	29	37	43	45	53	45	44
Th	15.3	31.5	14.0	19.0	17.0	20.0	14.0	14.0	14.3	17.5	18.0	14.0
U	2.2	3.7	2.6	5.6	4.6	2.4	4.2	4.5	2.9	4.5	5.9	7.7
La	40	63	42	44	49	44	41	32	47	39	39	30
Ce	78	108	78	83	72	73	76	66	86	73	76	43
Pr	-	-	-	-	-	-	-	7.7	-	-	-	-
Nd	32.5	41.5	32.0	34.0	34.0	32.0	33.0	31.1	35.0	31.0	29.0	21.0
Sm	6.52	7.32	6.27	7.69	8.08	7.01	6.01	6.69	6.66	5.97	6.86	4.24
Eu	1.44	0.89	1.28	1.03	1.38	1.19	1.17	1.53	1.58	0.95	0.77	0.87
Gd	-	-	-	-	-	-	-	6.73	-	-	-	-
Tb	1.25	1.05	1.20	1.10	1.30	1.20	1.00	1.15	1.15	1.10	1.10	0.50
Dy	-	-	-	-	-	-	-	7.51	-	-	-	-
Ho	-	-	-	-	-	-	-	1.61	-	-	-	-
Er	-	-	-	-	-	-	-	4.32	-	-	-	-
Tm	-	-	-	-	-	-	-	0.61	-	-	-	-
Yb	4.21	2.82	2.73	3.84	4.41	3.41	3.52	4.16	4.36	4.97	4.11	2.10
Lu	0.61	0.41	0.38	0.58	0.62	0.52	0.52	0.60	0.66	0.77	0.62	0.36
Cr	17	<1	10	8	10	15	15	12	6	9	8	9
Ni	6	3	7	4	3	5	5	4	4	5	4	5
Co	8.9	1.6	5.5	5.3	5.0	7.5	8.2	8.0	6.0	5.0	4.1	8.4
Sc	14.5	4.0	10.1	6.4	7.6	11.6	10.7	13.9	11.2	9.2	6.7	8.4
V	56	7	34	27	29	42	56	54	34	39	32	40
Cu	32	1	3	11	4	3	5	14	10	19	4	2
Pb	14	17	24	16	14	14	24	20	14	24	8	4
Zn	49	17	48	32	37	34	46	70	45	37	24	22
Mn	570	235	350	350	380	300	500	640	585	690	230	240
Bi	0.2	0.6	0.2	0.5	0.3	0.6	0.4	0.4	0.3	0.2	0.3	<0.1
Cd	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	5.3	2.3	12.0	3.5	5.5	4.5	3.0	5.0	4.0	12.0	2.5	5.5
W	13.3	<0.5	0.5	<0.5	2.0	1.0	<0.5	<0.5	<0.5	1.0	4.0	2.0
Mo	<0.5	<0.5	<0.5	2.0	<0.5	4.0	<0.5	3.0	<0.5	<0.5	<0.5	43.0
F	685	360	580	880	680	110	680	780	740	660	940	<20
Cl	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Br	0.3	<0.3	<0.3	<0.3	<0.3	0.5	<0.3	170.0	<0.3	<0.3	<0.3	<0.3
B	20	10	20	10	20	20	30	30	15	40	20	20
Be	4.0	3.5	4.0	3.0	4.0	2.0	3.0	4.0	4.5	5.0	4.0	3.0
Au	3	<0.3	<0.3	<0.3	<0.3	3	<0.3	5	4	<0.3	<0.3	3
Ge	5	<5	10	<5	<5	<5	<5	<5	<5	<5	<5	<5
As	0.3	<0.2	<0.2	1.0	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	2.0	1.0
Se	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Sb	0.2	0.1	0.1	0.5	1.5	0.8	0.4	0.7	0.4	0.2	0.4	2.8
206/204	-	-	-	-	-	-	-	18.479	-	-	-	-
207/204	-	-	-	-	-	-	-	15.697	-	-	-	-
208/204	-	-	-	-	-	-	-	38.342	-	-	-	-
DO18	-	-	-	-	-	-	-	8.7	-	-	-	-
E-Nd	-	-	-	-	-	-	-	-1.5	-	-	-	-
tDm	-	-	-	-	-	-	-	1.49	-	-	-	-
E-400	-	-	-	-	-	-	-	-1.9	-	-	-	-

APPENDIX 4 (cont'd.)

Pluton Unit MG or NB#	G9b 317	G9c 175	G10 39	G10 40	G10 41	G10 42	G10 43	G11 44	G11 45	G11 46	G11 54	G12 73
SiO <sub>2</sub>	69.20	74.20	66.50	59.00	68.90	67.50	65.65	72.00	70.75	71.10	70.30	72.90
TiO <sub>2</sub>	0.54	0.33	0.50	0.84	0.41	0.35	0.35	0.29	0.29	0.31	0.35	0.23
Al <sub>2</sub> O <sub>3</sub>	14.50	13.00	15.20	15.90	14.30	14.40	13.80	14.45	14.50	14.25	14.25	14.30
Fe <sub>2</sub> O <sub>3</sub>	1.64	0.83	2.01	3.31	1.22	1.91	1.81	0.70	0.62	0.48	0.71	0.48
FeO	2.00	1.30	1.70	3.80	1.60	2.35	2.90	1.10	1.10	1.30	1.30	0.90
MnO	0.06	0.04	0.06	0.13	0.06	0.08	0.09	0.07	0.06	0.06	0.07	0.05
MgO	1.28	0.38	1.19	2.50	1.28	1.66	2.20	0.53	0.66	0.62	0.80	0.58
CaO	2.80	1.03	2.83	5.23	1.01	4.09	4.58	1.26	1.62	1.63	1.54	1.68
Na <sub>2</sub> O	3.87	3.16	4.29	3.51	4.35	3.61	3.58	4.09	4.06	3.98	4.10	3.77
K <sub>2</sub> O	2.86	4.63	3.37	2.86	3.94	2.03	2.10	4.19	4.29	4.20	4.08	4.04
P <sub>2</sub> O <sub>5</sub>	0.12	0.17	0.15	0.28	0.11	0.06	0.06	0.10	0.11	0.12	0.13	0.10
LOI	0.70	0.58	1.39	1.54	1.54	1.77	1.73	0.62	0.77	0.85	0.93	0.77
H <sub>2</sub> O	-	-	-	-	-	-	-	-	-	-	-	-
CO <sub>2</sub>	-	-	-	-	-	-	-	-	-	-	-	-
TTE	0.21	0.22	0.24	0.25	0.20	0.12	0.13	0.20	0.16	0.18	0.20	0.18
Total	99.78	99.87	99.43	99.15	98.92	99.92	99.89	98.95	98.94	99.33	98.76	99.98
Trace Elements												
Rb	97	182	85	83	97	62	64	175	170	168	147	195
Cs	4.8	6.3	0.5	1.0	0.8	0.8	0.9	5.2	6.9	6.7	5.1	9.6
Ba	527	673	829	526	745	397	395	376	543	432	458	551
Sr	269	101	292	370	124	117	132	170	155	148	163	118
Ga	16	16	16	17	14	14	13	18	19	18	18	16
Li	-	14	6	8	6	10	8	48	58	64	78	52
Tl	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Ta	1.70	1.55	1.00	1.00	0.70	0.70	0.65	2.30	2.05	1.90	1.70	1.90
Nb	13	18	17	14	16	6	5	21	15	17	18	15
Hf	6.3	4.7	5.1	4.1	4.8	2.6	2.5	4.4	4.0	4.1	4.8	3.6
Zr	199	152	184	158	175	88	79	136	118	135	139	103
Y	34	36	22	26	21	14	9	41	26	29	29	30
Th	14.0	8.9	11.5	9.3	12.5	5.7	5.5	29.0	13.5	15.0	16.5	20.0
U	4.0	3.2	2.4	1.9	2.7	1.0	0.8	7.9	3.0	4.3	3.4	5.5
La	48	25	40	38	34	17	13	32	25	34	37	29
Ce	70	49	69	66	61	30	27	62	53	59	65	57
Pr	-	-	-	-	7.1	-	3.0	-	5.8	-	-	6.1
Nd	36.0	22.5	27.0	29.0	23.8	11.0	11.2	27.0	21.2	25.0	25.0	21.5
Sm	6.40	4.57	4.44	5.41	4.18	1.87	2.22	5.66	4.30	4.28	4.62	4.52
Eu	1.13	1.23	1.23	1.60	0.72	0.51	0.46	0.93	0.79	1.03	0.95	0.58
Gd	-	-	-	-	3.85	-	2.37	-	3.86	-	-	4.28
Tb	1.00	0.90	0.60	0.70	0.57	0.30	0.34	1.20	0.63	0.70	0.80	0.70
Dy	-	-	-	-	3.55	-	2.28	-	3.75	-	-	4.30
Ho	-	-	-	-	0.76	-	0.50	-	0.77	-	-	0.87
Er	-	-	-	-	2.05	-	1.40	-	2.12	-	-	2.42
Tm	-	-	-	-	0.30	-	0.21	-	0.31	-	-	0.35
Yb	3.69	3.20	2.39	2.59	2.06	1.52	1.50	4.31	2.04	2.77	2.70	2.43
Lu	0.52	0.49	0.36	0.38	0.33	0.25	0.24	0.65	0.28	0.43	0.42	0.36
Cr	27	7	<1	6	<1	7	34	<1	9	6	5	13
Ni	6	3	2	5	2	5	10	3	3	3	3	4
Co	9.8	4.1	7.4	18.0	5.1	10.5	13.0	3.2	3.7	3.7	4.2	3.4
Sc	15.4	5.4	10.1	18.9	7.4	17.3	19.6	6.5	5.3	5.5	6.3	5.5
V	74	16	70	170	51	114	123	24	23	26	32	20
Cu	4	4	3	81	2	11	28	2	2	6	3	1
Pb	6	20	12	8	4	3	1	20	20	20	14	20
Zn	32	23	17	44	20	33	39	34	32	31	34	28
Mn	430	345	470	1007	470	610	725	580	455	500	565	360
Bi	0.5	<0.1	<0.1	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	0.3
Cd	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	3.5	6.0	<0.5	<0.5	<0.5	1.0	1.0	10.0	4.0	6.0	6.0	14.0
W	1.0	1.3	<0.5	<0.5	1.0	<0.5	<0.5	0.5	<0.5	0.5	0.8	1.0
Mo	7.0	<0.5	2.0	2.0	2.0	<0.5	<0.5	2.0	1.0	13.0	<0.5	<0.5
F	610	760	710	770	520	195	235	740	285	550	700	430
Cl	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Br	<0.3	<0.3	<0.3	0.6	<0.3	<0.3	0.3	0.6	<0.3	<0.3	0.3	<0.3
B	14	10	30	30	20	10	30	20	10	20	25	40
Be	4.0	3.0	4.0	4.0	4.0	3.5	3.5	7.0	6.0	7.0	6.0	6.0
Au	<0.3	<0.3	<0.3	2	<0.3	3	1	<0.3	<0.3	<0.3	2	4
Ge	<5	<5	<5	10	10	<5	<5	<5	<5	<5	<5	10
As	<0.2	2.3	<0.2	0.5	<0.2	<0.2	<0.2	<0.2	0.5	0.5	0.8	0.5
Se	0.9	<0.4	<0.4	<0.4	<0.4	0.4	<0.4	<0.4	<0.4	<0.4	0.6	<0.4
Sb	0.2	0.3	0.1	0.4	0.1	0.1	<0.1	0.1	0.1	0.2	0.1	0.3
206/204	-	-	-	-	-	-	18.738	-	18.276	-	-	18.411
207/204	-	-	-	-	-	-	15.709	-	15.612	-	-	15.669
208/204	-	-	-	-	-	-	38.631	-	38.089	-	-	38.303
DO18	-	-	-	-	-	-	8.2	-	9.6	-	-	6.6
E-Nd	-	-	-	-	0.1	-	-5.4	-	-2.6	-	-	-3.1
tDm	-	-	-	-	1.09	-	1.67	-	1.37	-	-	1.43
E-400	-	-	-	-	-0.6	-	-6.1	-	-2.5	-	-	-3.3

APPENDIX 4 (cont'd.)

Pluton Unit MG or NB#	G12 74	G12 80	G12 81	G12 93	G12 94	G12 95	G12 240	G12 250	G12 257	G12 325	G12 75	G12 77
SiO <sub>2</sub>	71.30	72.90	71.00	74.90	72.60	71.10	75.50	73.30	70.10	73.30	54.40	52.40
TiO <sub>2</sub>	0.26	0.21	0.25	0.14	0.19	0.22	0.14	0.24	0.33	0.22	0.99	1.43
Al <sub>2</sub> O <sub>3</sub>	15.00	14.00	14.50	13.30	14.10	14.40	13.40	13.80	14.70	14.00	17.85	16.60
Fe <sub>2</sub> O <sub>3</sub>	0.38	0.43	0.56	0.16	0.79	0.51	1.19	0.77	0.95	0.51	1.09	2.13
FeO	1.35	0.90	1.10	0.85	1.20	1.00	-0.10	0.60	1.20	0.90	8.00	6.80
MnO	0.05	0.04	0.05	0.03	0.06	0.04	0.03	0.02	0.06	0.04	0.23	0.18
MgO	0.69	0.39	0.65	0.17	0.09	0.56	0.12	0.48	0.99	0.56	5.16	5.79
CaO	2.21	1.48	1.71	0.83	0.97	1.87	0.87	1.51	2.61	1.24	3.39	9.19
Na <sub>2</sub> O	4.13	3.75	3.98	3.96	4.05	3.96	3.89	3.76	3.71	3.80	1.47	3.57
K <sub>2</sub> O	3.57	4.51	4.07	4.61	5.07	4.11	4.69	4.44	3.72	4.32	3.53	0.93
P <sub>2</sub> O <sub>5</sub>	0.10	0.07	0.10	0.04	0.04	0.09	0.04	0.07	0.09	0.11	0.19	0.27
LOI	0.66	0.70	0.70	0.58	0.70	0.58	0.39	0.85	0.77	0.77	1.89	0.16
H <sub>2</sub> O	-	-	-	-	-	-	-	-	-	-	-	-
CO <sub>2</sub>	-	-	-	-	-	-	-	-	-	-	-	-
TTE	0.17	0.14	0.17	0.13	0.31	0.14	0.10	0.13	0.17	0.14	0.31	0.25
Total	99.88	99.52	98.83	99.72	100.17	98.59	100.27	99.97	99.39	99.90	98.51	99.70
Trace Elements												
Rb	177	185	173	243	231	200	213	171	162	200	134	28
Cs	11.2	7.0	10.9	8.1	7.5	8.3	7.0	5.2	5.5	8.8	9.6	1.5
Ba	522	378	466	416	1500	415	222	381	383	372	507	254
Sr	149	81	115	49	45	100	47	90	115	73	207	319
Ga	19	15	17	15	37	17	16	17	17	17	24	20
Li	40	56	84	36	30	10	40	18	36	-	43	50
Tl	2	<1	<1	<1	<1	<1	3	<1	<1	<1	<1	3
Ta	2.00	1.50	2.30	1.85	2.10	2.00	1.70	1.60	2.00	3.20	1.00	0.90
Nb	15	13	16	16	21	14	11	15	16	15	16	15
Hf	4.1	2.9	4.0	3.7	7.9	3.6	3.4	4.2	4.8	3.9	4.8	4.2
Zr	118	99	122	91	232	100	79	121	148	102	170	159
Y	27	30	33	39	78	27	29	32	45	39	32	34
Th	21.5	17.0	20.0	21.0	22.5	17.0	22.0	19.0	20.5	22.0	10.7	2.1
U	5.7	3.8	5.0	8.0	7.4	7.3	12.7	6.0	10.1	7.8	4.1	1.0
La	38	28	36	28	52	28	30	30	46	32	41	28
Ce	64	49	63	50	98	48	53	54	67	50	77	59
Pr	-	-	-	-	12.7	-	-	-	-	-	-	-
Nd	23.5	20.0	24.0	17.5	47.6	18.0	21.0	21.0	28.0	22.0	31.5	27.0
Sm	4.21	3.74	4.39	3.67	10.77	3.44	3.75	3.63	5.63	5.41	5.90	5.28
Eu	0.96	0.69	1.22	0.40	1.11	0.76	0.52	0.62	1.00	0.63	1.64	1.96
Gd	-	-	-	-	11.86	-	-	-	-	-	-	-
Tb	0.85	0.80	1.00	0.95	2.08	0.65	0.60	0.60	1.20	1.00	0.85	0.90
Dy	-	-	-	-	13.01	-	-	-	-	-	-	-
Ho	-	-	-	-	2.81	-	-	-	-	-	-	-
Er	-	-	-	-	7.37	-	-	-	-	-	-	-
Tm	-	-	-	-	1.04	-	-	-	-	-	-	-
Yb	2.56	3.09	3.28	4.04	7.00	2.46	3.07	2.58	4.07	4.56	3.22	3.11
Lu	0.42	0.46	0.48	0.63	1.04	0.40	0.50	0.42	0.61	0.66	0.49	0.47
Cr	11	5	7	1	11	10	<1	4	12	8	160	118
Ni	4	4	5	2	4	5	2	4	6	3	109	30
Co	4.0	2.8	3.6	1.5	1.4	3.5	1.5	3.3	5.8	4.2	36.3	34.0
Sc	5.8	4.7	6.0	4.4	7.3	5.4	4.1	4.7	7.7	7.2	27.3	33.0
V	24	18	24	5	7	21	7	19	37	22	213	220
Cu	1	2	1	1	2	1	2	2	8	4	63	24
Pb	19	24	20	19	20	24	24	12	16	14	24	8
Zn	27	18	24	10	41	22	16	15	31	22	130	99
Mn	385	300	360	240	450	345	270	130	450	280	1820	1394
Bi	0.2	0.1	<0.1	<0.1	7.4	1.0	0.5	0.2	0.4	0.4	0.3	<0.1
Cd	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	7.3	9.0	7.0	8.0	13.0	2.5	8.0	<0.5	<0.5	11.0	<0.5	<0.5
W	1.0	0.5	0.5	9.8	3.0	1.0	1.0	1.5	2.0	1.0	0.8	<0.5
Mo	<0.5	<0.5	<0.5	<0.5	<0.5	1.0	<0.5	<0.5	<0.5	<0.5	1.5	<0.5
F	360	330	360	180	540	240	150	230	420	300	1045	540
Cl	<25	<25	<25	<25	<25	<25	<25	50	<25	<25	<25	350
Br	<0.3	<0.3	<0.3	<0.3	0.6	<0.3	<0.3	1.8	0.9	<0.3	0.4	1.2
B	20	30	30	15	30	15	20	20	30	20	45	20
Be	5.5	5.0	5.0	6.5	9.0	6.5	7.0	6.0	8.0	6.0	5.5	4.0
Au	1	3	2	7	5	1	3	3	<0.3	6	3	3
Ge	<5	<5	<5	<5	<5	5	<5	<5	<5	<5	<5	<5
As	0.3	<0.2	1.0	<0.2	0.5	<0.2	<0.2	0.5	<0.2	1.0	19.8	<0.2
Se	<0.4	<0.4	<0.4	0.6	1.2	<0.4	2.3	2.7	<0.4	1.2	<0.4	<0.4
Sb	0.3	0.2	0.4	0.2	0.3	0.2	0.3	0.3	0.2	0.8	2.4	<0.1
206/204	-	-	-	-	18.399	-	-	-	-	-	-	-
207/204	-	-	-	-	15.670	-	-	-	-	-	-	-
208/204	-	-	-	-	38.294	-	-	-	-	-	-	-
DO18	-	-	-	-	8.7	-	-	-	-	-	-	-
E-Nd	-	-	-	-	-0.9	-	-	-	-	-	-	-
tDm	-	-	-	-	1.40	-	-	-	-	-	-	-
E-400	-	-	-	-	-1.1	-	-	-	-	-	-	-

APPENDIX 4 (cont'd.)

Pluton Unit MG or NB#	G12 91	G12 96	G12 99	G12 105	G12 238	G12 239	G12 241	G12 243	G12 244	G12 247	G12 251	G12 252
SiO <sub>2</sub>	45.60	53.60	49.50	42.05	54.30	51.20	53.90	49.90	47.30	47.90	51.40	56.30
TiO <sub>2</sub>	0.83	1.44	2.68	0.14	2.28	2.14	1.09	0.96	1.21	1.35	1.46	0.70
Al <sub>2</sub> O <sub>3</sub>	11.45	15.90	15.10	19.50	15.10	16.90	17.10	21.80	16.60	17.00	16.10	16.20
Fe <sub>2</sub> O <sub>3</sub>	1.84	1.84	0.76	1.65	2.85	3.10	1.99	1.72	1.94	2.64	2.37	1.23
FeO	8.65	6.60	11.10	4.70	6.70	8.10	5.20	3.50	7.70	6.20	7.05	5.10
MnO	0.19	0.15	0.24	0.09	0.14	0.21	0.14	0.13	0.21	0.16	0.19	0.19
MgO	19.35	5.64	4.39	14.80	3.34	3.85	4.84	4.03	8.76	7.79	5.60	6.46
CaO	7.18	8.25	7.33	10.25	7.31	7.66	8.26	11.90	11.60	11.30	9.56	8.42
Na <sub>2</sub> O	1.72	3.16	2.92	1.31	4.57	3.23	3.36	3.41	2.28	2.33	2.92	2.32
K <sub>2</sub> O	0.45	1.42	1.87	0.09	0.92	1.04	1.37	0.47	0.46	0.82	0.97	1.13
P <sub>2</sub> O <sub>5</sub>	0.11	0.16	0.39	0.03	0.93	0.57	0.15	0.10	0.11	0.14	0.20	0.17
LOI	0.54	1.23	0.93	3.96	0.77	0.47	1.35	1.08	0.93	1.23	0.70	1.31
H <sub>2</sub> O	-	-	-	-	-	-	-	-	-	-	-	-
CO <sub>2</sub>	-	-	-	-	-	-	-	-	-	-	-	-
TTE	0.26	0.16	0.43	0.16	0.29	0.25	0.17	0.17	0.53	0.31	0.35	0.25
Total	98.15	99.55	97.64	98.73	99.51	98.71	98.92	99.17	99.63	99.17	98.86	99.78
Trace Elements												
Rb	14	60	57	<5	33	33	53	12	10	42	35	50
Cs	1.0	3.2	2.2	0.4	3.6	1.5	2.7	0.4	1.1	3.6	3.3	2.1
Ba	53	150	1371	28	114	174	213	48	35	50	148	191
Sr	130	179	311	325	284	323	255	305	202	239	250	195
Ga	12	18	21	13	21	24	15	20	16	19	20	18
Li	9	26	6	1	8	18	16	20	9	8	14	15
Tl	<1	<1	<1	<1	<1	2	<1	<1	<1	<1	<1	3
Ta	<0.04	0.60	0.80	<0.04	0.90	<0.04	0.70	<0.04	<0.04	<0.04	0.50	0.50
Nb	4	8	10	1	13	9	8	4	3	5	10	7
Hf	1.8	4.0	6.0	0.2	3.4	2.5	3.6	1.9	2.3	2.2	3.7	2.9
Zr	73	133	313	21	102	94	120	66	79	88	120	71
Y	19	33	29	3	50	29	26	21	24	26	40	34
Th	1.6	5.7	5.2	0.3	6.1	4.0	5.7	1.8	0.5	1.4	4.1	6.0
U	0.5	2.2	1.6	0.1	1.8	1.2	2.0	0.6	0.5	0.4	1.0	1.9
La	7	18	21	3	36	19	20	8	5	9	21	20
Ce	16	35	40	5	72	36	36	18	15	22	47	44
Pr	2.1	-	-	-	-	-	-	-	-	-	-	-
Nd	9.3	18.0	21.0	2.0	39.0	19.0	17.0	10.0	10.0	12.0	22.5	22.0
Sm	2.44	4.16	4.61	0.38	7.99	4.20	3.72	2.39	2.59	2.88	4.89	4.52
Eu	0.82	1.59	4.74	0.38	2.67	1.97	1.30	1.42	1.25	1.36	1.68	1.41
Gd	2.84	-	-	-	-	-	-	-	-	-	-	-
Tb	0.48	0.90	0.60	0.10	1.30	0.70	0.75	0.50	0.60	0.50	0.95	0.80
Dy	3.07	-	-	-	-	-	-	-	-	-	-	-
Ho	0.67	-	-	-	-	-	-	-	-	-	-	-
Er	1.92	-	-	-	-	-	-	-	-	-	-	-
Tm	0.26	-	-	-	-	-	-	-	-	-	-	-
Yb	1.73	3.09	2.59	0.23	3.86	2.19	2.36	1.91	2.22	2.10	3.39	3.20
Lu	0.26	0.47	0.41	0.04	0.55	0.32	0.35	0.29	0.33	0.33	0.50	0.48
Cr	919	108	2	442	8	34	32	135	219	319	174	256
Ni	468	40	4	198	4	6	12	20	106	88	8	48
Co	77.0	32.5	26.5	66.5	17.0	26.5	29.0	20.0	48.5	43.0	32.0	25.0
Sc	24.9	29.6	49.1	5.3	33.6	28.0	27.7	25.9	40.8	38.0	40.7	38.8
V	149	224	288	27	182	263	175	176	250	232	269	124
Cu	40	23	4	99	3	10	16	6	43	72	10	6
Pb	6	8	8	5	<1	<1	10	<1	<1	<1	10	96
Zn	72	71	88	35	42	86	69	37	79	65	109	107
Mn	1471	1162	1859	660	1084	1626	1084	1007	1626	1239	1471	1471
Bi	0.5	<0.1	<0.1	<0.1	<0.1	0.4	<0.1	<0.1	<0.1	0.3	0.3	<0.1
Cd	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	1.5	5.0	<0.5	1.3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W	<0.5	<0.5	<0.5	<0.5	1.0	2.5	<0.5	<0.5	<0.5	1.0	<0.5	<0.5
Mo	<0.5	2.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	2.5	<0.5
F	180	270	420	30	1200	590	525	110	120	190	335	400
Cl	250	50	1200	275	600	650	25	600	4000	1500	1750	700
Br	2.5	<0.3	2.2	1.2	1.2	<0.3	0.9	0.9	1.2	3.2	3.0	1.6
B	10	20	20	5	40	20	20	30	30	30	20	20
Be	3.0	4.0	4.0	2.5	7.0	8.0	5.0	4.0	6.0	6.0	5.5	4.0
Au	1	<0.3	<0.3	1	<0.3	3	<0.3	<0.3	3	<0.3	3	2
Ge	5	10	10	5	<5	<5	5	<5	<5	<5	5	<5
As	1.5	<0.2	6.5	<0.2	3.0	0.5	0.5	2.0	1.5	5.0	2.3	16.5
Se	0.6	<0.4	<0.4	<0.4	6.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Sb	0.1	0.3	0.5	0.1	0.5	0.3	0.1	0.2	0.4	0.6	0.3	4.6
206/204	-	-	-	-	-	-	-	-	-	-	-	-
207/204	-	-	-	-	-	-	-	-	-	-	-	-
208/204	-	-	-	-	-	-	-	-	-	-	-	-
DO18	6.2	-	-	-	-	-	-	-	-	-	-	-
E-Nd	2.3	-	-	-	-	-	-	-	-	-	-	-
tDm	1.29	-	-	-	-	-	-	-	-	-	-	-
E-400	2.2	-	-	-	-	-	-	-	-	-	-	-

**APPENDIX 4 (cont'd.)**

Pluton Unit MG or NB#	G12 253	G12 256	G12 88
SiO <sub>2</sub>	43.50	43.00	63.60
TiO <sub>2</sub>	0.13	0.11	1.14
Al <sub>2</sub> O <sub>3</sub>	23.80	22.90	14.55
Fe <sub>2</sub> O <sub>3</sub>	1.28	1.44	2.32
FeO	2.90	3.40	4.05
MnO	0.06	0.06	0.09
MgO	10.90	11.20	1.31
CaO	12.60	12.00	3.99
Na <sub>2</sub> O	1.28	1.31	3.88
K <sub>2</sub> O	0.09	0.07	3.56
P <sub>2</sub> O <sub>5</sub>	0.03	0.02	0.38
LOI	3.23	4.47	0.35
H <sub>2</sub> O	-	-	-
CO <sub>2</sub>	-	-	-
TTE	0.13	0.13	0.37
Total	99.93	100.11	99.58

Trace Elements

Rb	<5	<5	110
Cs	0.2	0.6	3.7
Ba	3	12	461
Sr	406	340	152
Ga	14	13	21
Li	4	10	20
Tl	<1	<1	<1
Ta	<0.04	<0.04	1.85
Nb	1	<1	23
Hf	0.2	0.1	8.9
Zr	20	14	236
Y	2	2	59
Th	0.2	<0.2	15.3
U	<0.1	<0.1	4.4
La	2	1	53
Ce	3	3	104
Pr	0.4	-	-
Nd	1.6	3.0	47.5
Sm	0.38	0.23	9.72
Eu	0.29	0.37	2.29
Gd	0.38	-	-
Tb	0.06	0.10	1.70
Dy	0.37	-	-
Ho	0.07	-	-
Er	0.21	-	-
Tm	0.03	-	-
Yb	0.19	0.23	5.41
Lu	0.03	0.03	0.79
Cr	272	248	3
Ni	294	201	2
Co	41.0	39.5	11.1
Sc	4.4	5.8	20.8
V	18	23	102
Cu	11	84	3
Pb	4	<1	8
Zn	31	28	38
Mn	490	500	685
Bi	<0.1	<0.1	0.3
Cd	<0.5	<0.5	<0.5
Sn	<0.5	<0.5	0.5
W	<0.5	<0.5	1.0
Mo	<0.5	<0.5	1.0
F	40	20	1020
Cl	150	300	1150
Br	1.1	1.0	1.3
B	20	<5	10
Be	3.0	3.0	6.0
Au	1	4	4
Ge	<5	10	<5
As	<0.2	<0.2	0.3
Se	1.0	<0.4	<0.4
Sb	0.1	<0.1	0.2
206/204	-	-	-
207/204	-	-	-
208/204	-	-	-
DO18	6.6	-	-
E-Nd	1.2	-	-
tDm	1.05	-	-
E-400	1.1	-	-

APPENDIX 4 (cont'd.)

Pluton WKNB#	G12 100	G12 242	G12 255	G12 89	G12 108	G12 235	G12 76	G12 92	G12 245	G12 265	G12 273	G12 86
SiO <sub>2</sub>	52.30	67.00	64.10	63.40	61.30	65.90	61.65	70.70	63.00	68.20	62.60	74.80
TiO <sub>2</sub>	1.93	0.55	0.83	0.96	0.80	0.58	0.58	0.39	0.48	0.40	0.53	0.12
Al <sub>2</sub> O <sub>3</sub>	15.60	15.80	16.50	15.60	14.75	15.60	16.25	14.10	16.60	14.70	16.40	13.00
Fe <sub>2</sub> O <sub>3</sub>	2.43	1.22	1.03	2.58	2.54	2.25	1.31	2.23	1.62	1.61	1.59	0.50
FeO	6.90	2.00	3.90	2.90	5.50	2.30	5.15	1.10	3.60	2.10	4.60	0.40
MnO	0.16	0.05	0.09	0.07	0.24	0.07	0.26	0.05	0.18	0.10	0.23	0.03
MgO	5.08	1.17	2.52	1.27	0.57	0.50	0.05	0.27	0.02	0.07	0.01	0.05
CaO	8.34	2.77	2.81	3.75	2.55	2.34	2.55	0.99	2.01	1.09	2.39	1.12
Na <sub>2</sub> O	3.12	3.96	3.18	4.42	4.43	5.05	4.42	4.79	4.68	4.81	4.58	4.13
K <sub>2</sub> O	1.56	4.26	3.19	3.35	4.67	4.20	6.64	4.25	6.96	5.84	6.57	4.41
P <sub>2</sub> O <sub>5</sub>	0.27	0.10	0.11	0.23	0.16	0.09	0.07	0.06	0.05	0.04	0.06	0.02
LOI	1.35	0.62	1.31	0.54	0.85	0.31	0.12	0.39	0.08	0.47	0.16	0.39
TTE	0.25	0.28	0.33	0.28	0.52	0.33	0.33	0.26	0.24	0.38	0.28	0.16
Total	99.28	99.78	99.89	99.37	98.88	99.53	99.36	99.58	99.52	99.80	99.99	99.12
Trace Elements												
Rb	61	151	162	88	105	100	71	117	68	141	72	75
Cs	2.1	5.3	7.8	1.9	8.1	1.2	1.9	0.9	1.3	2.9	1.3	0.6
Ba	133	1371	475	530	2273	980	1548	709	738	263	1270	790
Sr	196	136	145	154	101	139	35	78	26	19	30	129
Ga	19	19	19	21	18	24	15	23	19	18	18	17
Li	12	40	34	1	8	8	12	4	10	2	8	<1
Tl	<1	5	7	<1	<1	<1	<1	3	<1	<1	<1	<1
Ta	1.1	1.1	1.4	1.6	1.3	1.1	0.8	1.3	0.5	1.3	0.8	1.8
Nb	15	12	16	24	27	18	14	25	13	30	12	14
Hf	4.8	7.7	6.1	9.8	17.8	17.0	24.0	13.5	28.5	63.0	21.0	4.3
Zr	186	234	198	322	771	570	1153	442	1270	2354	1031	115
Y	46	38	36	59	61	67	29	89	25	81	28	44
Th	6.0	15.0	17.0	14.0	8.8	11.0	5.2	17.5	3.7	13.0	3.7	24.5
U	2.0	6.8	3.5	6.9	1.9	4.1	3.0	6.4	2.5	6.2	1.9	9.8
La	23	54	43	46	33	39	12	75	15	43	21	55
Ce	50	81	75	87	72	76	29	132	33	91	40	81
Pr	-	-	-	-	-	-	3.9	-	-	-	-	-
Nd	26.5	30.0	30.0	40.5	37.0	38.0	18.4	63.0	17.0	48.0	21.0	34.0
Sm	5.74	5.15	5.80	8.10	8.31	8.28	4.50	11.70	3.85	10.50	4.54	6.05
Eu	1.87	1.38	1.48	2.17	5.74	2.38	6.75	1.96	4.95	1.31	6.75	0.77
Gd	-	-	-	-	-	-	4.59	-	-	-	-	-
Tb	1.05	0.90	0.80	1.45	1.40	1.60	0.78	2.20	0.70	1.90	0.88	1.20
Dy	-	-	-	-	-	-	5.05	-	-	-	-	-
Ho	-	-	-	-	-	-	1.18	-	-	-	-	-
Er	-	-	-	-	-	-	3.63	-	-	-	-	-
Tm	-	-	-	-	-	-	0.57	-	-	-	-	-
Yb	3.85	3.43	3.19	5.35	6.42	6.25	4.71	8.78	4.47	9.33	4.23	4.36
Lu	0.58	0.52	0.49	0.83	1.06	0.96	0.93	1.33	0.86	1.55	0.88	0.66
Cr	128	16	70	8	<1	4	<1	3	<1	<1	1	<1
Ni	26	5	25	4	1	3	1	4	2	2	1	3
Co	32.3	8.2	15.5	9.6	2.2	5.0	1.4	3.0	0.8	1.3	2.9	1.6
Sc	35.0	9.9	17.2	15.3	33.6	17.6	26.2	8.7	11.8	4.5	22.3	3.9
V	275	50	118	89	3	17	1	10	3	4	1	5
Cu	18	3	12	8	16	4	5	3	9	6	5	2
Pb	8	16	20	8	15	4	7	12	4	4	4	8
Zn	57	41	76	22	149	40	51	27	50	83	59	3
Mn	1278	410	690	560	1897	550	2014	390	1394	780	1781	260
Bi	<0.1	0.1	0.2	0.3	0.3	0.3	<0.1	0.5	<0.1	0.3	0.3	<0.1
Cd	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	<0.5	10.0	<0.5	<0.5	5.5	<0.5	1.0	12.0	<0.5	<0.5	<0.5	<0.5
W	<0.5	1.5	2.0	<0.5	4.0	<0.5	<0.5	1.0	0.5	1.0	<0.5	1.0
Mo	2.0	<0.5	2.0	6.5	4.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
F	540	390	530	630	690	520	185	460	80	450	90	130
Cl	600	<25	1100	600	725	600	25	250	<25	50	<25	<25
Br	0.6	<0.3	1.8	1.9	0.5	1.6	<0.3	<0.3	<0.3	<0.3	0.8	<0.3
B	15	20	30	20	15	20	10	30	20	20	20	20
Be	4.0	6.0	8.0	5.0	6.0	6.0	3.5	5.0	5.0	5.0	5.0	6.0
Au	<0.3	<0.3	2	<0.3	4.0	4.5	2.8	1.5	8.0	<0.3	<0.3	2.0
Ge	<5	<5	<5	5	5	<5	<5	<5	<5	<5	<5	<5
As	1.8	0.5	3.0	0.3	2.3	1.5	3.0	3.0	0.5	3.0	1.0	<0.2
Se	3.0	<0.4	<0.4	1.3	<0.4	<0.4	<0.4	2.0	<0.4	<0.4	2.8	<0.4
Sb	0.9	0.2	0.6	0.2	1.2	0.2	0.4	0.3	0.2	0.6	0.2	0.1
206/204	-	-	-	-	-	-	18.467	-	-	-	-	-
207/204	-	-	-	-	-	-	15.672	-	-	-	-	-
208/204	-	-	-	-	-	-	38.311	-	-	-	-	-
D180	-	-	-	-	-	-	7.4	-	-	-	-	-
E-Nd	-	-	-	-	-	-	-0.3	-	-	-	-	-
tDM	-	-	-	-	-	-	1.53	-	-	-	-	-
E-400	-	-	-	-	-	-	-0.4	-	-	-	-	-

APPENDIX 4 (cont'd.)

Pluton WXNB#	G12 87	G12 103	G12 234	G12 78	G12 85	G12 90	G12 101	G12 102	G12 107	G12 236	G12 237	G12 254
SiO <sub>2</sub>	66.30	73.30	73.70	73.70	71.50	72.10	71.50	76.00	72.40	70.50	72.90	72.80
TiO <sub>2</sub>	0.65	0.27	0.17	0.25	0.25	0.27	0.32	0.11	0.22	0.37	0.25	0.27
Al <sub>2</sub> O <sub>3</sub>	15.30	13.30	13.35	13.70	14.50	13.80	13.70	12.20	14.00	14.40	13.20	13.40
Fe <sub>2</sub> O <sub>3</sub>	2.45	1.25	0.81	1.16	0.91	1.11	1.23	1.30	1.38	1.72	1.29	1.65
FeO	1.30	0.80	0.60	0.50	1.30	0.70	1.20	0.20	0.80	1.30	0.90	0.90
MnO	0.03	0.02	0.02	0.03	0.03	0.03	0.04	0.02	0.05	0.05	0.05	0.02
MgO	1.03	0.24	0.14	0.18	0.21	0.18	0.39	<0.01	0.16	0.25	0.21	0.47
CaO	1.43	0.66	1.00	0.63	1.34	1.22	1.21	0.30	0.31	1.76	0.86	0.93
Na <sub>2</sub> O	5.63	3.89	3.98	4.45	4.40	4.18	3.72	4.18	4.13	4.80	4.08	3.96
K <sub>2</sub> O	4.27	5.26	4.94	4.89	4.57	4.86	5.03	4.66	5.82	4.37	4.83	4.59
P <sub>2</sub> O <sub>5</sub>	0.16	0.04	0.03	0.04	0.09	0.05	0.08	0.02	0.03	0.06	0.05	0.05
LOI	0.77	0.85	0.39	0.39	0.47	0.31	0.77	0.93	0.85	0.31	0.47	0.85
TTE	0.29	0.23	0.19	0.20	0.27	0.17	0.20	0.24	0.17	0.24	0.20	0.18
Total	99.61	100.12	99.32	100.13	99.83	98.99	99.38	100.16	100.33	100.13	99.28	100.08
Trace Elements												
Rb	87	198	78	182	154	141	181	239	131	129	157	148
Cs	0.3	1.1	0.8	0.8	1.0	1.3	2.7	1.8	1.9	0.9	2.4	2.9
Ba	726	611	1126	426	629	478	614	100	404	538	322	271
Sr	105	59	143	45	103	81	61	9	30	89	32	43
Ga	23	17	15	18	20	19	20	20	20	18	19	18
Li	6	<1	4	66	4	<1	2	<1	<1	16	6	20
Tl	<1	<1	<1	6	<1	<1	<1	<1	<1	<1	<1	<1
Ta	1.3	2.0	1.2	1.4	1.4	1.5	1.1	3.1	0.8	1.0	1.2	1.5
Nb	22	23	14	20	18	22	21	41	17	23	23	21
Hf	13.5	9.3	5.2	8.0	7.4	8.0	8.6	10.2	12.5	11.0	9.7	8.0
Zr	561	298	164	232	245	237	278	205	445	313	244	202
Y	82	78	42	67	49	75	61	138	49	77	69	50
Th	14.0	25.0	24.5	19.5	17.0	23.5	17.5	26.0	14.0	20.0	16.5	17.5
U	5.4	7.3	10.8	6.7	5.2	6.8	4.7	8.6	2.3	5.1	3.7	7.0
La	52	72	42	72	58	59	61	110	72	64	79	55
Ce	104	121	76	99	105	103	121	138	146	116	132	102
Pr	-	-	-	-	-	-	-	-	16.3	-	-	-
Nd	47.0	52.0	28.5	46.0	46.0	44.0	47.0	71.0	61.3	48.0	57.0	43.0
Sm	9.61	10.10	4.97	8.89	8.63	8.20	8.79	15.90	10.79	8.90	10.80	8.25
Eu	1.95	1.00	0.70	0.60	1.35	1.14	1.31	0.44	0.95	1.62	0.77	0.88
Gd	-	-	-	-	-	-	-	-	9.50	-	-	-
Tb	1.90	2.00	1.00	1.80	1.30	1.90	1.80	3.20	1.39	1.70	2.00	1.40
Dy	-	-	-	-	-	-	-	-	8.38	-	-	-
Ho	-	-	-	-	-	-	-	-	1.75	-	-	-
Er	-	-	-	-	-	-	-	-	4.72	-	-	-
Tm	-	-	-	-	-	-	-	-	0.69	-	-	-
Yb	8.20	7.44	3.67	6.46	4.39	7.08	5.77	11.10	4.66	6.61	6.16	4.94
Lu	1.25	1.10	0.56	0.94	0.68	1.09	0.86	1.65	0.71	1.01	0.88	0.73
Cr	2	3	1	<1	2	<1	7	7	2	<1	2	10
Ni	3	2	2	2	2	3	4	2	3	2	2	5
Co	2.9	1.9	2.1	2.6	2.6	2.8	3.7	0.9	1.0	3.2	2.0	4.5
Sc	9.9	4.8	4.3	5.2	8.2	5.1	5.9	0.9	2.4	8.9	3.7	5.0
V	39	10	7	9	12	11	23	5	7	11	10	19
Cu	5	4	2	7	9	4	3	2	11	3	13	36
Pb	8	24	4	8	12	12	20	20	28	8	20	8
Zn	21	46	9	15	9	19	22	38	51	29	68	18
Mn	250	190	140	240	260	220	280	140	420	400	370	180
Bi	0.5	0.3	0.3	1.9	0.4	0.5	0.3	0.3	<0.1	0.3	<0.1	<0.1
Cd	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	3.0	7.0	8.3	20.0	7.0	<0.5	<0.5	7.0	<0.5	6.0	11.0	<0.5
W	<0.5	4.0	2.8	4.0	1.0	1.5	2.5	4.0	4.0	1.0	3.5	2.5
Mo	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	3.0	<0.5	<0.5	<0.5	5.0
F	720	620	110	610	900	210	350	1200	160	650	480	390
Cl	250	<25	<25	<25	250	150	<25	<25	<25	200	150	300
Br	1.0	1.2	0.6	1.2	1.2	0.9	<0.3	<0.3	0.9	0.9	0.6	1.5
B	20	30	5	30	20	30	30	30	30	20	20	20
Be	5.0	5.0	6.5	5.0	6.0	6.0	5.0	7.0	4.0	7.0	6.0	6.0
Au	4.5	<0.3	1.5	2.0	<0.3	1.0	<0.3	1.5	1.5	<0.3	1.0	5.0
Ge	<5	<5	5	<5	<5	<5	<5	10	<5	<5	<5	<5
As	2.0	3.5	1.5	2.0	1.0	1.5	0.5	7.0	3.0	2.0	2.0	23.5
Se	1.6	<0.4	<0.4	<0.4	<0.4	1.7	<0.4	3.5	<0.4	<0.4	2.9	<0.4
Sb	0.2	0.5	0.2	0.3	0.2	0.4	0.2	0.6	1.0	0.2	1.1	0.5
206/204	-	-	-	-	-	-	-	-	18.574	-	-	-
207/204	-	-	-	-	-	-	-	-	15.696	-	-	-
208/204	-	-	-	-	-	-	-	-	38.415	-	-	-
D18O	-	-	-	-	-	-	-	-	8.8	-	-	-
E-Nd	-	-	-	-	-	-	-	-	-0.6	-	-	-
tDM	-	-	-	-	-	-	-	-	1.10	-	-	-
E-400	-	-	-	-	-	-	-	-	-0.7	-	-	-

APPENDIX 4 (cont'd.)

Pluton WXNB#	G12 259	G12 262	G12 283	G12 284	G12 285	G12 291	G13 115	G13 116	G13 117	G13 326	G14 119	G14 142
SiO <sub>2</sub>	66.60	73.10	70.80	76.60	75.90	67.80	71.10	70.80	70.95	71.50	54.40	58.20
TiO <sub>2</sub>	0.62	0.21	0.34	0.14	0.18	0.46	0.30	0.32	0.33	0.32	0.85	1.12
Al <sub>2</sub> O <sub>3</sub>	15.50	12.10	14.40	12.30	12.20	14.10	14.35	14.40	14.40	14.40	17.25	16.30
Fe <sub>2</sub> O <sub>3</sub>	1.59	1.38	0.94	1.02	1.20	3.57	0.79	0.59	0.85	0.71	1.71	2.02
FeO	2.10	0.70	1.60	0.30	0.40	1.70	1.10	1.40	1.25	1.30	4.20	4.40
MnO	0.05	0.03	0.05	0.03	0.03	0.12	0.05	0.07	0.05	0.04	0.10	0.11
MgO	0.79	0.26	0.42	0.04	0.05	0.41	0.79	0.70	0.75	0.69	5.42	3.45
CaO	2.29	0.58	0.84	0.46	0.43	1.15	1.91	1.72	1.81	1.75	8.70	6.33
Na <sub>2</sub> O	4.69	4.05	3.92	3.85	3.74	5.33	4.00	3.87	3.84	3.92	3.16	3.65
K <sub>2</sub> O	3.94	5.04	5.12	4.82	4.84	3.70	4.08	4.09	4.32	4.42	1.43	2.09
P <sub>2</sub> O <sub>5</sub>	0.15	0.04	0.10	0.02	0.03	0.05	0.09	0.10	0.10	0.09	0.12	0.18
LOI	0.77	0.62	1.08	0.54	0.70	0.85	0.77	0.77	0.66	0.54	1.54	0.77
TTE	0.29	0.15	0.23	0.23	0.19	0.23	0.16	0.16	0.17	0.17	0.18	0.22
Total	99.38	98.26	99.84	100.34	99.88	99.48	99.49	99.00	99.48	99.85	99.06	98.84
Trace Elements												
Rb	119	180	158	206	158	121	185	164	186	202	52	72
Cs	1.8	1.9	1.2	3.5	2.1	0.7	7.7	6.2	5.9	9.0	3.0	2.5
Ba	665	183	562	467	784	883	446	366	292	341	181	367
Sr	200	20	121	26	45	174	91	77	91	68	408	324
Ga	20	19	19	15	17	22	18	17	18	18	17	18
Li	8	10	4	8	2	6	40	36	40	-	18	9
Tl	<1	4	<1	4	<1	3	<1	<1	<1	<1	<1	<1
Ta	1.4	1.4	1.0	1.8	1.6	1.2	1.8	1.0	1.6	2.5	0.7	1.1
Nb	20	23	19	23	22	21	14	14	15	17	7	13
Hf	10.5	10.5	8.1	6.0	6.7	9.1	4.0	4.9	4.9	4.8	3.0	5.1
Zr	314	254	226	146	198	296	110	128	123	137	99	169
Y	60	79	61	75	70	73	37	40	42	62	18	29
Th	22.5	21.0	23.0	19.5	14.5	15.0	18.8	21.0	18.8	22.0	7.5	7.9
U	6.2	6.2	4.9	4.3	3.0	4.4	7.2	5.5	6.3	8.9	2.0	2.4
La	61	75	66	63	84	52	32	36	33	34	22	39
Ce	113	126	117	102	121	98	57	66	62	59	39	76
Pr	-	-	-	-	-	-	-	-	-	8.2	-	-
Nd	51.0	58.0	51.0	49.0	55.0	45.5	24.5	28.0	27.0	31.5	16.0	31.0
Sm	9.52	11.70	9.85	10.10	11.10	9.29	4.75	5.49	5.45	7.50	3.04	5.40
Eu	1.54	0.69	1.38	1.11	1.61	2.96	0.73	0.78	0.84	0.78	1.10	1.89
Gd	-	-	-	-	-	-	-	-	-	8.29	-	-
Tb	1.60	1.90	1.90	2.00	1.90	1.75	1.00	1.10	1.15	1.54	0.55	0.90
Dy	-	-	-	-	-	-	-	-	-	9.79	-	-
Ho	-	-	-	-	-	-	-	-	-	2.12	-	-
Er	-	-	-	-	-	-	-	-	-	5.63	-	-
Tm	-	-	-	-	-	-	-	-	-	0.80	-	-
Yb	5.57	6.77	5.51	6.87	5.80	6.34	3.65	3.46	3.98	5.18	1.70	2.62
Lu	0.81	1.00	0.81	1.00	0.84	0.96	0.56	0.51	0.61	0.74	0.26	0.38
Cr	10	3	5	5	1	<1	9	2	6	14	179	33
Ni	3	2	3	2	2	2	4	2	3	4	44	11
Co	5.9	1.8	3.0	1.0	0.7	1.0	4.4	4.8	4.3	5.9	26.5	22.0
Sc	15.2	2.9	15.3	5.6	6.9	17.6	7.9	7.8	7.8	8.8	24.6	22.5
V	51	6	23	4	4	3	30	29	30	33	161	168
Cu	1	2	2	3	3	1	5	5	5	7	18	21
Pb	4	4	12	24	8	14	19	28	19	18	6	8
Zn	20	30	33	40	31	80	26	39	33	36	54	62
Mn	360	210	400	220	230	945	350	550	395	340	795	860
Bi	0.3	0.2	0.2	<0.1	0.3	<0.1	<0.1	<0.1	0.5	0.3	<0.1	0.3
Cd	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	<0.5	3.0	3.0	5.0	2.0	7.5	7.3	5.0	10.0	9.5	<0.5	<0.5
W	<0.5	0.5	2.5	2.5	0.5	0.8	<0.5	<0.5	0.5	2.0	0.5	<0.5
Mo	<0.5	<0.5	<0.5	<0.5	<0.5	1.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
F	1100	220	680	770	240	320	410	480	555	540	355	630
Cl	<25	100	50	150	<25	50	<25	<25	<25	<25	<25	<25
Br	<0.3	0.7	0.8	0.7	<0.3	1.1	<0.3	<0.3	0.4	<0.3	<0.3	0.6
B	20	30	20	30	20	35	10	20	10	20	15	20
Be	8.0	8.0	6.0	5.0	5.0	6.0	5.5	5.0	5.5	6.0	3.5	4.0
Au	<0.3	1.0	3.5	6.5	1.5	0.5	1.5	<0.3	4.0	<0.3	2.8	<0.3
Ge	<5	<5	10	10	10	<5	<5	<5	<5	<5	<5	<5
As	1.0	2.0	1.0	4.5	2.0	2.8	0.3	<0.2	0.8	1.0	0.5	<0.2
Se	2.6	1.7	3.5	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Sb	0.3	0.4	0.2	0.6	0.3	0.6	0.3	0.2	0.2	0.7	0.1	0.1
206/204	-	-	-	-	-	-	-	-	-	-	-	-
207/204	-	-	-	-	-	-	-	-	-	-	-	-
208/204	-	-	-	-	-	-	-	-	-	-	-	-
D180	-	-	-	-	-	-	-	-	-	8.1	-	-
E-Nd	-	-	-	-	-	-	-	-	-	-1.9	-	-
tDM	-	-	-	-	-	-	-	-	-	1.62	-	-
E-400	-	-	-	-	-	-	-	-	-	-2.0	-	-

APPENDIX 4 (cont'd.)

Pluton WZNB#	G14 143	G14 308	G14 310	G14 109	G14 112	G14 113	G14 149	G14 266	G14 300	G14 318	G14 319	G14 114
SiO <sub>2</sub>	60.30	54.50	52.90	66.60	67.20	70.30	60.80	65.80	68.10	66.00	62.00	70.25
TiO <sub>2</sub>	1.09	1.15	1.49	0.79	0.81	0.53	1.05	0.89	0.56	0.77	1.22	0.47
Al <sub>2</sub> O <sub>3</sub>	16.40	17.10	17.20	14.60	14.50	13.90	16.70	15.20	15.40	15.70	16.40	14.75
Fe <sub>2</sub> O <sub>3</sub>	2.15	2.51	2.93	0.64	0.71	0.67	1.85	0.95	1.58	1.29	2.27	0.53
FeO	3.50	4.50	5.20	3.90	3.80	2.55	4.30	3.50	1.80	3.20	4.00	1.75
MnO	0.10	0.10	0.11	0.08	0.11	0.07	0.10	0.19	0.05	0.09	0.11	0.03
MgO	2.85	4.83	4.77	1.63	1.54	0.68	2.25	1.38	0.92	1.65	2.23	0.65
CaO	6.03	8.33	8.05	2.77	2.87	1.93	3.91	2.64	2.14	3.16	4.59	1.90
Na <sub>2</sub> O	3.37	3.18	3.39	3.21	3.42	3.73	3.67	3.44	3.93	3.75	3.46	3.93
K <sub>2</sub> O	2.29	1.81	1.88	3.59	3.32	3.95	3.01	3.77	3.91	2.91	2.05	4.06
P <sub>2</sub> O <sub>5</sub>	0.21	0.22	0.32	0.16	0.19	0.12	0.26	0.26	0.27	0.21	0.30	0.12
LOI	0.62	1.08	1.00	0.70	0.62	0.47	0.77	0.93	0.77	0.70	0.62	0.85
TTE	0.22	0.19	0.25	0.22	0.25	0.23	0.29	0.61	0.23	0.22	0.22	0.33
Total	99.14	99.50	99.50	98.89	99.33	99.13	98.97	99.55	99.66	99.65	99.48	99.62
Trace Elements												
Rb	67	59	56	141	147	157	119	232	142	130	93	118
Cs	1.9	2.7	2.6	5.3	5.3	5.1	4.3	13.3	5.9	8.0	5.3	3.9
Ba	383	259	348	487	466	579	662	628	616	453	325	1592
Sr	473	488	555	177	200	159	319	200	174	248	366	255
Ga	21	20	20	19	20	17	23	21	19	20	20	17
Li	16	-	-	26	24	24	20	110	-	-	-	10
Tl	2	<1	<1	<1	6	<1	<1	<1	<1	<1	<1	<1
Ta	1.2	0.8	1.0	1.6	1.3	1.0	0.8	1.8	1.9	1.6	2.4	0.7
Nb	14	11	16	16	16	18	12	21	20	10	19	9
Hf	5.4	3.8	4.7	5.5	6.3	7.5	7.4	4.9	7.5	5.7	7.2	7.4
Zr	203	142	179	186	184	229	241	176	259	182	219	228
Y	33	27	34	38	27	35	28	53	32	23	35	18
Th	8.1	6.0	6.3	12.5	8.9	18.0	4.7	11.5	16.0	13.0	9.0	7.9
U	2.3	2.5	1.5	6.8	1.6	3.2	1.9	3.6	6.5	3.7	6.5	1.8
La	40	35	52	37	42	57	32	43	43	48	41	92
Ce	74	70	98	78	79	97	58	82	78	71	69	144
Pr	-	-	-	8.9	-	-	-	-	-	-	-	-
Nd	32.0	27.0	43.0	34.1	31.0	40.5	26.0	35.0	31.0	33.0	38.0	40.5
Sm	6.16	5.00	8.72	6.80	5.52	7.46	4.74	6.29	7.09	6.26	7.71	5.26
Eu	1.92	1.37	2.13	1.37	1.56	1.64	1.72	1.67	1.53	1.44	1.83	2.30
Gd	-	-	-	6.47	-	-	-	-	-	-	-	-
Tb	0.95	0.70	1.10	1.04	0.80	1.15	0.80	1.20	1.00	0.90	1.10	0.70
Dy	-	-	-	6.41	-	-	-	-	-	-	-	-
Ho	-	-	-	1.34	-	-	-	-	-	-	-	-
Er	-	-	-	3.52	-	-	-	-	-	-	-	-
Tm	-	-	-	0.50	-	-	-	-	-	-	-	-
Yb	3.20	2.82	3.50	3.34	2.21	2.85	2.40	5.18	3.56	1.36	4.40	2.60
Lu	0.47	0.42	0.52	0.48	0.31	0.41	0.35	0.80	0.53	0.23	0.74	0.39
Cr	30	68	20	21	13	3	22	11	5	17	15	3
Ni	25	22	21	7	6	3	11	7	3	6	6	3
Co	18.0	26.0	29.0	10.5	11.5	4.7	16.0	8.5	6.8	12.0	16.0	4.0
Sc	18.9	26.3	28.7	13.9	15.0	11.0	15.7	27.2	10.9	14.5	22.5	8.0
V	131	188	216	100	107	35	124	98	41	99	142	33
Cu	15	20	22	12	11	2	14	3	3	13	24	1
Pb	9	6	2	20	20	14	12	12	16	8	6	14
Zn	61	60	80	49	60	47	85	128	40	61	78	26
Mn	760	770	860	650	860	545	810	1471	410	680	870	255
Bi	<0.1	0.3	0.1	0.3	0.3	<0.1	<0.1	1.5	0.4	0.3	<0.1	<0.1
Cd	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	6.3	2.5	4.5	4.0	4.0	3.0	5.0	6.0	3.0	8.0	1.0	2.0
W	1.5	<0.5	2.0	<0.5	<0.5	<0.5	1.0	<0.5	2.0	1.0	1.0	<0.5
Mo	<0.5	<0.5	<0.5	<0.5	<0.5	1.0	<0.5	2.0	<0.5	<0.5	<0.5	<0.5
F	520	360	680	700	930	705	1000	4100	690	670	610	615
Cl	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Br	<0.3	<0.3	0.7	<0.3	<0.3	<0.3	1.2	<0.3	<0.3	<0.3	3.1	0.4
B	10	<5	<5	20	20	10	30	20	20	20	10	10
Be	4.0	4.0	4.0	5.0	4.0	3.5	5.0	5.0	2.0	3.0	5.0	3.5
Au	0.8	<0.3	<0.3	<0.3	<0.3	4.5	1.5	<0.3	<0.3	<0.3	3.0	3.5
Ge	<5	<5	<5	<5	<5	5	<5	<5	<5	<5	<5	<5
As	1.0	1.0	<0.2	0.5	0.5	0.5	2.5	<0.2	1.0	1.0	<0.2	<0.2
Se	0.8	<0.4	<0.4	<0.4	<0.4	2.0	<0.4	<0.4	<0.4	1.9	<0.4	0.6
Sb	0.2	0.4	<0.1	0.2	0.2	0.1	0.3	0.2	0.5	2.2	0.3	0.1
206/204	-	-	-	-	-	-	-	-	-	-	-	-
207/204	-	-	-	-	-	-	-	-	-	-	-	-
208/204	-	-	-	-	-	-	-	-	-	-	-	-
D180	-	-	-	7.7	-	-	-	-	-	-	-	-
E-Nd	-	-	-	-3.0	-	-	-	-	-	-	-	-
tDM	-	-	-	1.41	-	-	-	-	-	-	-	-
E-400	-	-	-	-3.2	-	-	-	-	-	-	-	-

APPENDIX 4 (cont'd.)

Pluton WXNB#	G14 118	G14 121	G14 123	G14 139	G14 289	G14 301	G14 316	G14 106	G14 110	G14 120	G14 302	G14 307
SiO <sub>2</sub>	69.60	66.65	67.50	73.45	70.90	70.60	68.40	76.10	75.80	72.30	70.80	76.60
TiO <sub>2</sub>	0.55	0.78	0.67	0.28	0.53	0.42	0.66	0.14	0.18	0.29	0.34	0.09
Al <sub>2</sub> O <sub>3</sub>	14.30	15.20	14.95	13.40	14.70	14.60	15.20	12.40	12.90	13.70	15.00	12.90
Fe <sub>2</sub> O <sub>3</sub>	1.13	1.37	1.47	0.62	0.48	0.93	1.34	0.43	0.22	0.62	0.84	0.24
FeO	1.90	2.65	2.10	0.95	2.00	1.40	2.10	0.40	0.80	1.00	1.30	0.20
MnO	0.06	0.07	0.06	0.05	0.04	0.05	0.05	0.03	0.01	0.05	0.05	0.02
MgO	0.87	1.31	1.12	0.43	0.71	0.73	1.05	0.07	0.14	0.50	0.89	0.04
CaO	2.32	2.83	2.80	1.44	2.38	1.87	3.05	0.51	0.59	1.56	1.76	0.35
Na <sub>2</sub> O	3.59	4.23	3.78	3.57	4.04	3.68	4.04	3.60	3.56	3.55	3.80	4.28
K <sub>2</sub> O	3.81	3.14	3.76	4.43	3.18	4.46	3.01	5.06	4.99	4.58	3.59	4.56
P <sub>2</sub> O <sub>5</sub>	0.13	0.18	0.15	0.07	0.10	0.10	0.15	0.02	0.06	0.08	0.14	0.02
LOI	0.62	0.47	0.62	0.50	0.77	0.85	0.47	0.31	0.62	0.70	1.23	0.54
TTE	0.29	0.21	0.33	0.18	0.26	0.22	0.29	0.12	0.11	0.18	0.18	0.08
Total	99.17	99.10	99.31	99.37	100.09	99.91	99.80	99.19	99.98	99.11	99.92	99.92
Trace Elements												
Rb	138	93	115	198	121	156	109	174	159	234	128	283
Cs	4.5	2.6	2.6	11.2	3.4	4.9	3.6	3.2	2.1	9.7	4.9	10.3
Ba	1000	673	1377	431	965	709	991	175	206	442	489	16
Sr	200	183	256	94	247	128	274	35	40	96	178	9
Ga	16	19	18	16	17	18	17	14	14	16	20	15
Li	18	18	22	47	20	-	-	20	10	48	-	-
Tl	<1	<1	1	<1	<1	<1	<1	4	<1	<1	<1	<1
Ta	1.0	0.7	0.9	2.0	0.6	1.4	0.7	1.5	1.5	1.4	1.9	3.4
Nb	16	16	15	16	14	15	12	16	18	16	15	23
Hf	8.5	8.8	9.4	4.4	7.7	5.6	8.9	3.8	5.1	4.8	4.4	3.1
Zr	239	297	273	113	218	144	261	93	124	135	153	44
Y	34	28	30	30	34	35	21	49	70	32	31	66
Th	18.0	11.2	14.0	15.5	15.0	17.0	12.0	22.0	29.0	20.5	15.0	35.0
U	3.2	1.4	2.7	4.3	4.1	4.5	3.9	4.0	6.8	5.8	4.9	14.3
La	95	40	95	33	71	45	77	61	61	42	37	18
Ce	155	74	152	69	121	77	111	90	111	75	63	35
Pr	-	-	-	7.6	-	-	-	-	-	-	-	-
Nd	53.0	34.0	54.0	28.1	44.0	30.0	43.0	43.0	46.0	30.0	23.0	18.0
Sm	8.02	6.67	8.15	5.65	6.95	6.55	7.00	8.58	8.92	5.49	5.25	6.41
Eu	2.24	1.49	2.38	0.79	1.84	1.10	2.18	0.66	0.61	0.87	0.84	0.25
Gd	-	-	-	4.76	-	-	-	-	-	-	-	-
Tb	1.20	0.95	1.00	0.80	1.00	1.00	0.90	1.60	1.90	1.00	0.70	1.70
Dy	-	-	-	4.63	-	-	-	-	-	-	-	-
Ho	-	-	-	0.96	-	-	-	-	-	-	-	-
Er	-	-	-	2.63	-	-	-	-	-	-	-	-
Tm	-	-	-	0.39	-	-	-	-	-	-	-	-
Yb	3.20	2.38	2.94	2.63	3.55	3.22	2.55	4.34	7.00	3.29	2.75	8.21
Lu	0.43	0.34	0.42	0.40	0.53	0.51	0.41	0.61	1.05	0.48	0.43	1.28
Cr	7	10	8	8	6	8	9	1	1	7	8	<1
Ni	3	5	4	4	3	3	4	3	<1	3	3	1
Co	6.8	8.8	7.2	3.7	4.5	4.8	9.0	1.2	1.8	3.6	4.4	0.7
Sc	10.4	11.9	13.1	6.7	9.9	8.4	11.9	5.7	7.9	5.9	6.6	5.3
V	52	70	61	20	43	39	60	6	8	25	34	1
Cu	10	12	7	2	2	8	4	3	12	3	2	<1
Pb	20	17	13	24	20	18	8	24	32	32	16	20
Zn	40	57	44	25	24	33	45	12	4	23	39	8
Mn	500	520	440	365	320	370	390	220	100	390	400	170
Bi	<0.1	<0.1	0.8	0.3	0.3	0.2	0.8	<0.1	1.0	1.2	<0.1	0.3
Cd	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	<0.5	2.3	0.8	4.5	<0.5	5.0	3.0	<0.5	<0.5	28.0	4.5	6.0
W	<0.5	<0.5	0.8	0.5	<0.5	1.0	1.0	<0.5	<0.5	<0.5	1.0	1.0
Mo	<0.5	1.0	<0.5	1.0	<0.5	<0.5	<0.5	<0.5	4.0	<0.5	<0.5	<0.5
F	760	435	725	515	600	640	740	340	100	480	546	110
Cl	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Br	<0.3	<0.3	0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
B	20	15	5	25	20	20	20	30	30	20	30	20
Be	4.0	3.0	4.0	5.5	4.0	4.0	3.0	4.0	4.0	4.0	5.0	5.0
Au	1.5	<0.3	0.8	5.0	<0.3	43.0	<0.3	5.0	1.0	<0.3	<0.3	<0.3
Ge	<5	<5	<5	<5	10	<5	<5	<5	<5	<5	<5	<5
As	<0.2	0.3	<0.2	0.8	1.0	5.0	1.0	0.5	0.5	0.5	2.0	1.0
Se	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Sb	0.2	0.1	<0.1	0.3	0.1	0.3	0.3	0.2	0.1	1.3	0.5	1.0
206/204	-	-	-	18.539	-	-	-	-	-	-	-	-
207/204	-	-	-	15.665	-	-	-	-	-	-	-	-
208/204	-	-	-	38.250	-	-	-	-	-	-	-	-
D180	-	-	-	8.2	-	-	-	-	-	-	-	-
E-Nd	-	-	-	-2.5	-	-	-	-	-	-	-	-
tDM	-	-	-	1.36	-	-	-	-	-	-	-	-
E-400	-	-	-	-2.7	-	-	-	-	-	-	-	-

APPENDIX 4 (cont'd.)

Pluton WKNB#	G14 309	G14 313	G14 122	G14 124	G14 132	G14 145	G14 146	G14 314	G14 136	G14 137	G14 320	G14 321
SiO <sub>2</sub>	70.90	70.70	73.60	73.40	70.90	72.15	73.10	73.90	73.45	69.15	73.10	73.50
TiO <sub>2</sub>	0.45	0.37	0.18	0.17	0.31	0.25	0.25	0.21	0.27	0.36	0.25	0.22
Al <sub>2</sub> O <sub>3</sub>	14.30	14.70	14.05	13.80	14.20	14.10	14.30	13.80	13.55	14.75	13.90	14.00
Fe <sub>2</sub> O <sub>3</sub>	0.79	0.73	0.51	0.43	0.73	0.59	0.33	0.42	0.73	0.90	0.46	0.57
FeO	1.70	1.40	0.75	0.70	1.40	1.10	1.20	0.80	0.80	1.55	1.00	0.70
MnO	0.05	0.05	0.04	0.03	0.05	0.04	0.04	0.03	0.04	0.06	0.04	0.04
MgO	0.81	0.99	0.36	0.26	0.89	0.51	0.54	0.29	0.41	1.25	0.52	0.41
CaO	1.98	2.14	1.07	0.83	1.96	1.06	0.97	1.03	1.23	2.88	1.43	1.21
Na <sub>2</sub> O	3.68	3.74	3.86	3.48	3.60	3.57	3.53	3.52	3.34	3.83	3.58	3.54
K <sub>2</sub> O	4.03	4.17	4.67	5.29	4.37	4.95	4.87	4.87	4.84	3.39	4.40	4.66
P <sub>2</sub> O <sub>5</sub>	0.12	0.11	0.11	0.12	0.08	0.12	0.11	0.08	0.08	0.10	0.09	0.08
LOI	0.70	0.62	0.77	0.54	0.70	0.81	0.81	0.39	0.70	0.81	0.77	0.70
TTE	0.16	0.18	0.16	0.13	0.18	0.17	0.15	0.15	0.18	0.17	0.15	0.14
Total	99.67	99.90	100.14	99.19	99.37	99.43	100.21	99.49	99.60	99.20	99.69	99.77
Trace Elements												
Rb	171	176	230	230	208	228	229	233	217	136	218	222
Cs	5.9	6.2	8.2	7.0	13.1	7.0	7.4	5.8	9.2	4.6	15.8	11.3
Ba	485	486	350	289	386	385	366	416	449	423	443	431
Sr	116	117	67	54	91	89	70	60	99	174	93	97
Ga	17	16	18	16	18	19	17	16	18	16	14	16
Li	-	-	40	30	38	36	24	-	46	36	-	-
Tl	5	<1	<1	2	2	1	<1	<1	3	2	<1	<1
Ta	1.5	1.9	2.4	1.9	2.6	2.1	2.1	2.0	1.6	1.8	2.8	3.2
Nb	16	15	15	15	16	18	17	17	15	12	15	14
Hf	5.3	4.7	3.1	2.8	4.3	3.7	3.9	3.7	3.8	4.2	3.6	3.4
Zr	150	150	91	77	125	123	118	113	114	145	115	106
Y	33	36	30	30	38	38	38	32	31	26	30	28
Th	20.0	20.0	17.3	14.5	18.0	19.5	21.8	21.0	19.5	14.8	22.0	21.0
U	7.5	7.5	5.3	4.2	6.3	4.6	4.4	6.0	4.6	5.3	6.8	8.5
La	45	48	28	23	37	35	37	39	37	38	35	35
Ce	80	81	48	44	66	65	72	67	66	63	50	50
Pr	-	-	-	-	-	-	-	-	-	-	-	-
Nd	29.0	31.0	19.0	18.0	28.0	28.0	28.5	24.0	25.0	22.0	22.0	24.0
Sm	6.62	6.67	3.47	3.58	5.24	5.46	5.84	5.62	4.14	3.84	4.88	4.59
Eu	1.01	0.80	0.69	0.57	1.03	0.68	0.83	0.57	0.69	0.99	0.65	0.62
Gd	-	-	-	-	-	-	-	-	-	-	-	-
Tb	0.90	1.00	0.75	0.80	1.00	1.00	1.05	0.80	0.75	0.70	0.70	0.80
Dy	-	-	-	-	-	-	-	-	-	-	-	-
Ho	-	-	-	-	-	-	-	-	-	-	-	-
Er	-	-	-	-	-	-	-	-	-	-	-	-
Tm	-	-	-	-	-	-	-	-	-	-	-	-
Yb	3.22	3.08	2.62	2.69	3.62	2.95	3.15	2.93	2.62	2.62	3.03	2.83
Lu	0.55	0.50	0.40	0.40	0.55	0.44	0.46	0.44	0.39	0.41	0.50	0.50
Cr	6	18	5	3	16	9	8	3	6	22	7	10
Ni	4	5	2	1	5	3	2	2	3	9	3	3
Co	5.7	5.1	2.5	2.1	5.0	3.4	3.7	2.0	2.8	6.1	4.3	3.8
Sc	8.3	8.0	5.1	4.0	7.4	6.0	6.6	4.4	5.3	6.6	5.9	5.4
V	48	45	14	11	38	22	19	17	21	43	21	19
Cu	4	5	3	1	4	7	8	1	3	11	3	3
Pb	18	16	16	28	24	22	15	20	21	20	12	12
Zn	36	33	19	17	27	28	25	21	24	35	23	23
Mn	360	370	330	270	400	335	330	270	305	440	320	320
Bi	<0.1	0.4	0.2	<0.1	0.3	0.4	0.8	<0.1	0.2	<0.1	2.5	0.4
Cd	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	6.0	5.0	8.5	3.0	5.0	11.0	8.5	7.0	7.0	5.0	7.0	6.0
W	1.0	2.0	0.5	1.0	0.5	0.8	1.3	1.0	0.5	1.8	1.0	2.0
Mo	<0.5	<0.5	1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
F	290	440	500	330	560	450	335	310	495	380	280	230
Cl	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Br	<0.3	<0.3	<0.3	<0.3	<0.3	0.7	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
B	20	10	10	30	30	15	15	10	15	20	20	20
Be	3.0	5.0	4.5	4.0	7.0	4.5	5.0	5.0	4.0	4.5	4.0	4.0
Au	30.0	3.0	<0.3	1.0	<0.3	<0.3	4.5	<0.3	1.8	1.3	3.0	<0.3
Ge	<5	<5	<5	<5	<5	5	<5	<5	<5	<5	<5	<5
As	<0.2	<0.2	0.3	0.5	0.5	1.0	1.5	1.0	0.3	<0.2	<0.2	<0.2
Se	<0.4	<0.4	1.0	<0.4	<0.4	<0.4	<0.4	<0.4	0.6	<0.4	<0.4	<0.4
Sb	0.4	0.3	0.2	0.3	0.7	0.2	0.3	0.5	0.3	0.2	1.0	0.7
206/204	-	-	-	-	-	-	-	-	-	-	-	-
207/204	-	-	-	-	-	-	-	-	-	-	-	-
208/204	-	-	-	-	-	-	-	-	-	-	-	-
D180	-	-	-	-	-	-	-	-	-	-	-	-
E-Nd	-	-	-	-	-	-	-	-	-	-	-	-
tDM	-	-	-	-	-	-	-	-	-	-	-	-
E-400	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX 4 (cont'd.)

Pluton WKNB#	G15 131	G15 303	G15 304	G15 138	G15 144	G15 147	G15 152	G15 305	G16 127	G16 128	G16 129	G16 154
SiO <sub>2</sub>	52.25	46.50	48.50	70.10	73.00	75.10	72.80	75.70	73.20	53.10	69.10	66.65
TiO <sub>2</sub>	1.49	2.78	2.38	0.52	0.29	0.15	0.30	0.20	0.18	0.77	0.48	0.73
Al <sub>2</sub> O <sub>3</sub>	15.95	14.70	15.40	14.35	13.75	12.35	13.70	12.50	13.95	17.10	15.00	15.35
Fe <sub>2</sub> O <sub>3</sub>	1.81	3.21	2.79	1.24	0.82	1.16	0.82	0.65	0.41	1.85	0.98	0.65
FeO	6.40	8.90	8.20	1.75	0.80	0.40	0.90	0.60	0.70	4.50	1.70	3.50
MnO	0.19	0.22	0.13	0.07	0.04	0.01	0.03	0.01	0.06	0.11	0.07	0.06
MgO	5.80	6.75	7.55	0.93	0.26	0.06	0.35	0.25	0.38	6.88	1.00	1.53
CaO	7.97	9.33	9.61	2.36	1.14	0.56	1.45	0.66	0.76	8.43	3.01	2.88
Na <sub>2</sub> O	3.45	2.58	2.78	3.79	3.98	4.13	3.75	4.29	3.78	2.66	3.59	3.77
K <sub>2</sub> O	1.12	1.44	0.69	3.71	4.82	4.69	4.48	4.13	4.58	1.30	3.14	2.47
P <sub>2</sub> O <sub>5</sub>	0.20	0.36	0.26	0.13	0.05	0.02	0.06	0.04	0.12	0.13	0.10	0.20
LOI	1.74	2.16	0.62	0.70	0.62	0.43	0.62	0.77	1.00	1.47	0.70	0.89
TTE	0.18	0.23	0.25	0.20	0.22	0.24	0.22	0.17	0.14	0.17	0.15	0.24
Total	98.55	99.16	99.16	99.82	99.80	99.30	99.48	99.98	99.26	98.48	99.02	98.91
Trace Elements												
Rb	37	45	16	122	196	141	188	119	226	48	122	122
Cs	8.4	2.9	1.6	1.9	5.2	0.7	2.7	1.1	12.5	5.5	6.5	4.1
Ba	147	95	79	423	617	756	581	810	322	195	443	403
Sr	267	284	318	189	87	56	108	89	61	368	177	229
Ga	20	20	19	17	18	17	18	16	16	17	17	20
Li	21	-	-	12	30	4	10	-	43	46	24	14
Tl	<1	<1	<1	2	<1	<1	7	<1	2	<1	<1	2
Ta	<0.04	0.8	0.8	1.2	1.2	1.6	1.3	1.5	3.1	0.6	0.6	0.9
Nb	9	10	10	16	15	25	14	22	18	8	11	17
Hf	4.1	4.5	4.2	5.9	6.3	7.9	4.8	6.5	3.0	3.0	3.3	6.2
Zr	177	176	170	174	204	232	147	168	84	98	130	192
Y	31	35	29	43	48	69	47	65	27	19	19	24
Th	5.2	1.8	2.4	18.8	25.0	20.3	22.0	22.0	15.5	4.5	12.0	13.0
U	1.7	1.7	1.0	6.1	5.9	4.9	6.6	4.8	5.1	1.0	3.4	2.5
La	19	16	17	52	64	74	43	64	27	22	33	55
Ce	43	36	35	93	103	136	85	114	47	39	51	91
Pr	-	-	-	-	-	-	9.4	-	-	-	-	-
Nd	20.5	22.0	20.0	37.5	41.0	55.5	34.1	50.0	18.5	16.5	18.0	35.0
Sm	4.55	5.70	5.27	6.68	7.00	10.65	6.78	11.30	3.31	3.17	3.03	5.70
Eu	1.70	1.78	1.60	1.33	1.29	1.63	0.87	1.01	0.56	1.16	0.85	1.67
Gd	-	-	-	-	-	-	6.48	-	-	-	-	-
Tb	0.65	1.00	1.00	1.15	1.35	1.80	1.07	1.80	0.65	0.40	0.40	0.80
Dy	-	-	-	-	-	-	7.01	-	-	-	-	-
Ho	-	-	-	-	-	-	1.50	-	-	-	-	-
Er	-	-	-	-	-	-	4.20	-	-	-	-	-
Tm	-	-	-	-	-	-	0.59	-	-	-	-	-
Yb	2.94	3.44	3.07	4.13	4.51	6.35	4.04	6.51	2.16	1.61	1.64	2.15
Lu	0.47	0.53	0.51	0.62	0.68	0.94	0.58	1.02	0.32	0.25	0.25	0.30
Cr	143	181	201	8	2	1	3	3	4	214	4	19
Ni	60	56	87	4	2	2	6	1	2	90	3	8
Co	36.3	42.0	44.0	6.5	2.8	1.4	3.4	1.9	2.1	32.5	6.2	11.4
Sc	29.4	45.4	38.9	9.9	5.9	7.7	6.9	6.8	4.9	24.5	7.8	14.0
V	226	398	334	53	15	2	20	15	11	132	60	89
Cu	31	37	39	4	2	1	3	1	1	34	6	8
Pb	2	<1	<1	16	12	7	28	4	18	5	32	16
Zn	111	53	90	38	25	10	24	5	23	57	33	52
Mn	1471	1704	1000	525	325	105	270	90	430	830	570	440
Bi	<0.1	0.4	0.5	0.9	1.0	<0.1	<0.1	<0.1	<0.1	<0.1	2.5	0.5
Cd	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	8.0	2.5	<0.5	1.8	2.5	1.5	<0.5	8.5	4.5	1.3	<0.5	<0.5
W	<0.5	<0.5	1.0	1.0	3.0	0.8	1.5	2.0	3.8	0.8	<0.5	2.0
Mo	1.0	7.0	<0.5	<0.5	<0.5	<0.5	<0.5	3.0	<0.5	<0.5	<0.5	<0.5
F	325	260	280	615	640	730	740	110	400	255	280	915
Cl	25	500	650	<25	<25	25	<25	<25	<25	25	<25	<25
Br	0.9	0.8	<0.3	0.6	0.9	1.1	<0.3	0.6	<0.3	<0.3	<0.3	0.7
B	15	20	<5	15	15	15	30	24	25	10	30	20
Be	4.0	4.0	3.0	4.5	4.5	4.5	5.0	4.0	6.5	4.0	5.0	3.0
Au	6.8	140.0	5.0	5.8	11.0	0.3	<0.3	<0.3	3.5	5.3	<0.3	0.8
Ge	<5	<5	<5	5	<5	<5	10	<5	<5	<5	<5	5
As	4.5	3.0	2.0	<0.2	0.3	<0.2	0.5	1.0	0.5	<0.2	1.0	0.8
Se	<0.4	<0.4	<0.4	<0.4	<0.4	1.1	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Sb	0.9	1.6	1.1	0.2	0.3	0.2	0.2	0.3	0.4	0.2	0.3	0.2
206/204	-	-	-	-	-	-	18.708	-	-	-	-	-
207/204	-	-	-	-	-	-	15.684	-	-	-	-	-
208/204	-	-	-	-	-	-	38.420	-	-	-	-	-
D180	-	-	-	-	-	-	8.8	-	-	-	-	-
E-Nd	-	-	-	-	-	-	-1.7	-	-	-	-	-
tDM	-	-	-	-	-	-	1.30	-	-	-	-	-
E-400	-	-	-	-	-	-	-1.8	-	-	-	-	-

APPENDIX 4 (cont'd.)

Pluton WONB#	G16 155	G16 156	G16 292	G17 150	G17 153	G17 157	G17 159	G17 160	G17 161	G17 162	G17 165	G17 167
SiO <sub>2</sub>	57.80	56.00	71.90	64.20	68.10	61.10	72.20	72.85	67.75	70.70	71.10	68.90
TiO <sub>2</sub>	1.08	0.70	0.26	0.61	0.49	0.73	0.31	0.15	0.84	0.38	0.33	0.46
Al <sub>2</sub> O <sub>3</sub>	17.10	16.35	14.70	16.90	15.70	18.40	14.40	14.65	14.50	14.70	14.55	15.50
Fe <sub>2</sub> O <sub>3</sub>	2.54	1.38	0.83	0.84	1.54	1.54	0.53	0.33	1.17	0.63	0.66	0.82
FeO	4.40	5.35	1.00	3.40	1.15	3.00	1.35	0.85	3.15	1.70	1.50	2.20
MnO	0.11	0.11	0.06	0.06	0.07	0.08	0.04	0.07	0.10	0.05	0.06	0.06
MgO	3.98	7.14	0.52	1.21	0.81	2.14	0.41	0.27	1.44	0.87	0.48	0.88
CaO	6.32	6.09	1.67	3.74	2.90	6.00	2.02	1.18	2.63	1.76	2.10	2.85
Na <sub>2</sub> O	2.80	2.43	3.69	4.47	4.48	3.63	3.86	4.40	3.62	3.46	3.89	4.09
K <sub>2</sub> O	1.98	1.62	4.29	2.12	3.07	1.86	3.87	3.78	2.69	4.52	3.94	3.11
P <sub>2</sub> O <sub>5</sub>	0.22	0.14	0.12	0.30	0.14	0.20	0.09	0.19	0.14	0.17	0.10	0.18
LOI	0.70	1.50	0.70	0.85	0.70	1.08	0.43	0.81	0.85	0.81	0.62	0.93
TTE	0.17	0.22	0.16	0.29	0.20	0.16	0.20	0.16	0.17	0.21	0.21	0.21
Total	99.21	99.03	99.89	99.00	99.34	99.92	99.72	99.70	99.05	99.97	99.53	100.19
Trace Elements												
Rb	71	66	183	204	107	82	149	244	138	210	128	159
Cs	3.0	4.0	9.0	16.0	2.6	4.5	3.0	9.5	5.6	6.9	2.6	8.8
Ba	265	204	532	396	628	208	788	227	264	459	662	365
Sr	337	337	123	208	430	396	123	90	139	103	133	187
Ga	22	18	17	22	18	20	18	19	19	20	17	20
Li	20	21	34	98	22	24	34	120	24	90	40	64
Tl	1	<1	<1	4	<1	3	1	2	4	1	<1	<1
Ta	1.1	0.9	1.7	1.4	0.8	1.3	1.1	3.8	1.5	1.6	1.0	2.0
Nb	12	10	17	20	12	8	11	15	14	15	14	16
Hf	4.2	3.3	5.4	9.1	4.3	3.4	5.5	2.3	6.9	4.5	6.1	6.8
Zr	138	110	168	368	160	148	178	62	222	137	205	230
Y	20	20	27	32	20	22	23	15	8	23	26	24
Th	7.5	7.3	17.0	17.5	18.3	3.3	29.8	4.7	10.2	20.0	16.8	12.0
U	2.1	2.3	5.9	6.8	3.7	2.6	4.7	3.0	13.1	3.5	2.6	2.5
La	31	24	39	66	58	17	57	13	55	42	55	34
Ce	56	45	64	118	85	36	98	24	93	77	97	68
Pr	-	-	-	-	-	-	-	-	-	-	-	7.6
Nd	23.0	19.0	24.0	46.0	29.5	17.0	37.0	10.5	35.0	31.0	36.0	28.4
Sm	4.32	3.65	4.12	7.57	4.33	3.44	6.15	2.11	5.84	5.70	6.16	5.56
Eu	1.37	1.09	0.98	1.87	1.18	1.05	1.16	0.53	1.55	1.04	1.41	1.07
Gd	-	-	-	-	-	-	-	-	-	-	-	4.93
Tb	0.60	0.60	0.70	0.90	0.55	0.50	0.90	0.35	0.55	0.90	0.85	0.76
Dy	-	-	-	-	-	-	-	-	-	-	-	4.49
Ho	-	-	-	-	-	-	-	-	-	-	-	0.89
Er	-	-	-	-	-	-	-	-	-	-	-	2.31
Tm	-	-	-	-	-	-	-	-	-	-	-	0.34
Yb	2.15	2.04	2.40	2.89	1.74	1.84	2.23	1.14	0.60	1.91	2.51	2.32
Lu	0.32	0.30	0.38	0.40	0.27	0.28	0.33	0.17	0.10	0.28	0.36	0.35
Cr	62	297	8	8	1	2	1	1	15	16	3	11
Ni	30	115	4	6	3	6	3	1	8	5	2	7
Co	25.3	36.8	3.2	8.0	4.6	11.5	3.3	2.3	11.0	5.6	3.9	6.5
Sc	21.3	21.0	5.2	9.3	6.3	11.4	5.3	2.8	12.3	7.0	5.6	7.4
V	160	124	15	48	43	80	22	9	90	32	26	37
Cu	37	85	1	9	4	10	2	2	11	10	3	6
Pb	9	8	28	24	22	12	30	9	8	22	16	20
Zn	76	74	34	76	42	64	34	35	59	53	44	52
Mn	855	880	440	480	510	640	290	565	765	395	460	500
Bi	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	<0.1	<0.1	<0.1
Cd	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	1.3	<0.5	4.0	3.0	2.0	<0.5	8.0	17.5	0.8	6.3	2.8	13.0
W	<0.5	<0.5	1.0	0.5	1.5	<0.5	<0.5	1.5	0.8	<0.5	<0.5	1.0
Mo	<0.5	1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
F	290	520	250	1100	275	390	275	640	400	690	530	680
Cl	<25	25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Br	1.2	<0.3	<0.3	0.6	<0.3	0.5	0.3	<0.3	0.3	<0.3	0.5	<0.3
B	10	20	20	20	10	10	10	15	10	10	5	10
Be	4.0	4.5	6.0	6.0	4.0	4.0	3.0	16.0	5.0	4.5	4.5	7.0
Au	0.3	2.8	1.0	<0.3	0.5	<0.3	0.5	6.0	<0.3	3.5	6.3	<0.3
Ge	<5	<5	10	10	5	<5	<5	5	<5	<5	<5	<5
As	<0.2	1.3	0.5	<0.2	<0.2	0.5	<0.2	1.0	<0.2	<0.2	<0.2	5.0
Se	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Sb	0.1	0.1	0.6	0.5	0.1	0.7	0.1	0.3	0.2	0.2	<0.1	0.2
206/204	-	-	-	-	-	-	-	-	-	-	-	18.336
207/204	-	-	-	-	-	-	-	-	-	-	-	15.660
208/204	-	-	-	-	-	-	-	-	-	-	-	38.263
D180	-	-	-	-	-	-	-	-	-	-	-	5.6
E-Nd	-	-	-	-	-	-	-	-	-	-	-	-1.1
tDM	-	-	-	-	-	-	-	-	-	-	-	1.24
E-400	-	-	-	-	-	-	-	-	-	-	-	-1.1

APPENDIX 4 (cont'd.)

Pluton WGNB#	G18 226	G18 293	G18 294	G18 295	G18 296	G18 158	G18 224	G18 225	G19 166	G20 168	G20 170	G21 169
SiO <sub>2</sub>	71.35	75.10	73.40	75.50	72.30	73.00	73.10	73.55	64.45	66.00	67.40	66.40
TiO <sub>2</sub>	0.33	0.19	0.22	0.18	0.32	0.29	0.26	0.22	0.95	0.89	0.71	0.91
Al <sub>2</sub> O <sub>3</sub>	14.25	12.90	14.20	12.80	14.00	13.45	13.50	12.95	16.10	14.60	14.30	15.15
Fe <sub>2</sub> O <sub>3</sub>	0.68	1.08	0.43	0.56	0.52	0.82	0.53	0.48	1.08	1.45	1.22	1.39
FeO	1.30	0.30	0.80	0.70	1.30	1.20	1.20	1.00	5.10	3.30	2.65	4.45
MnO	0.07	0.04	0.05	0.06	0.05	0.05	0.07	0.05	0.11	0.08	0.07	0.11
MgO	0.59	0.20	0.23	0.18	0.46	0.34	0.40	0.31	2.78	1.48	1.14	2.09
CaO	1.71	0.94	0.79	0.91	1.46	1.01	1.29	1.02	0.75	2.80	2.44	1.52
Na <sub>2</sub> O	4.09	3.88	3.84	3.97	3.75	3.80	3.87	3.79	1.93	3.39	3.48	2.66
K <sub>2</sub> O	3.95	4.47	5.15	4.57	4.46	4.79	4.35	4.62	3.36	3.68	3.97	2.95
P <sub>2</sub> O <sub>5</sub>	0.09	0.05	0.11	0.05	0.10	0.08	0.07	0.06	0.11	0.22	0.18	0.13
LOI	0.81	0.62	0.62	0.47	0.77	0.62	0.70	0.62	1.58	0.85	1.08	1.27
TTE	0.37	0.18	0.29	0.20	0.29	0.20	0.33	0.27	0.26	0.24	0.23	0.23
Total	99.57	99.95	100.13	100.14	99.78	99.67	99.66	98.94	98.56	98.99	98.87	99.27
Trace Elements												
Rb	278	298	354	308	287	274	292	301	170	150	171	120
Cs	8.6	6.2	12.8	6.6	10.8	5.9	14.2	12.0	14.4	6.2	5.8	11.3
Ba	289	76	183	80	393	215	196	140	575	518	486	513
Sr	302	52	46	54	129	81	118	78	92	167	135	123
Ga	19	19	20	18	20	19	19	18	20	18	18	20
Li	135	96	130	100	88	17	100	88	70	30	27	48
Tl	<1	6	3	5	<1	3	<1	<1	2	2	1	<1
Ta	3.9	3.7	3.9	4.6	3.4	3.5	2.7	3.8	1.4	1.6	1.4	1.4
Nb	20	22	22	26	24	29	20	20	19	19	17	19
Hf	5.1	4.9	3.6	4.7	5.2	6.3	4.4	4.4	5.6	8.0	7.3	7.3
Zr	145	95	98	94	149	172	114	107	195	253	215	227
Y	49	48	34	58	48	57	49	50	35	41	44	31
Th	21.8	35.0	25.0	33.5	29.5	31.5	27.3	31.8	13.0	14.5	17.8	14.0
U	10.9	13.8	13.0	14.0	12.4	11.9	8.7	10.5	5.4	3.1	5.0	3.8
La	30	22	28	25	46	33	29	32	44	49	41	47
Ce	64	48	62	53	86	74	67	65	77	90	84	86
Pr	7.6	-	-	-	-	9.0	7.6	-	-	-	10.1	-
Nd	29.0	24.0	24.0	26.0	36.0	35.0	29.0	30.0	30.5	40.0	38.1	34.5
Sm	6.38	5.49	6.29	6.06	6.95	7.93	6.78	6.28	6.01	7.36	7.87	6.64
Eu	0.64	0.55	0.54	0.44	0.87	0.64	0.49	0.32	1.44	1.80	1.35	1.74
Gd	5.69	-	-	-	-	7.58	6.70	-	-	-	7.24	-
Tb	1.08	1.20	1.10	1.50	1.30	1.47	1.05	1.15	0.90	1.20	1.23	1.15
Dy	6.83	-	-	-	-	9.78	7.50	-	-	-	7.63	-
Ho	1.52	-	-	-	-	2.06	1.46	-	-	-	1.64	-
Er	4.35	-	-	-	-	5.68	4.54	-	-	-	4.28	-
Tm	0.70	-	-	-	-	0.89	0.70	-	-	-	0.61	-
Yb	4.95	5.51	3.29	6.57	4.88	6.02	4.84	5.09	3.48	3.83	4.12	3.44
Lu	0.74	0.88	0.61	1.03	0.76	0.85	0.73	0.83	0.53	0.57	0.60	0.51
Cr	1	8	4	<1	7	1	5	1	70	17	19	65
Ni	4	3	2	2	3	2	2	2	30	10	7	22
Co	3.9	1.8	1.6	1.8	3.4	3.2	2.9	2.1	17.0	12.0	9.2	16.5
Sc	6.1	4.1	3.0	4.7	5.2	7.2	5.6	5.0	17.3	13.9	11.6	16.8
V	25	9	10	11	23	15	20	18	126	89	69	109
Cu	1	1	1	1	1	2	1	1	16	12	12	17
Pb	14	20	24	20	28	20	23	21	15	20	20	13
Zn	32	23	23	25	35	32	33	27	78	65	56	68
Mn	520	310	410	460	400	360	520	415	850	640	575	830
Bi	0.9	0.7	<0.1	<0.1	<0.1	0.3	0.2	0.3	<0.1	<0.1	0.3	8.0
Cd	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	17.0	7.0	22.0	11.0	20.0	11.8	20.8	42.0	8.0	<0.5	2.5	2.8
W	4.8	1.0	2.5	1.0	1.0	1.5	0.5	<0.5	0.8	1.0	<0.5	1.3
Mo	1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.0
F	2100	830	1700	970	1400	760	2050	1550	815	740	715	685
Cl	<25	<25	<25	<25	<25	<25	<25	<25	25	<25	<25	<25
Br	0.4	<0.3	1.0	<0.3	0.9	<0.3	<0.3	<0.3	0.5	0.8	0.6	0.7
B	25	10	10	20	10	10	15	15	20	<5	15	15
Be	11.0	10.0	10.0	9.0	8.0	8.5	9.0	9.5	5.5	5.0	4.5	6.5
Au	1.5	2.0	<0.3	<0.3	<0.3	6.5	0.8	0.5	0.8	2.0	3.8	2.5
Ge	<5	10	<5	10	10	5	<5	<5	5	<5	<5	<5
As	1.8	0.5	1.0	0.5	<0.2	1.0	1.3	1.0	0.8	0.5	0.8	0.3
Se	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	1.1	0.7	<0.4	<0.4	0.9	<0.4
Sb	0.3	0.2	0.4	0.2	0.3	0.5	0.4	0.4	0.5	0.3	0.2	0.3
206/20418	329	-	-	-	-	18.327	18.356	-	-	-	18.348	-
207/20415	652	-	-	-	-	15.657	15.693	-	-	-	15.665	-
208/20438	252	-	-	-	-	38.261	38.377	-	-	-	38.247	-
D180	9.0	-	-	-	-	9.5	8.8	-	-	-	8.0	-
E-Nd	-0.8	-	-	-	-	-1.9	-1.6	-	-	-	-1.7	-
tDM	1.37	-	-	-	-	1.48	1.46	-	-	-	1.39	-
E-400	-0.6	-	-	-	-	-1.7	-1.4	-	-	-	-2.0	-

APPENDIX 4 (cont'd.)

Pluton WXNB#	G21 171	G22 172	G22 173	G22 174	G22 227	G23 1	G23 7	G23 14	G23 15	G24 8	G24 9	G24 12
SiO <sub>2</sub>	68.25	76.60	72.05	73.00	72.55	68.10	62.15	62.25	56.00	65.95	70.40	69.40
TiO <sub>2</sub>	0.58	0.11	0.30	0.17	0.22	0.55	0.82	0.88	1.53	0.87	0.68	0.72
Al <sub>2</sub> O <sub>3</sub>	14.95	12.80	14.60	14.70	14.25	15.10	16.55	16.60	16.05	15.80	13.50	14.10
Fe <sub>2</sub> O <sub>3</sub>	0.92	0.56	0.55	0.50	0.48	0.81	1.23	1.31	2.04	0.72	0.66	0.63
FeO	2.55	0.50	1.35	0.70	0.95	2.25	3.15	3.35	5.65	5.25	3.50	3.50
MnO	0.07	0.02	0.05	0.03	0.05	0.07	0.08	0.08	0.13	0.13	0.10	0.07
MgO	0.98	0.04	0.65	0.35	0.39	1.30	1.99	2.35	3.92	2.05	1.41	1.21
CaO	2.42	0.41	1.34	0.81	0.81	2.97	4.56	4.78	5.34	0.77	1.23	2.54
Na <sub>2</sub> O	3.65	3.49	3.65	3.87	3.33	3.71	3.94	3.82	3.19	1.87	2.34	3.13
K <sub>2</sub> O	3.90	5.00	4.18	4.48	4.86	3.57	2.68	2.40	2.46	3.77	3.48	2.78
P <sub>2</sub> O <sub>5</sub>	0.16	0.03	0.15	0.25	0.19	0.13	0.21	0.21	0.35	0.12	0.11	0.10
LOI	1.04	0.62	0.81	0.77	0.81	0.73	0.89	1.01	1.16	1.70	1.12	0.70
TTE	0.22	0.14	0.15	0.16	0.15	0.21	0.21	0.20	0.26	0.23	0.19	0.25
Total	99.69	100.32	99.84	99.79	99.05	99.51	98.46	99.23	98.06	99.23	98.71	99.12
Trace Elements												
Rb	156	222	193	174	224	150	109	104	88	150	133	102
Cs	8.5	4.7	10.7	14.2	11.6	8.7	4.1	6.9	4.5	9.7	7.4	2.2
Ba	524	355	375	170	355	450	521	462	446	491	515	652
Sr	174	53	85	25	60	202	313	310	341	87	102	168
Ga	18	18	17	16	19	18	21	22	21	22	19	18
Li	36	24	48	70	46	56	44	46	45	31	44	24
Tl	2	6	3	7	<1	<1	<1	<1	<1	3	4	<1
Ta	1.5	1.0	2.4	2.4	2.3	1.3	1.6	1.9	1.3	1.3	1.1	0.7
Nb	15	15	16	14	16	14	18	17	23	17	16	16
Hf	6.8	3.3	3.6	2.2	3.1	4.7	6.8	6.2	8.0	7.1	7.2	9.4
Zr	220	68	121	74	88	141	207	209	259	201	208	280
Y	34	23	26	41	23	24	29	29	37	33	34	45
Th	17.3	21.0	13.8	7.2	11.8	15.8	14.3	11.2	6.2	12.8	13.0	19.5
U	6.3	3.4	5.0	3.8	4.3	5.7	3.3	4.7	2.2	3.7	3.1	1.7
La	45	38	30	29	21	37	55	42	39	44	42	56
Ce	81	70	55	65	43	83	94	75	75	83	78	107
Pr	-	-	-	7.6	4.9	8.1	-	-	-	-	-	-
Nd	34.5	31.0	22.5	29.6	18.4	28.6	37.0	30.5	35.5	34.0	33.5	47.0
Sm	6.35	6.64	3.95	7.02	4.05	5.29	6.19	5.17	7.21	6.25	6.23	8.39
Eu	1.45	0.45	0.85	0.31	0.64	1.04	1.59	1.30	1.89	1.45	1.24	1.93
Gd	-	-	-	6.87	3.63	5.02	-	-	-	-	-	-
Tb	1.10	1.40	0.75	1.19	0.62	0.64	1.00	0.70	1.15	1.05	1.05	1.30
Dy	-	-	-	7.39	3.85	4.27	-	-	-	-	-	-
Ho	-	-	-	1.53	0.73	0.81	-	-	-	-	-	-
Er	-	-	-	4.20	1.84	2.34	-	-	-	-	-	-
Tm	-	-	-	0.57	0.24	0.35	-	-	-	-	-	-
Yb	3.27	3.85	2.23	3.60	1.69	2.32	2.67	2.36	2.99	3.41	3.60	3.66
Lu	0.49	0.56	0.33	0.50	0.23	0.34	0.38	0.35	0.42	0.53	0.54	0.52
Cr	11	1	9	4	7	18	24	35	52	65	44	15
Ni	4	4	5	4	3	6	6	12	21	22	16	9
Co	7.7	0.7	4.4	2.2	3.2	7.5	12.5	12.8	24.3	16.3	12.0	9.0
Sc	11.4	4.0	6.0	4.2	4.7	9.5	12.6	14.1	22.6	16.6	11.6	11.9
V	55	6	29	5	16	60	85	105	182	126	89	90
Cu	28	1	9	1	5	10	13	16	30	39	25	10
Pb	18	32	19	24	24	24	10	13	12	19	23	24
Zn	50	28	37	24	39	45	63	66	101	89	65	65
Mn	515	130	390	220	370	550	620	645	1046	1007	745	510
Bi	2.0	0.2	1.0	<0.1	<0.1	<0.1	0.3	<0.1	<0.1	0.3	0.3	0.3
Cd	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	3.3	<0.5	7.8	19.0	10.0	3.0	1.8	5.3	<0.5	1.3	3.8	<0.5
W	0.5	1.0	0.5	2.0	0.5	<0.5	0.5	<0.5	<0.5	1.3	<0.5	<0.5
Mo	2.0	<0.5	<0.5	<0.5	<0.5	1.5	<0.5	<0.5	<0.5	<0.5	1.5	<0.5
F	610	390	365	680	445	635	370	350	675	685	335	660
Cl	<25	<25	<25	<25	<25	<25	<25	25	<25	<25	25	<25
Br	<0.3	0.9	<0.3	<0.3	<0.3	<0.3	0.3	0.9	0.3	0.6	0.8	<0.3
B	15	20	10	20	15	10	20	10	15	55	25	40
Be	4.5	3.0	5.0	9.0	4.5	5.5	4.0	5.5	5.5	5.5	7.0	5.0
Au	3.5	1.5	<0.3	<0.3	2.0	<0.3	1.3	1.0	4.0	2.8	<0.3	<0.3
Ge	<5	<5	<5	<5	<5	<5	5	<5	<5	<5	<5	<5
As	1.0	1.0	2.5	5.0	1.3	1.3	<0.2	0.8	1.5	4.3	4.0	2.0
Se	0.9	4.1	<0.4	<0.4	<0.4	<0.4	1.6	<0.4	<0.4	2.1	1.1	<0.4
Sb	0.5	0.3	0.4	0.3	0.4	0.3	0.1	0.4	0.2	0.8	0.6	0.3
206/204	-	-	-	18.353	18.326	18.349	-	-	-	-	-	-
207/204	-	-	-	15.702	15.690	15.658	-	-	-	-	-	-
208/204	-	-	-	38.360	38.340	38.224	-	-	-	-	-	-
D18O	-	-	-	9.3	10.0	7.8	-	-	-	-	-	-
E-Nd	-	-	-	-2.1	-4.2	-1.6	-	-	-	-	-	-
tDM	-	-	-	1.46	1.68	1.33	-	-	-	-	-	-
E-400	-	-	-	-2.3	-4.4	-1.7	-	-	-	-	-	-

APPENDIX 4 (cont'd.)

Pluton WQNB#	G24 13	G24 22	G24 23	G24 26	G24 27	G24 28	G24 29	G24 30	G24 31	G24 34	G24 35	G24 36
SiO <sub>2</sub>	71.75	66.80	62.95	70.40	69.10	72.65	72.35	72.60	65.30	67.10	70.75	67.40
TiO <sub>2</sub>	0.27	0.87	0.80	0.40	0.45	0.18	0.22	0.20	0.85	0.54	0.32	0.46
Al <sub>2</sub> O <sub>3</sub>	14.55	14.25	17.60	14.65	14.90	14.55	14.25	14.55	15.45	15.30	14.65	15.45
Fe <sub>2</sub> O <sub>3</sub>	0.74	1.14	0.67	0.75	0.68	0.50	0.67	0.69	0.88	1.03	0.68	0.86
FeO	1.00	3.75	3.65	1.75	2.00	0.65	0.75	0.65	4.05	2.20	1.20	1.95
MnO	0.06	0.08	0.07	0.07	0.08	0.06	0.05	0.05	0.07	0.08	0.07	0.08
MgO	0.54	1.35	1.27	0.79	1.38	0.38	0.44	0.39	1.41	1.40	0.78	1.31
CaO	1.34	2.67	3.83	1.82	2.55	0.90	1.48	1.01	2.60	2.77	1.87	2.78
Na <sub>2</sub> O	3.98	2.98	3.99	3.56	3.52	3.84	3.82	3.79	3.34	3.60	3.88	3.80
K <sub>2</sub> O	4.19	3.36	3.04	4.65	3.75	4.91	4.19	4.72	3.65	3.72	4.27	3.29
P <sub>2</sub> O <sub>5</sub>	0.14	0.26	0.26	0.20	0.17	0.23	0.15	0.21	0.28	0.22	0.15	0.18
LOI	0.73	1.04	0.77	0.47	0.70	0.93	0.66	0.89	0.81	0.70	0.70	0.89
TTE	0.13	0.31	0.33	0.16	0.18	0.13	0.13	0.16	0.27	0.21	0.17	0.20
Total	99.42	98.85	99.22	99.66	99.45	99.90	99.17	99.90	98.95	98.86	99.49	98.66
Trace Elements												
Rb	180	113	88	160	158	241	200	238	140	150	205	171
Cs	10.2	4.0	2.2	8.1	6.4	17.9	10.1	10.3	4.3	6.4	16.4	12.7
Ba	280	892	1159	383	325	283	362	374	773	455	370	494
Sr	93	170	254	113	128	51	83	59	169	177	110	157
Ga	16	17	20	16	16	16	17	17	18	18	16	17
Li	96	38	22	54	82	88	70	72	42	70	70	74
Tl	<1	<1	<1	<1	<1	<1	1	2	<1	<1	1	<1
Ta	1.4	0.8	0.4	1.0	1.8	2.5	1.9	2.7	1.1	1.6	1.9	1.9
Nb	15	17	15	14	16	19	15	20	19	16	16	14
Hf	3.7	10.0	9.3	4.6	4.6	3.1	3.5	2.9	9.2	5.4	3.5	4.2
Zr	114	316	294	143	140	81	96	89	302	170	97	128
Y	28	37	32	32	27	26	18	26	34	28	22	24
Th	12.3	19.3	16.3	9.5	11.0	12.0	12.3	12.8	17.5	15.0	11.0	13.8
U	4.1	1.7	1.2	3.4	2.7	4.1	5.0	5.8	2.2	2.2	6.5	2.8
La	27	65	52	27	31	22	25	24	54	43	24	31
Ce	49	122	113	55	55	42	46	45	99	78	45	59
Pr	-	-	13.1	-	-	-	-	-	-	-	-	-
Nd	20.5	53.5	51.7	23.0	23.0	20.0	18.0	20.5	44.0	33.0	19.5	23.5
Sm	3.82	10.24	10.23	4.48	4.42	4.01	3.41	4.17	8.40	5.81	3.81	4.58
Eu	0.80	2.23	2.78	1.05	0.95	0.61	0.73	0.60	2.02	1.23	0.76	0.98
Gd	-	-	8.27	-	-	-	-	-	-	-	-	-
Tb	0.80	1.55	1.22	0.85	0.70	0.70	0.50	0.70	1.10	0.80	0.65	0.70
Dy	-	-	6.61	-	-	-	-	-	-	-	-	-
Ho	-	-	1.27	-	-	-	-	-	-	-	-	-
Er	-	-	3.17	-	-	-	-	-	-	-	-	-
Tm	-	-	0.41	-	-	-	-	-	-	-	-	-
Yb	2.57	3.64	2.57	2.79	2.38	1.86	1.66	1.87	2.07	2.38	2.27	1.88
Lu	0.41	0.50	0.37	0.41	0.36	0.26	0.25	0.29	0.32	0.35	0.37	0.28
Cr	4	22	25	11	26	3	4	4	16	18	10	21
Ni	3	26	10	4	15	2	3	2	8	9	8	10
Co	3.9	11.8	10.4	5.2	7.3	2.2	3.1	2.5	10.9	8.4	4.9	8.0
Sc	8.1	14.2	11.8	8.2	9.0	4.9	5.0	5.1	13.3	9.7	6.6	9.4
V	23	85	83	41	58	11	23	24	85	55	32	51
Cu	4	21	8	3	18	27	12	36	15	24	5	45
Pb	20	22	19	24	20	19	15	17	15	20	21	22
Zn	37	70	60	44	48	30	31	35	74	54	35	51
Mn	450	615	550	520	620	430	400	410	545	640	515	610
Bi	0.3	0.4	0.4	0.4	0.2	0.4	0.4	0.5	1.2	0.4	0.4	0.3
Cd	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	4.3	<0.5	4.8	4.5	9.0	4.5	1.5	4.0	<0.5	<0.5	3.8	2.5
W	1.5	<0.5	<0.5	0.5	<0.5	1.8	<0.5	1.8	0.8	1.0	<0.5	<0.5
Mo	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.0	<0.5	<0.5	1.0
F	230	960	840	405	540	285	250	425	720	610	520	585
Cl	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Br	<0.3	<0.3	0.7	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.3	0.3
B	25	20	10	20	20	20	10	15	15	20	20	25
Be	4.0	4.0	3.5	5.0	5.0	6.5	4.5	7.5	4.5	5.0	7.5	7.0
Au	1.3	<0.3	0.8	0.8	<0.3	0.5	<0.3	1.3	0.3	2.0	0.5	<0.3
Ge	<5	<5	<5	<5	10	<5	<5	5	<5	<5	<5	<5
As	3.3	2.3	2.3	1.8	1.0	0.8	0.3	0.3	2.3	1.0	1.8	0.8
Se	0.8	1.1	3.3	<0.4	3.6	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Sb	0.9	0.2	0.2	0.5	0.1	0.5	0.2	0.3	0.2	0.1	0.4	0.4
206/204	-	-	18.330	-	-	-	-	-	-	-	-	-
207/204	-	-	15.674	-	-	-	-	-	-	-	-	-
208/204	-	-	38.304	-	-	-	-	-	-	-	-	-
D180	-	-	10.4	-	-	-	-	-	-	-	-	-
E-Nd	-	-	-3.8	-	-	-	-	-	-	-	-	-
tDM	-	-	1.48	-	-	-	-	-	-	-	-	-
E-400	-	-	-3.9	-	-	-	-	-	-	-	-	-

APPENDIX 4 (cont'd.)

Pluton WXNB#	G24 37	G25 2	G25 3	G25 4	G25 5	G25 6	G25 10	G25 11	G25 17	G25 20	G25 21	G25 24
SiO <sub>2</sub>	67.55	67.80	66.85	67.40	67.10	69.95	69.15	70.05	70.40	70.70	70.30	70.95
TiO <sub>2</sub>	0.50	0.63	0.67	0.56	0.60	0.40	0.48	0.44	0.38	0.36	0.38	0.48
Al <sub>2</sub> O <sub>3</sub>	15.30	14.65	14.70	15.00	14.90	14.65	14.80	14.45	14.70	14.50	14.30	14.50
Fe <sub>2</sub> O <sub>3</sub>	0.84	1.17	1.39	0.96	1.06	0.91	1.09	0.87	0.79	0.69	0.79	1.09
FeO	2.35	2.30	2.35	2.00	2.05	1.20	1.45	1.35	1.35	1.30	1.30	1.35
MnO	0.08	0.07	0.08	0.08	0.08	0.06	0.07	0.06	0.06	0.06	0.06	0.07
MgO	1.78	1.02	1.50	1.23	1.33	0.81	1.05	0.86	0.78	0.69	0.66	0.83
CaO	2.99	2.08	2.67	2.63	2.62	1.88	2.32	2.20	1.99	1.88	1.62	1.91
Na <sub>2</sub> O	3.45	3.64	3.60	3.69	3.75	3.70	3.72	3.63	3.73	3.70	3.72	3.79
K <sub>2</sub> O	3.28	4.68	3.96	4.09	4.04	4.47	4.17	4.14	4.15	4.25	4.58	4.31
P <sub>2</sub> O <sub>5</sub>	0.14	0.19	0.22	0.19	0.19	0.16	0.17	0.15	0.16	0.16	0.13	0.15
LOI	0.74	0.47	1.08	0.85	0.81	0.81	0.66	0.58	0.74	1.00	0.70	0.47
TTE	0.17	0.24	0.23	0.25	0.24	0.18	0.20	0.18	0.27	0.20	0.22	0.22
Total	99.18	98.94	99.30	98.93	98.77	99.18	99.32	98.97	99.51	99.49	98.75	100.11
Trace Elements												
Rb	156	187	175	172	176	217	182	172	201	209	215	208
Cs	4.6	7.5	9.5	5.9	9.2	12.3	11.5	8.7	8.3	9.5	7.4	10.5
Ba	369	498	481	504	540	341	401	402	366	319	414	421
Sr	142	157	209	210	212	152	186	176	161	145	156	164
Ga	18	18	20	20	20	18	17	18	19	19	18	18
Li	58	24	66	60	58	72	58	54	100	76	76	92
Tl	<1	<1	<1	<1	<1	<1	<1	<1	1	<1	<1	<1
Ta	1.1	1.5	1.4	1.6	1.5	2.5	1.6	1.5	2.0	1.9	2.2	1.9
Nb	14	20	20	17	17	17	15	15	17	17	18	18
Hf	4.0	8.2	7.5	6.2	6.2	4.4	4.8	4.4	4.5	4.8	5.6	5.8
Zr	140	236	216	177	201	130	148	133	134	117	142	169
Y	24	41	38	29	34	25	27	25	23	23	37	36
Th	11.3	16.3	20.3	17.0	15.0	17.0	12.5	17.5	14.3	14.5	17.5	18.5
U	2.5	4.2	6.3	4.5	5.1	3.7	2.5	4	3.8	3.5	4.6	3.7
La	34	50	68	59	39	36	34	34	33	31	38	46
Ce	61	93	123	108	87	67	63	63	63	59	69	87
Pr	-	-	-	-	10.1	-	-	-	-	-	-	-
Nd	25.0	39.0	48.5	42.0	37.4	26.5	24.0	25.0	28.5	24.0	31.0	34.0
Sm	4.22	7.27	8.13	7.05	7.43	5.08	4.55	4.87	4.42	4.46	5.59	6.51
Eu	1.08	1.73	1.50	1.29	1.25	1.16	1.00	1.10	1.09	0.87	1.11	1.25
Gd	-	-	-	-	6.68	-	-	-	-	-	-	-
Tb	0.60	1.30	1.15	1.10	1.01	0.80	0.80	0.80	0.75	0.79	1.20	1.10
Dy	-	-	-	-	6.07	-	-	-	-	-	-	-
Ho	-	-	-	-	1.24	-	-	-	-	-	-	-
Er	-	-	-	-	3.38	-	-	-	-	-	-	-
Tm	-	-	-	-	0.50	-	-	-	-	-	-	-
Yb	2.20	3.27	3.77	2.82	3.33	2.29	2.43	1.97	1.74	2.20	3.80	3.66
Lu	0.34	0.48	0.56	0.41	0.45	0.34	0.36	0.29	0.26	0.32	0.56	0.55
Cr	32	14	23	15	23	9	14	10	7	6	7	10
Ni	18	5	8	8	8	4	5	4	3	4	4	5
Co	9.2	7.4	8.8	6.7	7.8	5.2	6.7	5.3	4.3	4.4	3.9	5.6
Sc	9.9	11.7	11.2	9.4	10.0	7.0	7.8	7.1	6.0	6.3	7.2	8.7
V	70	61	62	63	57	35	46	39	33	33	35	39
Cu	31	8	10	10	10	5	7	7	4	4	8	5
Pb	17	21	19	24	20	26	22	22	15	24	28	21
Zn	49	57	62	56	56	39	44	41	43	37	35	45
Mn	590	550	645	600	600	470	520	460	470	490	490	535
Bi	<0.1	<0.1	<0.1	0.6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3
Cd	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	8.0	4.0	5.8	<0.5	1.8	5.5	5.3	3.8	2.5	21.0	3.0	6.5
W	<0.5	<0.5	2.8	1.0	<0.5	0.5	1.0	0.8	1.0	<0.5	0.5	<0.5
Mo	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
F	360	825	565	880	710	560	610	450	1440	700	790	705
Cl	25	<25	<25	<25	<25	<25	<25	<25	<25	100	<25	<25
Br	0.3	0.7	0.4	<0.3	0.8	0.4	0.8	<0.3	<0.3	<0.3	<0.3	0.3
B	10	10	5	20	30	25	25	15	25	30	30	15
Be	5.5	4.5	4.5	6.0	6.0	6.5	5.0	4.0	3.5	6.0	6.0	5.5
Au	3.0	1.0	0.3	1.5	9.5	1.0	0.5	1.0	0.8	1.5	1.5	1.8
Ge	<5	<5	<5	<5	<5	5	<5	<5	5	<5	10	<5
As	0.8	1.8	1.8	1.5	3.0	1.3	0.8	0.8	0.5	0.5	1.0	2.0
Se	<0.4	1.3	<0.4	3.2	<0.4	<0.4	0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Sb	0.3	0.3	0.4	0.2	0.5	0.4	0.4	0.2	0.2	0.3	0.3	0.4
206/204	-	-	-	-	18.329	-	-	-	-	-	-	-
207/204	-	-	-	-	15.658	-	-	-	-	-	-	-
208/204	-	-	-	-	38.229	-	-	-	-	-	-	-
D180	-	-	-	-	9.6	-	-	-	-	-	-	-
E-Nd	-	-	-	-	-2.5	-	-	-	-	-	-	-
tDM	-	-	-	-	1.37	-	-	-	-	-	-	-
E-400	-	-	-	-	-2.5	-	-	-	-	-	-	-

APPENDIX 4 (cont'd.)

Pluton WKNB#	G25 25	G25 32	G25 33	G26 16	G26 18	G26 19	G26 38	G27 327	G28 187	G28 213	G28 214	G29 188
SiO <sub>2</sub>	70.80	66.50	69.00	71.45	71.50	71.35	72.00	68.90	75.75	73.45	73.40	75.15
TiO <sub>2</sub>	0.44	0.55	0.39	0.28	0.31	0.21	0.28	0.55	0.04	0.16	0.15	0.21
Al <sub>2</sub> O <sub>3</sub>	14.20	15.60	15.50	14.40	14.50	14.50	14.40	14.60	13.70	14.75	14.60	12.65
Fe <sub>2</sub> O <sub>3</sub>	1.02	0.83	0.75	0.43	0.36	0.62	0.59	0.59	0.27	0.39	0.32	0.69
FeO	1.30	2.10	1.35	1.20	1.40	0.75	1.00	2.30	0.55	0.65	0.60	0.60
MnO	0.06	0.09	0.06	0.04	0.07	0.06	0.06	0.06	0.06	0.03	0.03	0.04
MgO	0.92	1.22	0.81	0.58	0.62	0.39	0.49	1.17	<0.01	0.21	0.19	0.18
CaO	2.11	2.43	2.18	1.51	1.73	0.73	1.37	2.68	0.21	0.74	0.87	0.89
Na <sub>2</sub> O	3.66	3.87	3.99	3.89	3.96	3.68	3.59	3.77	4.63	3.82	3.91	3.91
K <sub>2</sub> O	4.20	4.12	4.42	4.06	3.72	5.08	4.56	3.45	4.19	4.96	4.95	4.73
P <sub>2</sub> O <sub>5</sub>	0.15	0.29	0.15	0.11	0.17	0.25	0.19	0.13	0.02	0.09	0.09	0.04
LOI	0.66	1.08	0.85	1.19	0.81	0.93	0.89	1.31	0.66	0.81	0.74	0.54
TTE	0.19	0.26	0.20	0.13	0.22	0.20	0.19	0.21	1.10	0.14	0.14	0.31
Total	99.70	98.94	99.66	99.29	99.38	98.76	99.60	99.73	101.19	100.20	99.99	99.95
Trace Elements												
Rb	190	194	202	166	225	314	235	164	1457	209	213	376
Cs	17.2	9.0	12.8	7.6	22.3	17.4	10.4	2.4	54.8	10.5	11.1	13.8
Ba	309	451	350	364	317	256	301	438	12	470	423	192
Sr	160	194	161	114	134	60	102	264	<4	82	85	55
Ga	17	21	19	18	17	17	17	18	29	22	20	18
Li	70	60	68	60	180	50	60	-	1100	90	130	100
Tl	<1	<1	2	<1	<1	<1	<1	<1	9	3	<1	2
Ta	2.0	1.6	2.0	1.4	2.1	2.5	2.4	2.3	16.5	1.5	1.2	4.3
Nb	16	17	17	13	15	19	17	13	44	14	12	37
Hf	4.6	4.5	4.6	4.6	3.2	3.3	3.1	6.3	5.0	2.8	3.1	6.0
Zr	127	166	135	137	102	87	106	140	57	78	79	147
Y	27	21	27	24	20	24	23	21	94	14	14	70
Th	28.0	9.4	16.0	16.5	9.1	14.3	13.3	17.0	25.5	16.3	16.5	43.5
U	6.3	2.9	3.6	13.9	3.1	3.4	2.9	4.9	14.9	3.3	3.3	16.5
La	41	35	34	18	23	25	27	46	30	25	30	57
Ce	75	67	65	38	44	49	53	74	80	50	50	103
Pr	-	-	-	4.5	-	-	-	-	-	5.4	-	-
Nd	31.5	27.0	26.0	17.4	18.5	21.5	22.5	34.0	30.5	19.0	18.5	39.0
Sm	5.88	4.47	4.86	3.63	3.53	4.17	4.32	7.14	7.38	3.87	3.41	6.99
Eu	1.16	1.21	1.02	0.57	0.81	0.49	0.76	0.97	0.10	0.54	0.59	0.58
Gd	-	-	-	3.32	-	-	-	-	-	3.28	-	-
Tb	1.00	0.50	0.80	0.55	0.55	0.65	0.65	1.20	2.00	0.44	0.40	1.60
Dy	-	-	-	3.19	-	-	-	-	-	2.21	-	-
Ho	-	-	-	0.63	-	-	-	-	-	0.35	-	-
Er	-	-	-	1.63	-	-	-	-	-	0.85	-	-
Tm	-	-	-	0.23	-	-	-	-	-	0.11	-	-
Yb	2.33	1.26	2.24	1.56	1.71	1.70	1.53	5.20	16.60	0.66	0.74	8.49
Lu	0.34	0.19	0.35	0.22	0.25	0.24	0.24	0.77	2.73	0.09	0.10	1.35
Cr	13	15	8	5	10	18	6	13	<1	4	1	<1
Ni	6	6	5	3	3	2	3	5	<1	1	1	1
Co	5.3	6.7	5.2	3.3	4.1	16.0	3.4	5.6	0.8	1.6	1.2	1.9
Sc	7.5	8.4	6.9	5.1	5.9	5.0	5.3	8.1	10.4	3.2	2.7	4.0
V	37	54	34	21	29	17	21	63	1	4	4	12
Cu	5	6	5	5	1	8	3	72	2	1	2	2
Pb	22	24	20	21	17	17	28	12	19	25	31	18
Zn	40	56	39	35	42	36	39	42	10	39	40	21
Mn	460	710	440	345	515	455	435	460	485	210	245	325
Bi	<0.1	<0.1	<0.1	<0.1	<0.1	1.1	<0.1	<0.1	0.3	0.3	0.7	0.3
Cd	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	5.3	3.0	4.3	4.8	5.8	4.3	13.5	1.5	7.8	3.8	6.0	8.8
W	1.5	2.0	2.0	0.8	2.0	6.3	<0.5	24.0	18.0	1.5	0.8	3.5
Mo	<0.5	<0.5	<0.5	2.5	<0.5	1.0	3.0	2.0	<0.5	<0.5	<0.5	<0.5
F	600	1100	670	205	965	930	820	610	7850	235	245	1700
Cl	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Br	0.3	<0.3	0.3	0.4	<0.3	<0.3	<0.3	<0.3	<0.3	0.3	<0.3	<0.3
B	30	20	20	20	20	25	15	30	20	10	20	40
Be	5.0	5.0	6.0	5.0	7.0	5.5	6.0	5.0	11.0	5.5	6.0	9.0
Au	<0.3	<0.3	1.5	0.8	<0.3	1.3	<0.3	<0.3	0.5	0.5	1.0	2.3
Ge	<5	<5	<5	<5	5	<5	5	<5	<5	<5	<5	<5
As	3.0	2.0	1.8	1.0	0.3	1.3	<0.2	3.0	2.0	2.0	<0.2	8.0
Se	<0.4	<0.4	<0.4	1.7	<0.4	0.6	<0.4	1.0	1.9	<0.4	0.4	2.0
Sb	0.8	0.3	0.4	0.2	0.5	0.4	0.2	0.2	1.4	0.3	0.2	1.0
206/204	-	-	-	-	18.369	-	-	-	-	18.312	-	-
207/204	-	-	-	-	15.672	-	-	-	-	15.628	-	-
208/204	-	-	-	-	38.270	-	-	-	-	38.196	-	-
D180	-	-	-	-	9.5	-	-	-	-	9.2	-	-
E-Nd	-	-	-	-	-1.6	-	-	-	-	-0.5	-	-
tDM	-	-	-	-	1.35	-	-	-	-	1.18	-	-
E-400	-	-	-	-	-1.6	-	-	-	-	-0.4	-	-

APPENDIX 4 (cont'd.)

Pluton WXNB#	A1 206	A1 207	A1 208	A1 209	A2 210	A2 211	A2 212	A2 221	A2 222	A2 223	A2 191	A2 192
SiO <sub>2</sub>	67.15	65.55	65.75	66.80	66.25	70.10	66.55	73.75	73.60	62.10	74.55	74.50
TiO <sub>2</sub>	0.61	0.63	0.66	0.63	0.47	0.39	0.54	0.26	0.22	0.65	0.19	0.21
Al <sub>2</sub> O <sub>3</sub>	15.35	15.50	15.55	15.60	15.60	13.55	14.20	12.20	11.70	16.60	11.80	11.90
Fe <sub>2</sub> O <sub>3</sub>	1.51	1.42	1.56	1.58	0.69	1.42	1.55	1.28	1.40	1.36	1.61	1.60
FeO	1.70	2.00	1.95	1.70	3.15	1.85	4.20	1.45	1.50	3.50	1.00	1.20
MnO	0.05	0.05	0.06	0.05	0.08	0.07	0.18	0.06	0.07	0.16	0.05	0.05
MgO	1.41	1.69	1.69	1.45	0.63	0.48	0.33	0.09	0.02	0.38	<0.01	<0.01
CaO	2.97	3.23	3.29	3.05	1.00	1.36	2.09	0.46	0.41	1.93	0.27	0.32
Na <sub>2</sub> O	4.37	4.33	4.35	4.42	4.05	4.67	4.22	4.81	4.90	5.77	4.62	4.52
K <sub>2</sub> O	3.89	3.67	3.65	3.57	4.65	4.50	4.04	4.74	4.78	5.73	4.96	4.91
P <sub>2</sub> O <sub>5</sub>	0.16	0.16	0.17	0.17	0.19	0.07	0.15	0.03	0.02	0.16	0.02	0.02
LOI	0.39	0.54	0.39	0.70	1.78	0.39	0.74	0.31	0.27	0.70	0.51	0.54
TTE	0.25	0.25	0.25	0.27	0.27	0.29	0.36	0.27	0.32	0.20	0.30	0.41
Total	99.82	99.02	99.32	99.98	98.81	99.14	99.13	99.72	99.20	99.24	99.89	100.18
Trace Elements												
Rb	153	157	144	159	166	187	148	174	180	56	248	249
Cs	3.8	3.3	3.1	5.8	2.4	6.9	4.9	2.3	2.6	2.0	2.0	3.1
Ba	699	679	675	669	738	240	549	70	54	670	1	6
Sr	358	384	386	389	88	61	138	7	5	58	10	4
Ga	21	20	20	21	20	26	25	31	31	25	31	28
Li	42	36	38	40	46	48	36	40	62	8	68	82
Tl	<1	<1	<1	4	<1	2	<1	<1	2	<1	2	5
Ta	1.2	1.0	0.9	1.1	1.1	3.9	1.5	2.9	4.6	1.3	4.1	4.5
Nb	14	12	12	13	19	47	31	54	75	23	61	75
Hf	6.5	6.2	6.1	6.2	11.0	16.3	21.0	18.5	24.0	7.0	25.5	26.0
Zr	182	183	185	191	362	477	914	614	700	273	795	947
Y	17	18	15	15	67	103	89	106	120	43	190	228
Th	23.5	19.3	19.5	23.0	20.5	25.5	14.5	17.8	21.8	3.8	36.8	34.0
U	6.5	4.3	4.5	4.8	4.0	5.1	3.9	4.2	6.5	0.8	7.8	8.8
La	86	46	46	52	65	74	59	84	109	32	104	138
Ce	88	79	79	82	125	144	120	181	198	74	208	245
Pr	9.4	-	-	-	-	-	-	21.4	-	-	-	-
Nd	33.2	28.0	28.0	26.0	55.0	60.0	57.0	83.4	88.5	35.0	99.0	116.0
Sm	5.50	4.19	4.26	3.66	10.80	12.20	11.65	17.60	17.10	6.94	21.75	24.60
Eu	1.20	1.12	1.23	1.16	1.54	0.92	2.87	0.36	0.52	2.78	0.51	0.93
Gd	4.38	-	-	-	-	-	-	16.84	-	-	-	-
Tb	0.58	0.45	0.60	0.50	1.85	2.30	2.15	2.84	2.90	1.00	4.75	5.40
Dy	3.18	-	-	-	-	-	-	17.56	-	-	-	-
Ho	0.64	-	-	-	-	-	-	3.68	-	-	-	-
Er	1.71	-	-	-	-	-	-	10.04	-	-	-	-
Tm	0.24	-	-	-	-	-	-	1.48	-	-	-	-
Yb	1.64	1.34	1.38	1.33	6.49	9.81	8.43	10.16	11.95	4.00	16.60	18.80
Lu	0.24	0.24	0.26	0.22	0.96	1.52	1.27	1.48	1.83	0.62	2.42	2.69
Cr	22	23	26	15	9	2	<1	1	2	<1	1	<1
Ni	10	12	13	9	4	4	<1	2	2	<1	1	2
Co	9.3	10.1	10.3	9.9	6.2	4.2	1.8	1.7	1.2	2.5	1.7	1.2
Sc	7.3	8.1	8.1	7.2	10.9	4.6	29.0	1.4	0.9	11.8	0.3	0.2
V	56	68	68	60	27	23	3	4	3	5	3	4
Cu	5	8	9	37	11	7	8	4	6	9	6	2
Pb	16	17	19	20	15	20	29	13	22	12	41	24
Zn	43	49	50	45	78	70	151	110	162	96	252	203
Mn	415	420	455	370	610	505	1394	485	505	1239	355	410
Bi	0.2	<0.1	<0.1	<0.1	0.2	0.2	0.2	0.2	0.1	0.3	<0.1	0.3
Cd	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	1.3	1.3	1.8	<0.5	3.8	10.5	3.5	9.8	18.3	<0.5	10.8	16.0
W	0.5	<0.5	0.5	1.0	1.3	0.8	0.8	0.8	1.8	1.0	3.3	1.0
Mo	1.0	1.5	2.0	<0.5	1.0	26.5	<0.5	<0.5	<0.5	<0.5	3.0	<0.5
F	630	665	650	700	675	1100	780	950	1250	490	770	1500
Cl	25	<25	<25	50	<25	125	375	<25	<25	50	<25	100
Br	0.4	0.4	0.3	0.7	0.5	0.5	0.5	0.4	<0.3	1.1	1.3	1.1
B	15	15	15	20	30	30	15	20	30	20	10	40
Be	4.0	4.0	4.0	4.0	6.0	9.0	6.0	8.5	9.0	3.0	7.5	11.0
Au	0.3	0.3	0.3	<0.3	1.3	<0.3	3.8	0.8	0.8	<0.3	2.5	<0.3
Ge	5	5	5	<5	5	10	<5	<5	<5	<5	<5	<5
As	0.3	0.5	1.3	6.0	3.0	6.0	1.0	3.3	5.5	5.5	1.3	7.0
Se	<0.4	<0.4	<0.4	<0.4	0.6	2.9	2.3	0.9	1.8	3.2	5.4	2.8
Sb	0.3	0.3	0.3	0.6	0.8	0.9	0.7	0.5	0.6	0.5	1.3	1.2
206/20418	371	-	-	-	-	-	-	-	-	-	-	-
207/20415	645	-	-	-	-	-	-	-	-	-	-	-
208/20438	241	-	-	-	-	-	-	-	-	-	-	-
D180	8.1	-	-	-	-	-	-	8.6	-	-	-	-
E-Nd	1.1	-	-	-	-	-	-	3.3	-	-	-	-
tDM	0.94	-	-	-	-	-	-	0.93	-	-	-	-
E-400	1.2	-	-	-	-	-	-	3.2	-	-	-	-

APPENDIX 4 (cont'd.)

Pluton WXNB#	A3 193	A3 194	A3 197	A3 198	A3 200	A3 201	A3 216	A3 217	A3 218	A3 219	A3 220	A4 179
SiO <sub>2</sub>	75.55	72.65	72.85	73.35	76.40	75.75	76.05	74.15	77.20	76.05	73.70	74.40
TiO <sub>2</sub>	0.24	0.26	0.40	0.31	0.12	0.14	0.13	0.21	0.12	0.16	0.25	0.18
Al <sub>2</sub> O <sub>3</sub>	12.25	13.95	13.10	13.20	11.90	12.45	12.40	12.65	12.20	12.30	12.70	12.50
Fe <sub>2</sub> O <sub>3</sub>	1.15	0.46	1.07	0.90	0.32	0.44	0.59	0.85	0.31	0.46	0.83	0.66
FeO	0.50	1.30	0.90	0.70	0.70	0.65	0.50	0.45	0.70	0.70	0.90	0.90
MnO	0.04	0.04	0.04	0.03	0.04	0.04	0.04	0.03	0.03	0.04	0.05	0.03
MgO	0.22	0.39	0.42	0.38	0.04	0.06	0.07	0.18	0.02	0.08	0.24	0.08
CaO	0.70	1.60	1.28	1.24	0.48	0.55	0.50	0.74	0.55	0.64	0.88	0.75
Na <sub>2</sub> O	3.58	3.70	3.66	3.59	3.60	3.84	3.89	3.65	3.82	3.67	3.59	3.94
K <sub>2</sub> O	5.00	4.50	5.08	5.11	4.69	5.06	4.84	5.21	4.79	4.89	4.84	4.78
P <sub>2</sub> O <sub>5</sub>	0.05	0.07	0.08	0.07	0.02	0.02	0.02	0.04	0.02	0.03	0.06	0.03
LOI	0.47	0.89	0.58	0.42	0.73	0.66	0.62	0.51	0.31	0.73	0.92	0.77
TTE	0.26	0.29	0.25	0.23	0.27	0.30	0.27	0.25	0.32	0.34	0.29	0.26
Total	100.01	100.11	99.72	99.54	99.33	99.96	99.93	98.92	100.39	100.09	99.25	99.29
Trace Elements												
Rb	328	224	231	255	360	422	363	274	449	425	325	238
Cs	11.7	10.6	5.9	7.7	5.6	17.3	9.0	6.7	17.7	14.2	17.8	7.3
Ba	146	623	469	511	12	51	57	175	14	63	185	58
Sr	38	139	92	102	16	15	24	46	9	30	50	21
Ga	17	16	17	16	18	18	17	15	18	17	17	25
Li	78	60	60	60	37	120	64	64	130	140	92	66
Tl	<1	<1	<1	<1	3	<1	<1	<1	<1	<1	5	<1
Ta	3.1	1.5	2.5	1.9	3.2	3.5	2.9	2.4	4.6	4.6	2.4	2.4
Nb	23	14	23	18	27	32	33	21	35	35	26	38
Hf	5.5	5.1	7.0	5.8	4.5	5.3	5.1	5.9	5.6	5.6	6.0	7.6
Zr	147	178	204	155	108	119	109	132	116	123	146	171
Y	69	33	51	36	72	75	82	52	95	83	73	95
Th	37.8	19.8	39.5	28.0	38.5	46.3	43.3	28.0	55.5	46.3	34.0	24.0
U	11.6	6.0	7.3	6.9	10.1	15.8	9.1	7.8	13.9	15.0	10.7	6.3
La	66	45	42	48	47	57	47	71	48	56	59	68
Ce	123	77	103	87	102	102	95	126	94	110	117	133
Pr	-	-	10.2	-	11.4	-	-	-	-	-	-	-
Nd	49.0	30.5	35.6	30.5	40.5	36.5	38.5	45.5	36.0	43.0	48.0	57.0
Sm	8.58	4.87	6.92	5.09	8.79	6.59	7.51	7.11	7.49	7.56	8.43	11.70
Eu	0.41	0.84	0.65	0.85	0.20	0.30	0.31	0.48	0.22	0.28	0.56	0.27
Gd	-	-	6.65	-	8.72	-	-	-	-	-	-	-
Tb	1.75	0.90	1.21	0.90	1.54	1.65	1.65	1.30	2.00	1.70	1.50	2.40
Dy	-	-	7.94	-	11.08	-	-	-	-	-	-	-
Ho	-	-	1.81	-	2.29	-	-	-	-	-	-	-
Er	-	-	4.95	-	7.07	-	-	-	-	-	-	-
Tm	-	-	0.75	-	1.11	-	-	-	-	-	-	-
Yb	7.56	3.48	5.42	4.26	7.45	8.07	7.99	5.95	10.00	8.80	7.57	9.27
Lu	1.19	0.53	0.79	0.67	1.07	1.29	1.27	0.94	1.55	1.39	1.19	1.41
Cr	<1	1	1	2	<1	<1	<1	<1	<1	<1	<1	<1
Ni	2	2	2	2	2	2	1	2	1	1	<1	1
Co	2.0	2.4	3.6	3.0	1.1	1.3	1.4	2.2	1.1	1.3	2.8	1.4
Sc	5.5	4.7	5.2	3.3	2.9	3.2	2.6	3.8	4.0	4.3	6.4	14.5
V	13	17	23	19	2	4	5	10	5	6	15	6
Cu	3	2	46	1	3	2	2	5	4	2	3	2
Pb	18	16	15	12	30	33	24	22	24	24	24	16
Zn	24	23	38	18	14	19	15	13	18	17	31	39
Mn	325	340	320	235	310	320	300	245	220	315	360	250
Bi	<0.1	0.4	<0.1	0.5	<0.1	<0.1	0.2	0.3	<0.1	<0.1	<0.1	<0.1
Cd	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	7.8	18.8	2.5	1.0	6.5	5.5	5.8	6.0	4.0	1.5	12.0	3.0
W	4.0	1.3	1.3	3.3	2.0	13.5	4.0	3.3	4.5	3.3	3.5	2.5
Mo	<0.5	<0.5	<0.5	<0.5	8.5	5.5	<0.5	1.0	<0.5	3.5	<0.5	<0.5
F	1300	1300	935	835	1650	1750	1600	1300	2000	2100	1600	1500
Cl	<25	50	<25	<25	<25	25	<25	<25	<25	<25	<25	<25
Br	<0.3	<0.3	0.3	<0.3	0.3	0.4	<0.3	<0.3	0.6	5.0	<0.3	<0.3
B	25	10	15	15	20	15	15	20	20	20	20	20
Be	7.0	4.0	5.5	6.0	6.5	7.5	7.0	6.5	11.0	8.5	8.0	9.0
Au	<0.3	1.8	0.8	1.0	0.5	0.5	0.8	0.5	1.5	1.5	1.0	<0.3
Ge	<5	<5	<5	<5	5	<5	5	<5	<5	<5	<5	<5
As	8.8	1.8	1.5	1.3	0.8	3.0	1.3	3.3	5.5	6.5	13.0	9.0
Se	2.1	1.9	<0.4	<0.4	<0.4	3.6	<0.4	<0.4	2.3	<0.4	<0.4	<0.4
Sb	1.4	0.3	0.4	0.5	0.4	1.0	0.5	0.4	0.6	0.8	1.2	1.4
206/204	-	-	18.442	-	18.451	-	-	-	-	-	-	-
207/204	-	-	15.649	-	15.643	-	-	-	-	-	-	-
208/204	-	-	38.276	-	38.261	-	-	-	-	-	-	-
D18O	-	-	7.2	-	7.7	-	-	-	-	-	-	-
E-Nd	-	-	1.4	-	1.3	-	-	-	-	-	-	-
tDM	-	-	0.96	-	1.09	-	-	-	-	-	-	-
E-400	-	-	1.8	-	1.6	-	-	-	-	-	-	-

APPENDIX 4 (cont'd.)

Pluton WGNB#	A4 180	A4 181	A4 182	A4 183	A4 184	A4 185	A4 189	A5 186	A5 190	A5 195	A5 196	A5 199
SiO <sub>2</sub>	74.10	73.95	76.30	76.30	74.50	73.15	73.20	69.35	62.00	68.50	68.95	74.80
TiO <sub>2</sub>	0.18	0.26	0.12	0.09	0.22	0.22	0.23	0.47	0.90	0.69	0.53	0.25
Al <sub>2</sub> O <sub>3</sub>	12.90	12.95	12.25	12.30	12.85	13.55	13.40	14.95	16.15	14.65	14.85	12.45
Fe <sub>2</sub> O <sub>3</sub>	0.62	0.72	0.42	0.34	0.66	0.78	0.79	1.39	1.25	1.81	1.26	0.71
FeO	0.90	1.25	0.70	0.70	1.10	0.90	1.00	1.10	3.60	1.55	1.45	0.90
MnO	0.03	0.04	0.03	0.03	0.04	0.04	0.04	0.06	0.09	0.06	0.06	0.04
MgO	0.13	0.23	0.03	0.02	0.17	0.19	0.20	0.91	2.41	1.30	1.09	0.21
CaO	0.75	0.99	0.54	0.55	0.88	0.79	0.83	2.28	3.86	2.85	2.32	0.90
Na <sub>2</sub> O	4.11	3.93	3.83	3.94	4.03	4.00	3.84	4.27	3.81	4.10	4.10	3.56
K <sub>2</sub> O	5.00	4.82	4.86	4.74	4.87	5.11	5.04	4.14	3.33	3.69	4.27	4.97
P <sub>2</sub> O <sub>5</sub>	0.04	0.05	0.02	0.02	0.04	0.06	0.07	0.15	0.29	0.20	0.15	0.05
LOI	0.73	0.54	0.58	0.70	0.51	0.54	0.62	0.85	1.31	0.62	0.66	0.62
TTE	0.26	0.22	0.26	0.31	0.28	0.23	0.22	0.22	0.67	0.26	0.24	0.27
Total	99.76	99.95	99.95	100.04	100.16	99.58	99.48	100.12	99.67	100.28	99.95	99.78
Trace Elements												
Rb	240	176	269	301	226	244	206	184	116	132	168	272
Cs	5.9	4.5	7.5	7.0	8.8	10.2	5.4	8.2	4.0	3.9	8.4	12.3
Ba	65	126	24	9	95	175	269	513	782	515	625	234
Sr	23	37	7	6	30	39	41	257	619	383	329	52
Ga	24	22	23	26	23	20	20	19	22	19	19	18
Li	57	60	54	72	62	92	69	100	40	44	70	<1
Tl	<1	2	2	6	3	<1	1	2	<1	<1	<1	<1
Ta	3.3	2.2	3.1	3.7	2.3	2.6	1.7	1.1	1.7	1.8	1.4	2.5
Nb	36	30	42	53	35	32	26	14	18	18	16	22
Hf	7.4	8.3	5.9	5.5	7.8	5.5	5.6	5.5	6.9	6.9	5.9	5.7
Zr	158	204	122	102	183	131	142	163	252	198	186	160
Y	88	74	99	122	91	60	46	19	27	23	22	55
Th	22.8	21.8	23.3	29.3	24.3	25.5	26.0	24.5	16.0	29.8	22.5	30.8
U	6.3	4.0	6.3	10.5	7.8	5.8	3.7	4.7	5.6	4.7	6.6	10.0
La	62	77	51	43	62	40	45	51	64	69	55	51
Ce	124	150	110	94	149	72	86	86	115	141	95	125
Pr	-	-	-	-	17.3	9.8	-	-	-	14.5	-	12.0
Nd	55.5	65.0	52.0	47.0	60.7	34.9	35.5	29.0	44.5	48.8	32.0	41.2
Sm	11.40	12.15	11.20	10.95	14.22	8.38	6.81	4.57	7.06	8.21	4.81	8.46
Eu	0.32	0.60	0.26	0.15	0.41	0.41	0.59	0.96	1.97	1.60	1.19	0.65
Gd	-	-	-	-	13.63	9.52	-	-	-	6.70	-	8.07
Tb	2.40	2.30	2.40	2.60	2.55	1.52	1.45	0.60	1.00	0.96	0.70	1.42
Dy	-	-	-	-	16.03	11.23	-	-	-	5.51	-	9.07
Ho	-	-	-	-	3.49	2.34	-	-	-	1.12	-	1.98
Er	-	-	-	-	9.42	7.20	-	-	-	2.83	-	5.46
Tm	-	-	-	-	1.41	1.14	-	-	-	0.41	-	0.82
Yb	9.41	7.54	9.22	11.00	9.51	7.48	4.80	1.74	2.63	2.68	2.10	5.61
Lu	1.41	1.08	1.35	1.67	1.37	1.07	0.71	0.27	0.41	0.39	0.33	0.83
Cr	6	<1	<1	1	<1	2	<1	8	43	17	14	1
Ni	2	1	1	1	1	2	2	3	16	6	5	2
Co	4.1	2.7	1.2	1.3	2.8	2.4	2.6	5.9	13.8	8.1	7.6	1.8
Sc	14.2	18.3	19.2	18.8	13.6	9.1	8.5	6.3	11.9	7.5	7.0	5.0
V	6	13	1	1	9	10	12	38	107	58	47	11
Cu	2	1	2	7	5	1	2	4	17	7	8	1
Pb	14	11	21	17	14	17	8	20	8	12	16	15
Zn	35	46	42	42	43	26	24	42	73	47	54	22
Mn	255	325	215	215	310	325	300	440	685	490	480	295
Bi	<0.1	<0.1	0.5	-	-	-	-	-	-	-	-	-
Cd	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	6.0	2.0	8.0	15.5	8.5	3.5	<0.5	3.0	0.8	2.8	3.0	4.0
W	2.0	1.0	4.8	2.8	9.0	3.0	3.3	<0.5	5.3	<0.5	<0.5	3.3
Mo	<0.5	2.5	2.0	<0.5	1.0	5.0	3.5	<0.5	1.5	1.0	<0.5	<0.5
F	1500	995	1550	2000	1350	1050	1040	590	4270	730	595	1450
Cl	<25	<25	<25	<25	225	75	100	<25	<25	<25	<25	<25
Br	0.8	0.3	0.4	<0.3	1.2	0.3	0.3	<0.3	<0.3	0.3	<0.3	<0.3
B	20	10	15	15	10	20	25	20	10	10	15	10
Be	8.5	5.5	7.5	6.0	6.5	6.5	6.5	5.5	5.0	4.0	6.5	7.0
Au	2.5	3.3	1.5	0.5	0.3	<0.3	0.8	1.5	1.0	<0.3	0.5	0.8
Ge	5	<5	<5	<5	<5	<5	<5	<5	5	<5	<5	5
As	2.5	2.5	3.0	3.8	4.3	4.5	4.0	11.5	2.0	2.5	3.3	2.0
Se	<0.4	0.7	4.5	3.1	2.5	1.9	1.2	<0.4	<0.4	0.8	<0.4	<0.4
Sb	0.5	0.4	0.6	0.8	0.5	0.8	0.5	1.5	0.6	0.7	0.9	0.5
206/204	-	-	-	-	18.294	18.236	-	-	-	18.354	-	18.528
207/204	-	-	-	-	15.612	15.618	-	-	-	15.640	-	15.643
208/204	-	-	-	-	38.054	38.046	-	-	-	38.201	-	38.277
D180	-	-	-	-	8.8	9.1	-	-	-	8.3	-	8.1
E-Nd	-	-	-	-	1.7	2.4	-	-	-	1.5	-	1.3
tDM	-	-	-	-	1.12	1.06	-	-	-	0.88	-	1.01
E-400	-	-	-	-	2.0	2.1	-	-	-	1.6	-	1.4

APPENDIX 4 (cont'd.)

Pluton WKNB#	A6 178	A6 204	A6 203	A6 215	A6 205	A6 176	A6 177	A6 202	G 261	G 272	G 286	G 288
SiO <sub>2</sub>	50.50	46.85	64.65	72.15	68.45	74.95	75.25	72.00	47.80	55.20	49.80	52.30
TiO <sub>2</sub>	2.06	1.30	0.86	0.24	0.66	0.18	0.15	0.36	1.60	2.37	1.81	2.11
Al <sub>2</sub> O <sub>3</sub>	15.90	15.70	14.85	14.05	13.50	12.80	12.65	13.95	15.75	14.30	16.50	15.50
Fe <sub>2</sub> O <sub>3</sub>	2.80	2.99	1.84	0.63	1.64	0.40	0.45	0.93	4.89	4.49	4.61	6.31
FeO	8.10	7.30	3.00	1.10	3.05	0.80	0.85	1.25	5.45	6.40	5.30	4.40
MnO	0.19	0.15	0.09	0.05	0.12	0.03	0.04	0.05	0.19	0.22	0.22	0.21
MgO	4.91	10.04	1.97	0.50	0.64	0.12	0.08	0.56	7.08	3.29	5.08	3.07
CaO	8.18	10.25	4.39	2.06	2.08	0.70	0.56	1.78	10.65	6.40	4.64	6.52
Na <sub>2</sub> O	3.22	2.22	4.15	3.92	4.72	3.65	3.91	4.09	3.01	3.31	5.29	5.31
K <sub>2</sub> O	1.68	0.40	2.50	3.94	3.39	5.33	5.00	4.19	0.34	1.66	1.26	0.42
P <sub>2</sub> O <sub>5</sub>	0.38	0.17	0.22	0.06	0.20	0.03	0.03	0.08	0.18	0.38	0.31	0.56
LOI	0.96	1.81	0.70	0.62	0.54	0.43	0.43	0.47	1.58	1.31	4.47	2.16
TTE	0.24	0.17	0.19	0.19	0.28	0.17	0.22	0.16	0.17	0.21	0.20	0.22
Total	99.12	99.35	99.40	99.50	99.28	99.60	99.62	99.88	98.70	99.54	99.49	99.09
Trace Elements												
Rb	45	10	86	194	108	194	237	149	10	56	39	9
Cs	2.4	1.8	2.4	8.3	2.5	10.1	11.6	4.6	1.8	2.3	0.5	0.9
Ba	260	10	326	643	555	168	133	475	102	271	157	52
Sr	348	258	160	90	123	22	16	90	253	234	180	230
Ga	20	15	16	14	19	19	22	17	18	21	19	25
Li	40	22	28	46	36	50	94	18	4	12	12	2
Tl	<1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1	<1
Ta	1.4	<0.04	0.9	1.2	1.4	2.0	1.2	1.2	0.1	1.0	<0.04	1.0
Nb	20	5	11	11	21	23	35	11	7	15	13	17
Hf	5.7	1.9	5.8	4.5	12.3	6.0	4.8	5.7	3.2	5.6	5.5	8.3
Zr	203	72	192	138	350	127	107	149	133	227	208	322
Y	40	20	43	32	82	72	103	43	32	54	43	66
Th	4.5	0.6	13.3	20.3	13.3	20.3	24.5	20.5	2.1	7.4	5.5	5.1
U	1.3	0.2	3.0	6.5	4.0	5.5	6.7	5.4	0.6	2.1	1.6	2.0
La	32	6	35	35	59	52	59	30	9	29	24	30
Ce	65	16	66	57	116	101	122	57	27	60	51	75
Pr	-	2.3	-	-	-	-	-	6.7	-	-	-	-
Nd	32.0	11.1	28.0	20.5	57.0	43.0	49.5	24.9	15.0	28.0	28.0	39.0
Sm	6.58	2.98	5.42	3.39	12.50	8.57	11.00	5.35	3.68	6.59	5.75	8.70
Eu	2.44	1.19	1.35	0.68	2.97	0.48	0.48	0.81	1.43	2.14	1.93	3.27
Gd	-	3.49	-	-	-	-	-	5.61	-	-	-	-
Tb	1.10	0.58	1.05	0.70	2.40	1.80	2.65	1.00	0.80	1.30	1.00	1.70
Dy	-	3.69	-	-	-	-	-	6.53	-	-	-	-
Ho	-	0.78	-	-	-	-	-	1.48	-	-	-	-
Er	-	2.00	-	-	-	-	-	4.39	-	-	-	-
Tm	-	0.28	-	-	-	-	-	0.68	-	-	-	-
Yb	3.83	1.85	4.54	3.39	9.03	6.90	10.18	4.90	2.97	4.25	3.80	5.95
Lu	0.57	0.27	0.71	0.56	1.35	1.03	1.45	0.73	0.44	0.62	0.59	0.92
Cr	98	196	19	5	2	<1	1	5	232	1	117	<1
Ni	24	165	9	3	2	3	3	1	3	62	4	17
Co	36.0	52.3	13.5	3.8	3.8	2.4	1.9	4.6	45.0	22.0	36.5	25.0
Sc	36.8	35.8	14.5	4.6	20.2	14.9	21.4	6.5	42.9	36.2	35.6	34.3
V	267	196	115	21	16	6	4	31	272	318	235	187
Cu	32	72	50	15	8	5	3	3	24	7	2	7
Pb	2	2	14	20	17	24	13	19	4	8	<1	8
Zn	110	81	51	24	69	46	54	28	56	101	127	77
Mn	1471	1197	680	385	930	245	330	380	1471	1704	1704	1626
Bi	-	-	-	-	-	-	-	-	-	-	-	-
Cd	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	1.5	1.0	1.0	3.8	1.5	2.8	2.5	3.5	<0.5	<0.5	<0.5	<0.5
W	<0.5	<0.5	0.5	3.0	<0.5	3.0	3.3	1.3	<0.5	<0.5	<0.5	1.5
Mo	2.0	<0.5	<0.5	<0.5	1.0	<0.5	4.5	2.5	1.0	<0.5	<0.5	2.0
F	705	385	525	480	625	525	850	255	210	480	680	990
Cl	<25	<25	75	<25	400	150	150	100	150	50	<25	<25
Br	0.4	0.3	1.0	0.6	0.3	1.4	1.3	0.8	0.6	<0.3	<0.3	<0.3
B	15	<5	10	15	20	25	15	10	15	30	20	20
Be	5.5	3.5	4.0	3.0	5.0	5.5	4.5	4.0	5.5	7.0	6.0	6.0
Au	2.5	<0.3	3.0	0.3	2.8	2.8	4.3	<0.3	<0.3	<0.3	<0.3	2.5
Ge	5	5	<5	<5	<5	<5	5	<5	<5	<5	<5	<5
As	4.8	0.8	0.5	0.3	5.0	11.8	7.3	1.0	4.5	16.0	3.0	4.5
Se	<0.4	<0.4	0.9	<0.4	<0.4	2.4	6.3	1.8	<0.4	<0.4	1.7	5.5
Sb	0.4	0.1	0.1	0.3	1.0	2.0	1.5	0.5	1.4	0.4	0.7	1.5
206/204	-	-	-	-	-	-	-	-	-	-	-	-
207/204	-	-	-	-	-	-	-	-	-	-	-	-
208/204	-	-	-	-	-	-	-	-	-	-	-	-
D180	-	5.4	-	-	-	-	-	9.0	-	-	-	-
E-Nd	-	5.3	-	-	-	-	-	2.7	-	-	-	-
tDM	-	0.98	-	-	-	-	-	1.03	-	-	-	-
E-400	-	5.1	-	-	-	-	-	2.4	-	-	-	-

APPENDIX 4 (cont'd.)

Pluton WCNB#	G 298	G 299	G 260	G 263	G 264	G 287	G 297
SiO <sub>2</sub>	53.50	53.05	70.10	68.40	68.90	70.60	61.00
TiO <sub>2</sub>	1.54	0.92	0.27	0.43	0.39	0.37	1.17
Al <sub>2</sub> O <sub>3</sub>	16.60	18.10	13.30	15.50	15.20	14.30	15.00
Fe <sub>2</sub> O <sub>3</sub>	4.50	2.36	2.56	1.41	2.00	0.97	3.86
FeO	5.40	6.10	0.60	1.70	1.00	1.20	3.50
MnO	0.18	0.16	0.03	0.05	0.05	0.04	0.16
MgO	3.43	5.02	0.26	1.63	1.71	0.38	1.55
CaO	3.47	2.08	1.52	1.13	1.07	0.46	3.02
Na <sub>2</sub> O	6.67	1.76	2.03	4.25	3.96	3.05	5.32
K <sub>2</sub> O	0.11	4.70	7.47	3.39	3.75	7.22	3.26
P <sub>2</sub> O <sub>5</sub>	0.46	0.16	0.03	0.12	0.10	0.12	0.38
LOI	2.39	4.66	0.54	1.31	1.16	1.00	0.93
TTE	0.21	0.31	0.31	0.27	0.27	0.23	0.25
Total	98.46	99.36	99.02	99.59	99.56	99.94	99.40
Trace Elements							
Rb	<5	182	135	125	135	173	90
Cs	0.2	11.4	0.6	4.2	4.8	0.8	0.7
Ba	20	681	1225	529	586	1012	519
Sr	125	116	147	127	112	105	185
Ga	26	24	24	22	22	17	23
Li	6	17	4	18	22	2	2
Tl	<1	<1	2	4	<1	6	3
Ta	1.3	1.1	1.9	1.2	1.1	1.2	1.2
Nb	24	16	35	21	21	16	21
Hf	10.5	4.4	14.5	11.0	10.5	6.3	10.7
Zr	416	153	544	393	374	211	403
Y	70	35	88	61	62	55	70
Th	8.9	11.5	19.0	24.5	25.0	20.5	11.5
U	3.5	3.1	6.3	6.6	6.7	6.7	4.3
La	42	44	76	66	66	60	42
Ce	88	80	146	125	122	102	84
Pr	-	-	-	-	-	-	-
Nd	42.0	33.5	61.0	53.0	51.0	45.0	41.0
Sm	8.85	5.96	13.00	10.40	10.20	8.51	8.75
Eu	2.81	1.69	2.75	1.64	1.38	1.34	2.78
Gd	-	-	-	-	-	-	-
Tb	1.70	0.80	2.30	1.70	1.50	1.50	1.60
Dy	-	-	-	-	-	-	-
Ho	-	-	-	-	-	-	-
Er	-	-	-	-	-	-	-
Tm	-	-	-	-	-	-	-
Yb	6.15	3.05	8.59	5.40	5.15	4.48	6.24
Lu	0.95	0.47	1.29	0.79	0.77	0.64	0.94
Cr	<1	145	3	3	3	3	<1
Ni	3	109	2	1	1	2	3
Co	17.0	21.8	1.8	2.5	2.7	3.3	9.4
Sc	20.3	25.0	10.4	16.8	14.2	10.4	16.6
V	125	195	4	26	21	29	46
Cu	1	2	2	2	2	4	2
Pb	<1	8	4	<1	<1	4	20
Zn	72	82	7	25	27	10	75
Mn	1394	1239	210	350	380	280	1239
Bi	-	-	-	-	-	-	-
Cd	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sn	4.0	<0.5	10.0	4.0	6.0	9.0	6.0
W	<0.5	0.5	1.5	1.5	1.0	2.5	2.0
Mo	<0.5	1.0	<0.5	<0.5	<0.5	<0.5	2.0
F	970	1050	370	920	810	220	820
Cl	<25	<25	100	100	200	200	<25
Br	<0.3	1.2	1.4	<0.3	<0.3	1.2	0.5
B	<5	30	30	30	40	20	<5
Be	6.0	7.5	7.0	8.0	9.0	3.0	6.0
Au	<0.3	<0.3	2.5	<0.3	<0.3	1.0	<0.3
Ge	<5	5	<5	<5	<5	<5	10
As	3.5	6.5	1.5	2.0	1.0	0.5	2.5
Se	3.6	<0.4	3.2	<0.4	1.8	2.6	2.7
Sb	0.9	1.1	1.1	0.4	0.5	0.3	0.8
206/204	-	-	-	-	-	-	-
207/204	-	-	-	-	-	-	-
208/204	-	-	-	-	-	-	-
D18O	-	-	-	-	-	-	-
E-Nd	-	-	-	-	-	-	-
tDM	-	-	-	-	-	-	-
E-400	-	-	-	-	-	-	-

## APPENDIX 5

### Analytical techniques

#### Sampling procedures and preparation

The freshest material obtainable was collected in areas of previous road construction blasting or by the use of a 10 lb sledge hammer. Usually one piece of rock containing a volume of about 800 cm<sup>3</sup> was collected. Two cuts with a diamond saw were made on one side of this piece to obtain a slab which was subsequently trimmed and polished into a 12 x 17 cm slab for modal analyses. The remaining piece was washed with detergent, then broken up into about 4-cm cubes, with care being taken to discard any weathered surfaces or any sawn surfaces which might have metal contamination from the rock saw. This material was reduced to pea size in jaw and cone crushers. About 1 100 g split of this was further reduced to a powder in a swing mill. Gaspésie samples (WXMG prefix) were pulverized in a WC (tungsten-carbide) mill, whereas New Brunswick samples were reduced in an agate mill. Three mill loads were required for the agate mill and only one for the WC mill. At each step of the crushing process, care was taken to clean the crushing equipment. To further ensure against cross sample contamination, a portion of each sample was first processed and discarded before actually preparing a sample.

#### Modal analysis

For coarse- to fine medium-grained samples, modal data was obtained by a combination of points counts on a 17 x 12 cm rock slab, stained using the methods of Norman (1974), and a regular thin section. Percentages of quartz, plagioclase, K-feldspar, and mafics were obtained from the slab, whereas proportions of mafic minerals and percentages of accessory phases were obtained from the thin section. For Gaspésie samples (WXMG prefix), 2000 points were counted on a slab and 1000 points on a thin section; whereas for New Brunswick samples (WXNB prefix) 1000 points were counted on both slab and thin section. For fine grained samples, 1000 points were counted on a stained thin section only.

#### Rock major and trace element analysis

Geochemical analyses were obtained from a number of different sources and by a combination of different techniques. To monitor and improve quality of analyses, a large portion (about 30-40%) of samples were analyzed as blind duplicates. Duplicates that compared closely were averaged whereas those that didn't were reanalyzed. Also to obtain information on precision and accuracy, two personal

standards, a granite and a basalt, were analyzed 4 to 10 times as blind duplicates. Accepted values for these standards were obtained from some of the best analytical labs in the world, including Australia National University, Memorial University, and the Geological Survey of Canada. Standard accepted values and information on the precision and accuracy of analytical data presented in this report are tabulated below. Analytical techniques employed are outlined below. Based on standard results and many duplicate and triplicate analyses, the major and most trace element data presented in this report are of very high quality. However, an examination of precision data indicates that results for some trace elements (e.g. Bi, Sn, Au) are of poor quality. These values are reported only because they are for elements of potential economic interest. They should be treated with caution.

All major element analyses were carried out by X-ray Assay Laboratories (XRAL), Toronto on fused glass discs by X-ray fluorescence spectrometry (XRF) using the method of Norrish and Hutton (1969). For Gaspésie samples (WXMG prefix), H<sub>2</sub>O and CO<sub>2</sub> were determined at University of Montreal by C. Gariépy by collection on microabsorption tubes. The FeO was determined by dichromate titration at University of Montreal (WXMG samples) or XRAL (WXNB samples).

For most "WXMG" samples, analyses were carried out at the University of Montreal: Rb, Ba, Sr, Ga, Nb, Zr, Y, Cr, Ni, Cu, and Zn were analyzed on pressed powder pellets by XRF techniques and Cs, Ta, Hf, Th, U, La, Ce, Nd, Sm, Eu, Tb, Ho, Tm, Yb, Lu, As, and Sb were analyzed by instrumental neutron activation techniques (INAA). For both "WXMG" and "WXNB" samples for which the full spectrum of REE are reported, the following trace element analyses were carried out at Memorial University of Newfoundland (MUN): Cs, Li, Ta, Hf, Th, U, REE, and Sc by inductively coupled plasma-mass spectrometry (ICP-MS) using techniques of Jenner et al. (1990). For "WXNB" samples, Rb, Ba, Sr, Ga, Nb, Zr, and Y analyses were carried out on pressed powder pellets by XRF techniques at MUN. For Cr, Ni, V and Zn, values obtained by XRF at MUN were averaged with values obtained by direct current plasma atomic emission spectrometry (CDPAES) (Ni, Zn, and V) and INAA (Cr) at XRAL. All other trace element analyses were carried out by XRAL employing the following techniques: INAA (Cs, Ta, Hf, Th, U, La, Ce, Nd, Sm, Eu, Tb, Yb, Lu, Co, Sc, W, Mo, Br, Au, As, Se, and Sb), DCPAES (Cu, Pb, Mn, Bi, Cd, B, Be, and Ge), XRF (Sn and Cl), atomic absorption spectrometry (AAS) (Li) and wet chemical technique (F).

APPENDIX 5 (cont'd.)

Basalt Standard - TB135											Granite Standard - TB121										
	A.V.	Lab	Avg	SD	N	Prec	Acc	Min	Max	Lab	A.V.	Lab	Avg	SD	N	Prec	Acc	Min	Max	Lab	
SiO <sub>2</sub>	43.10	G	43.53	0.13	10	0.3	101	43.33	43.75	X	69.24	G	68.86	0.11	10	0.2	99	68.59	68.99	X	
TiO <sub>2</sub>	4.02	G	4.06	0.04	10	1.1	101	3.99	4.14	X	0.43	G	0.43	0.01	10	1.4	100	0.43	0.44	X	
Al <sub>2</sub> O <sub>3</sub>	14.29	G	14.28	0.06	10	0.4	100	14.21	14.43	X	14.36	G	14.45	0.04	10	0.3	101	14.37	14.55	X	
Fe <sub>2</sub> O <sub>3</sub>	5.30	G	5.81	0.15	10	2.6	110	5.50	6.01	X	1.43	G	1.97	0.12	10	6.1	138	1.76	2.18	X	
FeO	10.58	G	10.36	0.14	10	1.3	98	10.24	10.72	X	2.21	G	1.73	0.10	10	5.8	78	1.60	1.94	X	
MnO	0.28	G	0.27	0.00	10	1.2	96	0.26	0.27	X	0.09	G	0.09	0.00	10	2.0	101	0.08	0.09	X	
MgO	6.48	G	6.51	0.04	10	0.6	100	6.44	6.57	X	1.29	G	1.31	0.02	10	1.6	102	1.28	1.36	X	
CaO	8.99	G	8.95	0.04	10	0.5	100	8.86	9.00	X	3.88	G	3.87	0.02	10	0.5	100	3.84	3.90	X	
Na <sub>2</sub> O	2.76	G	2.57	0.08	10	3.0	93	2.47	2.71	X	2.51	G	2.74	0.09	10	3.4	109	2.62	2.87	X	
K <sub>2</sub> O	1.01	G	1.02	0.02	10	1.7	101	0.99	1.05	X	3.30	G	3.32	0.05	10	1.6	101	3.26	3.41	X	
P <sub>2</sub> O <sub>5</sub>	0.57	G	0.58	0.00	10	0.6	102	0.58	0.59	X	0.08	G	0.08	0.00	10	5.3	107	0.08	0.09	X	
LOI	2.61	G	2.05	0.15	10	7.3	79	1.89	2.37	X	1.19	G	1.14	0.09	10	8.0	96	0.94	1.26	X	
Rb	37	A	36	2	4	4	99	34	38	M	99	A	96	1	4	1	97	95	97	M	
Cs	2.7	M	2.6	0.2	9	9	96	2.4	3.2	X	1.4	M	1.3	0.1	9	10	89	1.1	1.5	X	
Ba	258	A	245	17	4	7	95	227	272	M	748	A	849	2	4	0	113	846	850	M	
Sr	358	A	362	1	4	0	101	360	363	M	193	A	188	1	4	1	97	187	190	M	
Ga	23.5	A	23.8	0.4	4	2	101	23	24	M	13.5	A	14.3	0.4	4	3	106	14.0	15.0	M	
Li	16	M	19	1	7	6	118	17	20	X	26	M	29	1	6	5	112	27	31	X	
Ta	0.9	M	0.7	0.2	9	22	81	0.5	1.0	X	0.8	Q	1.0	0.2	9	20	127	0.6	1.3	X	
Nb	9.3	A	11.9	0.4	4	3	127	11.3	12.3	M	10.3	A	11.5	0.4	4	4	111	11.1	12.1	M	
Hf	4.7	M	4.8	0.3	9	7	103	4.1	5.2	X	4.9	M	4.6	0.2	7	4	95	4.4	4.8	X	
Zr	210	A	214	2	4	1	102	212	217	M	138	A	133	2	4	1	96	131	135	M	
Y	32	A	36	0	4	1	111	35	37	M	13	A	15	1	4	7	115	13	16	M	
Th	0.7	M	0.8	0.1	9	20	116	0.6	1.1	X	8.0	M	8.0	0.3	9	4	101	7.6	8.5	X	
U	0.23	M	0.16	0.15	9	96	66	0.0	0.4	X	1.4	M	1.6	0.2	9	14	113	1.3	2.0	X	
La	14.5	M	17.3	0.8	9	5	119	16.1	18.5	X	26.6	M	29.5	1.5	9	5	111	26.6	31.4	X	
Ce	38	M	45	3	9	7	116	39	50	X	51	M	51	3	9	6	101	48	58	X	
Nd	25	M	26	2	9	9	103	23	30	X	18	M	18	1	9	5	101	17	20	X	
Sm	6.40	M	5.86	0.20	9	3	92	5.58	6.25	X	3.08	M	2.80	0.08	9	3	91	2.67	2.91	X	
Eu	2.92	M	3.06	0.09	9	3	105	2.90	3.18	X	0.83	M	0.82	0.07	9	9	98	0.68	0.91	X	
Tb	1.13	M	0.96	0.11	9	11	85	0.80	1.10	X	0.41	M	0.48	0.06	9	13	116	0.40	0.60	X	
Yb	2.86	M	3.05	0.11	9	4	107	2.95	3.26	X	1.40	M	1.50	0.10	9	6	107	1.34	1.64	X	
Lu	0.41	M	0.45	0.02	9	3	108	0.43	0.48	X	0.21	M	0.23	0.02	9	7	108	0.19	0.25	X	
Cr	38	A	33	2	4	7	85	30	36	M+X	10	A	10	1	4	6	95	9	11	M+X	
Ni	61	A	50	0	4	0	81	50	50	M+X	3	A	3	0	4	0	112	3	3	M+X	
Co	-	-	55	2	9	3	-	52	58	X	-	-	57	2	9	3	-	54	59	X	
Sc	36.5	M	41.1	1.3	9	3	112	38.9	43.4	X	11.6	M	12.9	0.3	9	3	100	12.4	13.4	X	
V	398	A	459	2	4	0	115	457	462	M+X	65	A	79	1	4	2	120	77	81	M+X	
Cu	41	A	30	0	4	1	75	30	31	M+X	4	A	3	0	4	0	75	3	3	M+X	
Pb	3	M	1	1	8	265	14	0	4	X	8	M	8	2	8	20	95	4	10	X	
Zn	129	A	153	1	4	0	118	152	154	M+X	34	A	28	0	4	1	81	28	28	M+X	
Mn	1737	A	2047	38	7	2	118	2014	2091	X	615	A	656	25	8	4	107	610	700	X	
Bi	-	-	0.0	0.1	7	245	-	0.0	0.2	X	-	-	0.03	0.07	7	245	-	0	0	X	
Cd	-	-	0.0	0.0	9	0	-	0.0	0.0	X	-	-	0.00	0.00	8	0	-	0	0	X	
Sn	-	-	1	2	9	212	-	0	7	X	-	-	0	1	8	186	-	0	2	X	
W	-	-	11	2	9	20	-	7	15	X	-	-	488	15	9	3	-	470	510	X	
Mo	-	-	2	1	9	75	-	0	4	X	-	-	5	1	9	28	-	2	7	X	
F	-	-	571	84	8	15	-	380	680	X	-	-	243	73	8	30	-	160	400	X	
Cl	-	-	25	66	8	265	-	0	200	X	-	-	0	0	8	0	-	0	0	X	
Br	-	-	3.3	0.8	9	23	-	2.5	5.1	X	-	-	2.7	0.7	9	25	-	1.5	3.7	X	
B	-	-	6	7	8	111	-	0	20	X	-	-	19	11	8	56	-	0	30	X	
Be	-	-	5	0	8	6	-	5	6	X	-	-	3	1	8	17	-	2	4	X	
Au	-	-	1	3	9	283	-	0	10	X	-	-	2	3	9	153	-	0	11	X	
Ge	-	-	4	5	9	112	-	0	10	X	-	-	4	5	8	129	-	0	10	X	
As	-	-	0	0	9	187	-	0	1	X	-	-	1	0	9	89	-	0	1	X	
Se	-	-	1.0	1.3	9	124	-	0.0	3.4	X	-	-	0.0	0.0	9	0	-	0.0	0.0	X	
Sb	-	-	0.1	0.1	9	118	-	0.0	0.2	X	-	-	0.1	0.1	9	75	-	0.0	0.3	X	

A.V. = accepted values.  
 Lab = abbreviation for analytical lab where analyses carried out:  
 G = Geological Survey of Canada; A = Australian National University;  
 M = Memorial University of Newfoundland; Q = University of Montreal;  
 X = X-ray Assay Laboratories.  
 Values obtained in this study: Avg = mean; SD = standard deviation;  
 N = number of analyses; Prec = precision ((SD\*100)/avg); Acc = accuracy  
 (100\*mean)/accepted value); Min = minimum value; Max = maximum value.