APPENDIX A1

Rock sample locations and descriptions

JCU No.	Sample No.	Northing (m)	Easting (m)	Location	Thin Section	Microprobe	XRD	Majors	Traces	REE	$^{40}Ar/^{39}Ar$	Sr Isotopes	Nd Isotopes	Pb Isotope
67720	S-16	9227017	794204	El Galeno Region	X	X		X	X	X	X	X	X	
67721	S-26	9226745	794774	El Galeno Region	X	X		X	X	X				
67722	S-55	9225913	794465	El Galeno Region	X	X		X	X	X				
67723	S-57	9226680	796058	El Galeno Region	X	X		X	X	X		X	X	
67724	S-18	9230960	794720	El Galeno Region	X			X	X	X				
67725	S-87	9235216	784989	Mishacocha	X	X		X	X	X				
67726	S-11	9211157	800904	Aurora Patricia	X	X		X	X	X	X	X	X	
67727	S-38	9228798	801199	La Carpa Region	X	X		X	X	X	X	X	X	
67728	S-35	9224490	799321	Michiquillay North	X			X	X	X				
67729	S-36	9224565	799745	Michiquillay North	X			X	X	X				
67730	S-54	9224321	800967	Michiquillay North	X			X	X	X				
67731	S-58	9224008	796602	Michiquillay North	X			X	X	X				
67732	S-59	9223743	797582	Michiquillay North	X	X		X	X	X	X	X	X	
67733	S-60	9223187	799620	Michiquillay North	X			X	X	X				
67734	S-MCarpa	9230300	802600	Minas Carpa (CP012)	X			X	X	X				
67735	S-Chail	9232500	791300	Chailhuagon	X	X		X	X	X		X	X	
67736	H-1 (152m)	9232130	791250	Chailhuagon	X									X
67737	S-Hual	9235440	790840	Hualyamachay Sur	X			X	X	X				
67738	S-H22 (244)	9221145	795729	Michiquillay Prospect	X	X		X	X	X				
67739	S-H22(176)	9221140	795725	Michiquillay Prospect	X	X		X	X	X	X	X	X	
67740	S-H22(180)	9221140	795725	Michiquillay Prospect	X	X		X	X	X				
67741	H-22 (176m)	9221140	795725	Michiquillay Prospect	X									
67742	I-23 (269m)	9221046	795833	Michiquillay Prospect	X		X							
67743	L-17.5 (180m)	9221594	796143	Michiquillay Prospect	X		X							
67744	L-17.5 (288m)	9221594	796143	Michiquillay Prospect	X									
67745	J-20 (170m)	9221335	795920	Michiquillay Prospect	X									
67746	J-20 (178m)	9221335	795920	Michiquillay Prospect	X									
67747	J-20 (333m)	9221335	795920	Michiquillay Prospect	X									
67748	J-20 (347m)	9221335	795920	Michiquillay Prospect	X									X
67749	S-T1	9228264	795871	El Galeno GN-46 (57m)	X	X		X	X	X				
67750	S-T2	9229000	795598	El Galeno GN-37 (310m)	X	X		X	X	X	X	X	X	
67751	S-T3	9228695	795763	El Galeno GN-42 (246m)	X	X		X	X	X				
67752	S-T4	9228700	796044	El Galeno GN-39 (432m)	X	X		X	X	X	X	X	X	
67753	GA-04 (192m)	9228780	795640	El Galeno	X									

JCU No.	Sample No.	Northing (m)	Easting (m)	Location	Thin Section	Microprobe	XRD	Majors	Traces	REE	$^{40}Ar/^{39}Ar$	Sr Isotopes	Nd Isotopes	Pb Isotope
67754	GN-41 (258m)	9228597	795899	El Galeno	X									
67755	GN-42 (96m)	9228695	795763	El Galeno	X									
67756	GN-42 (465m)	9228695	795763	El Galeno	X									
67757	GN-39 (400m)	9228700	796044	El Galeno	X									
67758	GN-39 (166m)	9228700	796044	El Galeno	X									X
67759	GN-39 (432m)	9228700	796044	El Galeno	X									X
67760	GN-39 (436m)	9228700	796044	El Galeno	X									
67761	GA-04 (174m)	9228780	795640	El Galeno	X		X							
67762	GN-39 (215m)	9228700	796044	El Galeno	X		X							
67763	GN-43 (14.9m)	9228400	795950	El Galeno	X		X							
67764	GN-43 (14.9m)	9228400	795950	El Galeno	X		X							
67765	S-Yana	9227200	777600	Yanacocha CLL-5 (795m)	X			X	X	X		X	X	X
67766	Yana	9227200	777600	Yanacocha CLL-5 (569m)	X									X
67767	S-46	9233180	795720	Cerro Perol East	X	X		X	X	X	X	X	X	
67768	S-50	9233920	792940	Cerro Perol	X			X	X	X				
67769	S-28	9225911	814373	Cerro Montana	X			X	X	X		X	X	
67770	S-31	9223290	815725	Cerro Montana	X	X		X	X	X	X	X	X	
67771	S-32	9221344	807480	Cruz Conga	X	X		X	X	X	X	X	X	
67772	S-21	9231380	797708	La Carpa Region	X	X		X	X	X	X	X	X	
67773	S-61	9218321	762720	Yanacocha Rd	X			X	X	X	X	X	X	
67774	S-64	9219230	764453	Yanacocha Rd	X	X		X	X	X				
67775	S-66	9219490	766253	Yanacocha Rd	X			X	X	X				
67776	S-68	9218935	766313	Yanacocha Rd	X			X	X	X				
67777	S-MC4	9229470	788645	Minas Conga Region	X	X		X	X	X	X	X	X	
67778	S-63	9219560	764260	Yanacocha Rd	X			X	X	X				

ROCK DESCRIPTIONS FOR GEOCHEMICAL SAMPLES

MAFIC DYKES

Sample 18 (Galeno)

In thin section, this sample is characterised by abundant acicular or needle-like feldspar grains. The feldspar grains are plagioclase, approximately 0.2 mm in length and display minor twinning. No zoning in the plagioclase grains was observed. The fine-grained, acicular feldspar have a trachytic texture appearance and are slightly aligned. Minor clinopyroxene grains and possibly hornblende are evident but are strongly replaced by carbonate plus chlorite. Calcite infill is evident in amygdule-like features that are angular in shape. Calcite infill is rimmed by light green chlorite. Amygdules are suggestive of suggest of shallow level emplacement. This idea of a shallow level emplacement is supported by the trachytic texture of the matrix, possible the result of a flow system. The groundmass has been strongly-pervasively replaced by secondary carbonate and chlorite. Chlorite alteration is pervasive throughout the sample. Very fine-grained opaque minerals, dominantly magnetite, are euhedral-subhedral shape and abundant. This sample is inferred to be a gabbroic dyke.

Sample 55 (Galeno)

In hand specimen, the sample contains cloudy white feldspar phenocrysts that display minor sericite replacement, 0.5-2.5 mm in length and euhderal-subhedral. Pyroxene grains appear moderately altered, are dusty in appearance and 0.6-3.0 mm in length. Veins composed of feldspar-calcite crosscut all other features. The matrix is dark grey to black in colour.

In thin section, the plagioclase phenocrysts are dominantly euhedral, display both zoning and twinning features and exhibit minor-moderate sericite replacement. Sericite alteration occurs toward the cores of the feldspar grains. Clinopyroxene phenocrysts exhibit primary euhedral grain boundaries, however the grains have undergone moderate-pervasive sericite replacement. Sericite replacement is strongest along and around intragranular fractures. Hornblende phenocrysts are rare and have jagged grain boundaries. The groundmass is composed of fine-grained plagioclase grains that display twinning and weak zoning textures. Strong-moderate carbonate and sericite replacement has overprinted some of the primary groundmass. Medium-grain magnetite is also present, as well as very weak chalcopyrite mineralisation. This sample is inferred to be a hornblende gabbroic dyke.

Sample 57 (Galeno)

This rock is characterised by coarse (2-8 mm) equigranular feldspar grains that are generally clear-cloudy white, 1-2 mm and mostly euhedral-subhedral. Pyroxene grains are ~2 mm in size, dominantly anhedral and appear in close association with chlorite minerals.

In thin section, the holocrystalline sample is dominantly composed of euhedral-subhedral plagioclase phenocrysts that display both twining and zoning textures. Large, phenocryst-size, plagioclase grains are euhedral in shape, whereas the smaller grains are dominantly anhedral. Both plagioclase grain populations exhibit minor-moderate sericite replacement that is commonly well developed along fracture planes. Clinopyroxene phenocrysts are subhedral-euhedral and may display simple twinning. Grain boundaries between pyroxene grains are undulose. Medium-grained magnetite grains are often angular to euhedral. Chlorite alteration is evident throughout the sample and appears to have preferentially replaced certain minerals. Pervasive chlorite alteration of the minerals has made is difficult to determine its primary composition. Weak secondary muscovite is also present. Minor carbonate alteration is generally found within late fractures as an infill mineral. This rock is inferred to be a gabbroic diorite dyke.

Sample 16 (Galeno)

This weakly porphyritic sample contains phenocrysts of clinopyroxene and plagioclase. The groundmass is medium-grained and composed of angular feldspar grains. Plagioclase grains display both simple twinning and oscillatory zoning. Some grains have been affected by minor-moderate sericite replacement. Some of the clinopyroxene grains display zoning and twinning and contain feldspar ± Fe-Ti oxides. Grains are generally euhedral-subhedral. Rare hornblende phenocrysts are evident. Minor sericite-carbonate-chlorite alteration is evident, and contains minor amounts of pyrite and chalcopyrite. Overall the sample is generally fresh with a weak propylitic alteration and is inferred to be a hornblende gabbro.

Sample 87 (Laguna Mishacocha)

In hand specimen this sample is characterised by feldspar phenocrysts that are ~0.3-2.0 mm in size, euhedral-subhedral in shape and generally clear in appearance. Relict mafic minerals(?) are evident, often bordered by a magnetite or hematite and probably undergone strong alteration. Wormy silicic vein(s) are evident, these are ~1-2 mm thick and are crosscut by late brittle fractures. The fractures appear to be infilled with hematite and have a thin selvage of magnetite. The matrix is black-dark grey and trachytic in appearance.

In thin section, there are two populations of plagioclases, a phenocryst group (greater than 1 mm) that are subhedral in shape, display both twinning and zoning textures and show evidence of weak sericite replacement towards the cores. A second population of feldspar grains are less than 1 mm in size and define the groundmass. The feldspar groundmass grains are elongate-acicular in shape, subhedral-anhedral and exhibit minor zoning textures. Euhedral-subhedral, fine-grained pyroxene grains also define the groundmass. The groundmass has undergone moderate carbonate and sericite replacement. Fine-grained primary magnetite is present, along with weak chalcopyrite mineralisation. No quartz grains were observed and possible mafic minerals are pervasively replaced. This sample is inferred to be a gabbroic diorite.

Sample 26

In hand sample, this rock contains acicular plagioclase grains (0.5 mm) and calcite amygdules. The sample is dark grey to dull green. The dull green appearance suggests chlorite alteration. This is confirmed in thin section, where the groundmass has been partially replaced by chlorite. Plagioclase grains display simple twinning and oscillatory zoning. Chlorite and minor calcite has pervasively replaced pyroxene(?) grains that are ~0.5 mm in length. Overall, the sample displays a moderate-strong chlorite alteration.

INTRUSIVE ROCKS

Sample 28 (Co Montana)

This porphyritic sample contains phenocrysts of plagioclase and hornblende, with minor amounts of magnetite, apatite and zircon. Plagioclase phenocrysts are euhedral-subhedral, display oscillatory zoning and twinning features, some grains display evidence of K-feldspar and minor sericite replacement. Hornblende phenocrysts range from euhedral-subhedral and show moderate chlorite replacement around the rims or along fracture planes. Accessory minerals include fine to medium-grained magnetite, apatite and zircon, although no quartz grains are evident. The groundmass has a trachytic-mosaic texture and feldspathic composition. Minor amounts of sericite-carbonate-chlorite alteration are evident, especially within the groundmass. The sample is inferred to be hornblende diorite.

Sample 31 (Co Montana)

This sample has a crowded porphyritic texture and contains phenocrysts of plagioclase, clinopyroxene and hornblende. Minor amounts of apatite and zircon are also present. The plagioclase grains display moderate-strong sericite-carbonate-chlorite alteration and some of the grains display oscillatory zoning and twinning. Subhedral-euhedral hornblende grains are moderately cracked and contain Fe-Ti oxide plus feldspar inclusions. Clinopyroxene grains are generally fractured with moderate-minor sericite replacement. Overall the sample contains moderate-strong chlorite-sericite alteration and is classified as a hornblende diorite.

Sample 11 (Aurora Patricia)

This moderately crowded porphyritic sample contains phenocrysts of hornblende and plagioclase that are set in a feldspathic groundmass. Euhedral-subhedral hornblende grains commonly contain small feldspar and/or magnetite inclusions, and are light green to green in colour. Some hornblende grains display fractures and weak chlorite alteration. Plagioclase grains display oscillatory zoning and simple or crosshatched twinning, some grains have minor fractures. Rounded quartz grains are rare. Sericite-carbonate replacement of plagioclase grains is particularly evident near the core or along fractures. The sample also contains minor apatite and zircon grains, as well as a moderate amount of medium-fine grained magnetite as accessory minerals. Overall, the sample appears to be generally unaltered and is inferred to be a hornblende granodiorite.

Sample 38 (La Carpa)

This sample is characterised by large feldspar phenocrysts, 1-4 mm in size, that are cloudy white-clear in colour and subhedral-anhedral. Euhedral hornblende grains are moderately abundant, mostly 1-2mm in length, acicular in shape and contain minor inclusions. Quartz grains are sub-anhedral, generally well rounded and ~2 mm in size. The matrix is light grey, feldspathic in appearance.

In thin section, plagioclase grains exhibit oscillatory zoning and twinning are generally unaltered. Some plagioclases contain intragranular fractures with minor carbonate and muscovite replacement. Hornblende grains are a yellowish green to green in colour, in parts show replacement textures that are associated with fractures, and grains often have chlorite, hematite and magnetite spots around the rim. Most quartz grains are well rounded and have a fine-grained recrystallised boundary. Biotite phenocrysts have a piokilitic texture with inclusions of feldspar, light brownish green-dark brown in colour and also rimmed with hematite and magnetite, they also exhibit minor chloritic replacement. Fine apatite and zircon crystals also occur throughout the slide. The sample is relatively unaltered, although contains very minor amount of sericitic, carbonate and chlorite alteration.

Sample 35 (Michiquillay North)

This sample is characterised by moderately abundant cloudy feldspar phenocrysts, they are generally subhedral, 0.7-4.0 mm in size. Hornblende phenocrysts occur in two populations, small (0.3 mm) dominant population and a larger (~2 mm) less abundant population. Quartz grains are generally rounded and range is size from 0.5-2.0 mm. The matrix is grey to light grey in colour.

In thin section, plagioclase grains show twinning and oscillatory zoning, occasionally have minor fracture and in places have minor-moderate sericitic alteration. Hornblende grains are mostly unaltered and green-dirty brown in colour. Quartz grains are often rounded, some grains contains good fluid inclusion trails, dominantly brine and vapour inclusions and have a thin recrystallised rim. Others minerals include minor amounts of apatite, zircon and magnetite. The occurrence of carbonates and epidote indicates minor propylitic alteration. This sample is inferred to be a hornblende granodiorite.

Sample 36 (Michiquillay North)

In thin section, plagioclase grains show strong zoning and twinning, grains are generally euhedral with minor intragranular fractures filled with sericite, chlorite and calcite. Relict biotite and hornblende grains have undergone intense chlorite and carbonate alteration with only the original grain shape preserved, plus very fine-grained opaque minerals are located within zones of chlorite alteration. These strongly altered grains appear to have a higher proportion of opaque minerals in comparison with the rest of the sample. Other minerals present within the sample include epidote, apatite, zircon and minor quartz (with few inclusions). Minor amounts of subangular opaques are found throughout the sample and range from fine to medium-grained. The matrix is equigranular, of feldspathic composition and shows very little evidence of alteration (possibly some K-feldspar alteration). The main alteration features are calcite and chlorite replacement that is mostly restricted to hornblende and biotite grains. This sample is a hornblende-biotite granodiorite.

Sample 54 (Michiquillay North)

Sample is characterised by a moderate abundance of sub-euhedral feldspars, dominantly with a cloudy to white appearance and ~0.5-2 mm in length. Mafic minerals are present in two populations a) (~3mm) euhedral, slightly dirty population with small inclusions possibly biotite and b) a smaller (~0.5mm) population with euhedral-subhedral boundaries, probably hornblende. Rounded quartz grains occur and are ~3-5mm in diameter. The matrix is a clear, light grey and feldspathic.

In thin section, the plagioclase grains are moderate-strongly replaced by sericite and carbonate material, with replacement occurring both along the grain boundaries as well as in the core. Biotite and hornblende grains have been completely replaced by carbonate and chlorite minerals, with only the original grain boundary remaining. Quartz crystals are generally rounded, some with embayment features and in parts contain small brine-vapour fluid inclusion and trails (although not particularly large or abundant inclusions). Small, euhedral fine-grained apatite and zircon crystals are also apparent within the rock. The matrix is feldspathic and contains minor amounts of carbonate replacement. There also rare amygdules with calcite infill. The rock has a porphyritic texture and has undergone strong sericite-chlorite-carbonate alteration. Muscovite alteration is dominantly associated with the replacement of plagioclase, while chlorite and carbonate alteration appear to be have replaced biotite and hornblende grains. Minor amounts of opaques (magnetite) are present. This is an altered hornblende-biotite granodiorite.

Sample 58 (Michiquillay North)

Moderately abundantly feldspar phenocrysts (0.7-4 mm) are clear-cloudy white in colour and sub-euhedral. Mafic grains are subhedral-euhedral, often have a dusty black colour and range in size from 0.4-2 mm. Occasional quartz grains are rounded and ~1.5-2.0 mm in diameter. The matrix is a dark grey-black.

In thin section, the porphyritic rock has euhedral plagioclase phenocrysts showing strong oscillatory zoning. Most grains are unaltered although some grains show sericitic replacement. A minor amount of carbonate infill is also apparent in some cores. Quartz grains are unaltered and are often rounded-globular in shape. Grain boundaries often have a fine-grained recrystallised rim and crystals also contain small fluid inclusion trails (inclusions are mostly brine or brine-vapour). Hornblende grains have been pervasively replaced by chlorite-carbonate-sericite alteration with most retaining their euhedral crystal shape. Grains often have a rim of magnetite and/or hematite. Randomly throughout the matrix are regions rich in carbonate minerals (probably calcite), epidote, apatite and fine-medium grained magnetite. The matrix is a very fine-grained feldspathic composition. This sample is moderately altered and has undergone carbonate-chlorite-sericite alteration. The sample is a inferred to be a hornblende granodiorite.

Sample 59 (Michiquillay North)

This sample is characterised by cloudy white-clear feldspar phenocrysts, 0.5-4.0 mm in size and subhedral in shape. Quartz grains are rounded and range in size from 0.3-3.0 mm. Biotite grains are evident (~5 mm). Hornblende crystals are moderately abundant, acicular and elongate in shape, euhedral, 0.8-2.5 mm in size with the larger grains occasionally having inclusions. The matrix is a light grey colour with a slightly green tinge.

In thin section, the plagioclase phenocrysts exhibit some intracrystalline fractures and are weakly-strongly replaced by sericite. Grains are dominantly euhedral, show good oscillatory zoning plus multiple twinning, and may contain minor-moderate sieve textures toward the rim. Abundant hornblende grains are euhedral-subhedral, green-yellowish green in colour and occasionally show zoning. Quartz grains are globular in shape, occasionally contain embayments and have very small, rare inclusions. Biotite grains have been pervasively replaced by chlorite and muscovite but retained their original crystal shape. The replaced grains often have a fine-grained magnetite/hematite rich rim. Minor amount of clinopyroxene, apatite and zircon are also evident in thin section. The matrix is of felspathic composition. This sample is inferred to be a hornblende-biotite granodiorite.

Sample 60 (Michiquillay North)

In hand specimen, this sample is characterised by subhedral-euhedral feldspar grains, dominantly cloudy white in colour and range in size from ~0.5-3.0 mm in length. Minor amounts of mafic minerals are present, grains are generally very small (~0.3 mm) in size but have a wide distribution throughout the sample. Grains have a dull black appearance. Minor amounts of quartz and fine-grained pyrite are also present. Pyrite grains occur both within other minerals and as individual spots throughout the matrix. The matrix is a light grey in colour with a slightly green tinge.

In thin section, plagioclases contain abundant intragranular fractures that are filled with carbonate, muscovite and occasionally epidote. Plagioclase grains are euhedral and show moderate twinning. Rounded quartz grains are relatively common, subhedral in shape, medium to coarse grained and generally clean with small inclusions (brine-vapour inclusions, rare salt crystals). Hornblende grains have been totally replaced by chlorite and calcite. Fine magnetite crystals often rim the replaced hornblende grains. The sample also contains large calcite crystals that have an infill appearance. Other minerals evident within the slide are epidote and minor amounts of sulphide minerals. The sample has undergone strong chlorite and carbonate alteration. It is inferred to be a hornblende granodiorite.

VOLCANIC ROCKS

Sample 21 (La Carpa)

Sample contains moderate-abundant feldspar grains that are generally 0.5-3 mm, subhedral, cloudy white-dirty green in colour. Hornblende grains are euhedral, occasionally subhedral in shape, range in size from 0.5-7.0 mm, larger grains may contain fine inclusions of white grains (possibly feldspar). Quartz phenocrysts are rounded in shape and ~2 mm in size. The matrix is a greenish grey colour with patches of abundant green minerals (probably epidote or chlorite).

In thin section, the sample has a crowded porphyritic texture with phenocrysts of plagioclase and hornblende. Plagioclase crystals are moderately altered showing varying degrees in sericitic replacement and intragranular fractures, fractures are often filled with muscovite and epidote, some grains have a vague melting rim with twinning and oscillating zoning is common. Hornblende grains are green-dark green in colour, with occasional inclusions of feldspar and opaque minerals. Clinopyroxene and apatite grains are also evident. The matrix is feldspathic and has a slightly trachytic texture. Overall, sample 21 is a crowded porphyritic volcanic that has undergone a moderate chlorite-sericite-carbonate alteration and is inferred to be a hornblende andesite.

Sample 32 (Cruz Conga)

In hand sample, this weakly porphyritic volcanic sample contains plagioclase, hornblende and pyroxene phenocrysts that are set within a pinkish red matrix. The plagioclase grains are generally clear whilst the hornblende grains are dusty-dull in appearance.

In thin section, the plagioclase phenocrysts are mostly euhedral-subhedral in shape, display simple-multiple twinning features and in parts has been replaced by K-feldspar. Some of the grains have undergone moderate muscovite alteration. Euhedral hornblende phenocrysts have a brown and have hazy iron oxidations rim characteristic of calc-alkaline igneous rocks. Opaque rims result from the formation of magnetite by oxidation of iron in ferro-magnesium minerals, which is common for hornblende in volcanic rocks. Clinopyroxene grains are subhedral-euhedral in shape, weakly pleochroic from light orange to light yellow, some display oscillatory zoning and twinning, and occur both freely within the groundmass as well as inclusions in hornblende phenocrysts. The sample contains fine to medium-grained, euhedral apatite minerals that are slight blue in colour. The sample also contains minor-moderate amounts of magnetite. The groundmass has a very fine-grained trachytic texture and is of feldspathic composition. The sample displays very weak chlorite alteration. The sample is inferred to be basaltic andesite volcanic rock.

Sample 50 (C^o Perol)

In thin section the slide exhibits a chlorite-epidote vein that has resulted in an alteration selvage. Away from the vein and related features, feldspar phenocrysts are euhedral and range from little-intense sericite replacement. Feldspar grains close to the veins have a considerably strong alteration appearance with intense-pervasive sericite-chlorite replacement. Throughout the entire slide, hornblende grains have been totally replaced by chlorite and minor amounts of carbonate material, but the original grain shape has been preserved. Amygdules are often filled with carbonate material and range in size from 4-1mm in length. The matrix is felspathic in composition with slight-moderate chlorite alteration and has a quasi-trachytic texture. The matrix texture as well as the presence of amygdules is suggestive of a volcanic or extrusive system. The chlorite-epidote vein is ~0.3mm thick and resulted in an alteration selvage that ranges in thickness from 1-5mm thick. The vein is dominantly composed of epidote that appears to have been partially destroyed by late calcite infill. The selvage is epidote and chlorite rich, dirty in appearance and destroyed most the original wall rock features. Very little opaque minerals are found within or around the vein-selvage area.

Sample 61 (Cajamarca)

Sample contains abundant sub-euhedral feldspar grains of 0.5-2 mm size, white-clear in colour with rare inclusions of a dark mineral. Pyroxene minerals are also present, rose in colour, euhedral and ~1 mm in size. Hornblende grains are dominantly acicular, 1-4 mm, occasional inclusions are evident and few grains have a corroded hematite rim. The sample is brown in colour with abundant feldspar and pyroxene grains. Calcite rich fragments are also present and have a dark rim.

Eu-subhedral plagioclase grains show strong twinning and zoning, grains are abundant and most are unaltered although some have a sericitic rim. Pyroxene minerals are moderately abundance, occasionally exhibit zoning and twinning, are euhedral-subhedral in shape. Few hornblende grains are present, often display a thick hematite rim and are acicular in shape. The matrix is composed of fine, elongate felspar minerals and has a slight trachytic texture. This sample is a hornblende andesite.

Sample 64 (Cajamarca)

In outcrop exposure and in hand specimen the sample is characteristic of a porphyritic basalt lava flow. Subhedral-euhedral feldspar phenocrysts range in size from

0.5-3 mm, with the larger grains (~3-5 mm) having a cloudy white colour and the smaller grains being generally translucent. Mafic grains are dominantly subhedral, 1-5 mm, often contain inclusions and have a corroded hematite rim. Minor amounts of pyroxene is visible, they are often rose-olive in colour and ~1-2 mm in size. The sample is dark-dirty brown in colour and in places small feldspar grains appear to be aligned. Flow layers vary in thickness from millimetres to several centimetres.

In thin section, abundant plagioclase grains are mostly clean, occasionally with minor sericite, often show good twinning and zoning. Some grains are slightly fractured and may have thin boiling rims. Clinopyroxene are dominantly fine grained (~1 mm or less in size, rarely larger) and lack twinning or zoning textures. Hornblende grains have a corroded rim of magnetite and/or hematite. Often they appear poikilitic in texture with numerous feldspar and occasional pyroxene inclusions. The matrix is feldspathic in composition and granular in appearance (not necessarily trachytic). Flow layer boundaries are subtle to discrete and evident by minor changes in the appearance of the matrix and abundance of phenocrysts. These rocks are inferred to be hornblende andesite flows.

Sample 66 (Cajamarca)

In hand specimen the rock is dark brown in colour, has a weak fine-grained porphyritic texture and appears to be part of a possible massive flow unit. Few phenocrysts of mafic minerals are present and ~2-6 mm long and appear to be slightly altered with a corroded hematite rim. Feldspar grains are generally equigranular and ~1 mm in size. The sample contains a moderate amount of anastomosing fractures that are possibly filled with quartz-feldspar-calcite type minerals.

In thin section, plagioclase grains are euhedral-subhedral, mostly unaltered although minor-moderate sericite replacement is evident. There is a semi-preferred orientation of grains and most have a strong zoning or twinning texture. Hornblende grains have a thick hematite rim but are generally have a fresh core. Minor amounts of fine-grained clinopyroxene grains are present, they are generally euhedral and in places have a thin corroded rim. The matrix is dominantly composed of felspathic material with minor amounts of clay. Its texture is granular-glassy, possibly tuffaceous. This is inferred to be a hornblende andesite.

Sample 68 (Cajamarca)

In this sample feldspars are characterised by a large phenocryst population that is 4-6 mm in size, clear-cloudy white and dominantly euhedral. The smaller population is more abundant, ~1 mm or smaller in size, elongate and euhedral in shape, appear to have a preferred orientation and a light hazy white in colour. Hornblende grains are often euhedral, ~2 mm in length, commonly contain small white inclusions and have a brown hematite rim. The matrix is a dirty grey-brownish grey.

In thin section, euhedral plagioclase grains are clear-dusty in appearance, occasional zoning and twinning is apparent, grains show minor sericite alteration and the smaller grains have a slight-moderate alignment. Pyroxene grains are often fine grained (~0.5 mm or smaller), mostly clean and subhedral-euhedral in shape. Some pyroxene grains may have feldspar or magnetite overgrowths. Corroded hornblende phenocrysts have a slight piokilitic texture with fine grains of feldspar. The matrix is of feldspathic composition and is generally dirty in appearance.

APPENDIX A2

Laboratory analytical procedures for $^{40}Ar/^{39}Ar$ analyses

LABORATORY ANALYTICAL PROCEDURES

New Mexico Geochronology Research Lab

NMGRL Analytical Procedures - Hornblende separates were obtained using heavy liquid separation and handpicking techniques. The samples were loaded into a Al disc and irradiated for seven hours in the D-3 position at the Nuclear Science Centre reactor, Texas A&M University. The irradiated samples were monitored with a 27.84 Ma sanidine NMGRL standard (FC-1).

Irradiated hornblende grains were placed in a Mo furnace crucible and step-heated for three minutes by a 50W CO_2 laser at the NMGRL. During heating, gases evolved from the samples heated in the furnace react with the first stage getter, i.e. a SAES GP-50 getter heated at 450^{o}C. Following heating the gas expanded into a second stage for two minutes. The second stage is comprised of a SAES GP-50 getter operated at 20^{o}C and a tungsten filament operated at ~2000^{o}C. During second stage cleaning, the furnace and the first stage are pumped out. After gettering in the second stage, the gas is expanded into a MAP-215-50 mass spectrometer. Gases evolved from the samples heated in the laser are expanded via a cold finger operated at –140^{o}C directly into the second stage. Following cleanup, the gas in the second stage and laser chamber is expanded in the mass spectrometer for analysis. Isotopes are detected on a Johnston electron multiplier operated at ~2.1 kV. Blanks for the furnace are run every three to six heating steps and between every four analyses for the laser system.

Argon Geochronology Laboratory (University of Queensland)

Hornblende and biotite separates were obtained using heavy liquid separation and handpicking techniques Ten to twenty pure grains from each sample were loaded into irradiation disks along with Fish Canyon (nominal age of 28.02 Ma) and Cobb Mountain sanidine (nominal age of 1.194 Ma) standards (Renne *et al*., 1998). The disks were wrapped in Al-foil, vacuum sealed in silica glass tubes and irradiated for 14 hours at the B-1 CLICIT facility at the Radiation Centre, Oregon State University, USA.

Sample and flux monitor irradiation geometry followed those of Vasconcelos (1999). After a two-month cooling period, the samples were analysed by the laser incremental-heating $^{40}Ar/^{39}Ar$ method at the UQ-AGES (University of Queensland Argon Geochronology in Earth Sciences) laboratory following procedures detailed by Vasconcelos (1999). Air pipettes and full system blanks were analysed before and after each grain, yielding $^{40}Ar/^{36}Ar$ discrimination values ranging from 0.9845 ± 0.0026 to 1.0139 ± 0.0022, with an average value of 0.9996 ± 0.0024. Average blank value for the analyses was 0.0069 ± 0.0001 nA of current in the electron multiplier. All dates are reported using 5.543 x 10^{-10} a-1 as the total decay constant for 40^{K} (Steiger and Jäger, 1977) and the following values for the reactor correction factors: (2.64 ± 0.02) x 10^{-4} for $(^{36}Ar/^{37}Ar)Ca$, (7.04 ± 0.06) x 10^{-4} for $(^{39}Ar/^{37}Ar)Ca$ and (8 ± 3) x 10^{-4} for $(^{40}Ar/^{36}Ar)K$. J-factors for each sample are shown in Appendix A3.

References

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Vasconcelos, P.M., 1999. $^{40}Ar/^{39}Ar$ geochronology of supergene processes in ore deposits. In: J.P. Richards and R.M. Tosdal (Editors), Structural controls on ore genesis. Society of Economic Geologists Reviews, 14: 157-181.

APPENDIX A3

$^{40}Ar/^{39}Ar$ incremental step heating data

ID	Temp (^oC)	$^{37}Ar/^{39}Ar$	$^{40}Ar/^{39}Ar$	$^{36}Ar/^{39}Ar$ (x 10^{-3})	$^{39}Ar_K$ (x 10^{-6} mol)	K/Ca	^{40}Ar (%)	^{39}Ar (%)	Age (Ma)	Error (1σ) (Ma)
21, 17.19 mg hornblende, J=0.0007388										
A	5	295.60	1.998	985.70	5.72	0.26	1.5	0.9	6.00	4.50
B	10	673.60	17.930	2172.80	2.40	0.03	4.9	1.3	44.00	17.00
C	15	385.50	15.300	1207.50	1.64	0.03	7.8	1.6	40.00	14.10
D	20	66.88	14.130	124.10	6.24	0.04	46.9	2.6	41.90	1.20
E	25	37.38	6.088	20.02	41.60	0.08	85.5	9.3	42.33	0.21
F	30	34.07	5.816	8.00	118.40	0.09	94.5	28.5	42.62	0.12
G	35	33.36	5.815	5.38	181.30	0.09	96.7	57.8	42.70	0.11
H	40	33.30	5.899	5.95	173.60	0.09	96.2	85.9	42.42	0.10
I	45	30.88	5.124	14.32	66.50	0.10	87.7	96.6	35.90	0.15
J	50	12.29	0.371	28.55	12.80	1.40	31.6	98.7	5.17	0.33
K	50	12.34	0.177	32.55	8.12	2.90	22.2	100.0	3.64	0.49
total gas age					618.30	0.15			40.21	0.58[#]
Plateau (steps B-H)		MSWD = 0.90			525.10	0.09		84.9	**42.55**	**0.12[#]**
59, 0.2 mg hornblende, J=0.0007399										
A	5	315.00	4.366	1025.10	5.73	0.12	4.0	1.5	16.60	5.30
B	10	87.23	4.561	252.30	14.20	0.11	15.0	5.2	17.40	1.00
C	15	40.66	2.943	87.33	16.10	0.17	37.1	9.4	20.09	0.50
D	20	23.73	5.124	28.71	90.60	0.10	66.0	33.1	20.89	0.14
E	25	20.26	4.868	17.56	150.70	0.10	76.4	72.4	20.63	0.10
F	30	22.70	4.568	26.33	76.50	0.11	67.4	92.4	20.39	0.15
G	35	26.55	3.526	40.73	9.92	0.14	55.8	95	19.72	0.42
H	40	28.48	2.924	40.86	2.63	0.17	58.5	95.7	22.10	1.40
I	45	28.26	2.998	42.85	2.92	0.17	56.1	96.4	21.10	1.20
J	50	26.98	4.078	41.08	10.90	0.13	56.3	99.3	20.22	0.51
K	50	27.61	4.072	41.10	2.73	0.13	57.2	100.0	21.00	1.30
total gas age					372.90	0.11			20.42	0.6[#]
Plateau (steps C-K)		MSWD = 1.7			363.00	0.11		94.8	**20.61**	**0.14[#]**
38, 19.76 mg hornblende, J=0.0007392										
A	5	414.40	2.354	1368.70	7.29	0.22	2.4	1.0	13.50	5.60
B	10	155.10	1.174	479.50	13.90	0.43	8.7	3.0	17.90	1.70
C	15	41.41	2.033	94.10	14.30	0.25	33.3	5.0	18.31	0.50
D	20	17.92	5.023	16.38	76.30	0.10	75.3	15.6	17.99	0.12
E	25	15.64	4.804	8.64	207.80	0.11	86.2	44.7	17.98	0.07
F	30	14.60	5.357	5.79	229.00	0.10	91.3	76.6	17.77	0.06
G	35	14.16	5.435	4.27	143.00	0.09	94.3	96.6	17.80	0.06
H	40	16.03	5.132	10.30	16.70	0.10	83.7	98.9	17.88	0.21
I	45	20.94	5.168	35.22	4.09	0.10	52.3	99.5	14.62	0.79
J	50	24.87	5.357	40.52	2.76	0.10	52.6	99.9	17.80	1.10
K	50	51.60	5.056	155.50	0.72	0.10	11.8	100.0	8.10	4.70
total gas age					715.90	0.11			17.81	0.38[#]
Plateau (steps A-H)		MSWD = 1.2			708.30	0.11		98.9	**17.85**	**0.06[#]**

[#] = 2σ error; J = error in neutron flux

ID	$^{40}Ar/^{39}Ar$	$^{38}Ar/^{39}Ar$ (x 10^{-2})	$^{37}Ar/^{39}Ar$ (x 10^{-2})	$^{36}Ar/^{39}Ar$ (x 10^{-3})	^{40}Ar (moles) (x 10^{-15})	$^{40}Ar/^{39}Ar$	% Rad	Age (Ma)	Error (1σ) (Ma)
S-46, hornblende, J=0.003688									
A	224.83	0.05	0.00	0.53	1.37	68.62	30.50	407.00	49.19
B	18.22	0.04	19.34	0.04	25.42	8.90	48.20	58.26	22.77
C	9.48	0.03	6.99	0.00	73.87	9.01	94.60	58.96	4.05
E	7.69	0.02	6.41	0.00	64.09	8.51	110.20	55.78	3.35
D	13.28	0.03	31.49	0.01	12.32	14.13	104.10	91.64	30.07
F	12.75	0.02	0.00	n/a	10.80	21.24	166.70	136.07	32.61
G	35.75	n/a	20.18	n/a	924.24	42.80	118.00	264.39	102.53
H	19.11	n/a	3.93	n/a	174.64	290.23	1514.90	1312.87	167.77
I	5.23	n/a	0.00	n/a	2409.66	455.34	8715.00	1778.01	646.57
total gas age								87.00	4.00#
Plateau (steps B-E)								**57.00**	**3.00#**
S-31, hornblende, J=0.003688									
A	43.62	n/a	0.00	0.01	15.88	41.71	95.60	258.15	77.85
B	23.43	0.00	132.25	0.25	338.06	-43.10	-166.90	-312.33	276.96
C	7.92	0.02	14.50	0.01	55.82	6.15	77.00	40.49	4.74
D	7.03	0.02	10.21	0.00	1.32	6.93	97.90	45.53	1.79
E	7.30	0.03	11.74	0.00	97.56	7.78	105.80	51.07	2.65
F	8.46	n/a	0.00	0.07	360.60	-11.59	-137.00	-78.83	74.80
G	8.75	n/a	0.00	n/a	157.75	60.50	691.70	363.34	125.61
H	8.01	n/a	5.38	0.00	677.44	9.63	119.70	62.93	32.43
I	7.30	n/a	2.93	0.06	284.38	-9.07	-124.10	-61.39	71.14
total gas age								47.00	2.00#
Plateau (steps B-F)								**47.00**	**3.00#**
S-16, hornblende, J=0.003688									
A	352.38	0.26	7.68	1.34	0.12	-44.36	-12.50	-322.31	99.21
B	79.23	0.06	9.74	0.27	0.25	1.56	2.00	10.35	10.18
C	32.16	0.03	10.94	0.10	0.21	4.12	12.70	27.20	3.75
D	8.84	0.02	2.53	0.02	0.13	4.41	49.80	29.11	1.19
E	7.10	0.02	4.04	0.01	4.39	4.93	69.10	32.48	1.96
F	7.86	0.02	5.91	0.01	5.29	4.87	61.80	32.14	2.02
G	6.24	0.01	26.98	0.01	4.57	4.03	63.30	26.59	1.80
H	5.63	0.01	57.86	0.02	3.45	3.11	53.10	20.61	2.01
I	6.67	0.02	197.36	0.07	2.79	2.72	35.10	18.02	4.12
J	7.69	0.04	608.04	0.17	57.05	7.79	58.00	51.09	29.07
K	7.06	0.13	771.35	0.23	967.27	-4.34	-28.10	-29.11	190.74
total gas age								24.60	1.20#
Plateau (steps C-H)								**29.40**	**1.40#**
S-11, hornblende, J=0.003688									
A	59.29	0.03	22.36	0.18	40.80	7.05	11.70	46.31	47.90
B	10.58	0.01	34.59	0.06	11.77	-3.11	-28.70	-20.82	26.72
C	3.63	0.02	7.69	0.00	35.18	3.76	103.10	24.87	2.96
E	2.98	0.02	7.01	0.00	1.34	3.25	108.50	21.49	0.73
D	3.05	0.02	7.42	0.00	1.22	3.16	102.90	20.88	0.85
F	5.04	0.03	14.26	0.01	20.07	1.87	36.70	12.39	7.22
G	4.72	n/a	7.57	n/a	218.03	19.49	410.60	125.24	40.22
H	5.36	n/a	79.39	n/a	n/a	149.65	2635.10	792.86	135.35
I	12.93	n/a	0.00	n/a	2033.25	1205.22	9324.90	3057.32	348.02
total gas age								24.70	0.80#
Plateau (steps A-F)								**21.30**	**0.80#**
H-22, biotite, J=0.003688									
A	31.23	-6.97	0.00	n/a	49.30	131.28	420.30	712.35	60.33
B	29.38	1.67	2.00	28.70	2.84	20.91	71.10	133.99	13.91
C	8.34	1.91	11.80	n/a	1.66	9.24	110.80	60.43	6.84
D	4.70	1.42	9.33	0.43	3.26	4.58	97.50	30.24	2.03
E	4.16	1.27	1.48	n/a	2.62	4.38	105.10	28.88	2.16

ID	$^{40}Ar/^{39}Ar$	$^{38}Ar/^{39}Ar$ (x 10^{-2})	$^{37}Ar/^{39}Ar$ (x 10^{-2})	$^{36}Ar/^{39}Ar$ (x 10^{-3})	^{40}Ar (moles) (x 10^{-15})	$^{40}Ar/^{39}Ar$	% Rad	Age (Ma)	Error (1σ) (Ma)
F	4.18	1.53	8.04	n/a	3.36	4.62	110.60	30.50	1.75
G	3.25	1.53	3.63	0.37	3.67	3.15	96.70	20.82	1.20
H	3.19	1.49	2.09	n/a	5.86	3.25	101.80	21.50	0.71
I	3.01	1.48	1.51	n/a	8.61	3.18	105.60	21.01	0.51
J	3.02	1.49	1.38	0.71	0.13	2.81	93.10	18.62	0.33
K	2.99	1.46	1.05	0.37	0.22	2.88	96.30	19.08	0.21
L	2.98	1.47	1.23	0.37	0.33	2.87	96.30	19.02	0.14
M	2.99	1.50	1.80	0.13	0.42	2.95	98.70	19.54	0.13
N	3.02	1.45	2.02	0.16	0.58	2.98	98.50	19.70	0.12
O	3.05	1.50	2.25	0.17	0.79	3.00	98.40	19.86	0.10
P	3.05	1.46	2.92	0.45	0.98	3.01	99.60	19.92	0.08
Q	3.07	1.47	3.55	0.34	0.57	2.97	96.80	19.66	0.10
R	3.03	1.51	3.41	0.38	0.33	2.92	96.40	19.35	0.14
S	3.02	1.51	2.07	0.26	0.98	2.95	97.50	19.51	0.53
total gas age								20.02	$0.05^{\#}$
Plateau (steps M-Q)								**19.77**	**$0.05^{\#}$**
T-2, hydorthermal biotite, J=0.003688									
A	56.61	7.07	15.90	20.20	11.10	-3.11	-5.50	-20.79	14.63
B	6.61	1.66	2.77	4.96	2.89	5.14	77.80	33.90	3.67
C	3.26	1.33	0.89	1.95	4.49	2.69	82.40	17.80	1.33
D	2.98	1.52	1.34	0.57	4.79	2.81	94.30	18.63	1.01
E	2.84	1.48	1.55	0.34	5.78	2.74	96.60	18.14	0.83
F	2.77	1.53	2.30	0.68	6.52	2.57	92.90	17.03	0.67
G	2.75	1.45	1.54	0.61	8.25	2.57	93.50	17.03	0.51
H	2.79	1.46	1.62	0.93	9.43	2.52	90.20	16.88	0.52
I	2.96	1.54	7.48	0.39	4.82	2.85	96.10	18.83	0.94
total gas age								17.50	$0.30^{\#}$
Plateau (steps C-I)								**17.50**	**$0.30^{\#}$**
T-4, magmatic biotite, J=0.003688									
A	10.11	2.07	12.00	19.50	2.17	4.36	43.10	28.77	6.42
B	3.32	1.60	3.05	n/a	4.46	3.58	107.80	23.64	1.11
C	2.71	1.40	1.42	n/a	6.32	2.93	108.30	19.40	0.68
D	2.66	1.46	0.83	0.30	9.38	2.57	96.70	17.03	0.44
E	2.63	1.43	1.09	0.62	0.11	2.45	93.00	16.23	0.34
F	2.64	1.40	1.36	0.33	0.15	2.54	96.30	16.83	0.29
G	2.63	1.44	1.87	0.71	0.11	2.42	92.10	16.02	0.38
H	2.66	1.45	2.46	0.78	6.73	2.43	91.40	16.09	0.59
I	2.67	1.36	0.35	0.18	5.20	2.62	98.00	17.35	0.77
J	2.70	1.35	0.28	1.27	1.89	2.33	86.10	15.41	1.89
K	2.68	1.34	1.43	0.45	2.05	2.55	95.10	16.87	1.73
total gas age								17.24	$0.18^{\#}$
Plateau (steps D-K)								**16.53**	**$0.18^{\#}$**

$^{\#}$ = 2σ error; J = error in neutron flux; n/a = no detection

APPENDIX C1

Electron microprobe analyses

Electron microprobe analyses of feldspar grains

Gabbroic Dyke

	Hbl Gabbro									
Sample No.	16	16	16	16	16	16	16	16	16	16
Analysis No.	1r	1c	1r1	1c1	2r	2c	3r	3c	4r	4c
Oxide Weight Percent										
SiO_2	50.48	47.52	57.12	49.43	53.21	49.95	55.84	46.89	47.53	45.77
TiO_2	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Al_2O_3	29.84	32.85	26.02	31.40	28.52	30.52	27.12	33.40	32.79	34.35
Fe_2O_3(T)	0.72	0.49	0.74	0.76	0.97	0.97	0.46	0.71	0.53	0.48
MnO	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
MgO	0.21	0.39	<0.20	0.40	0.66	0.43	0.41	0.42	0.64	0.56
CaO	14.12	16.90	8.78	15.46	12.40	14.65	10.36	17.66	17.01	18.20
Na_2O	3.21	1.80	5.97	2.38	4.28	2.91	5.47	1.41	1.56	1.16
K_2O	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Cl	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Total	98.77	100.02	99.46	99.88	100.36	99.61	100.17	100.58	100.50	100.82
Number of atoms per formula unit (32 oxygens)										
Si	9.34	8.74	10.34	9.07	9.66	9.19	10.07	8.60	8.72	8.40
Ti	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Al	6.50	7.12	5.55	6.79	6.10	6.62	5.77	7.22	7.09	7.43
Fe^{2+}	0.11	0.07	0.11	0.12	0.15	0.15	0.07	0.11	0.08	0.07
Mn	-	-	-	-	-	-	-	-	-	-
Mg	0.06	0.11	-	0.11	0.18	0.12	0.11	0.12	0.18	0.15
Ca	2.80	3.33	1.70	3.04	2.41	2.89	2.00	3.47	3.34	3.58
Na	1.15	0.64	2.09	0.84	1.51	1.03	1.91	0.50	0.55	0.41
K	-	-	-	-	-	-	-	-	-	-
Cl	-	-	-	-	-	-	-	-	-	-
Total	20.00	20.04	19.99	19.98	20.06	20.04	20.04	20.04	20.05	20.09
An	0.71	0.84	0.45	0.78	0.62	0.74	0.51	0.87	0.86	0.90
Ab	0.29	0.16	0.55	0.22	0.38	0.26	0.49	0.13	0.14	0.10
Or	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	Hbl Gabbro				
Sample No.	55	55	55	55	55
Analysis No.	1r	2c	2r	3c	3r
Oxide Weight Percent					
SiO_2	46.27	48.55	51.71	47.22	46.85
TiO_2	<0.20	<0.20	<0.20	<0.20	<0.20
Al_2O_3	32.92	31.30	29.32	32.85	33.32
Fe_2O_3(T)	0.52	0.57	0.98	0.63	0.63
MnO	<0.20	<0.20	<0.20	<0.20	<0.20
MgO	0.61	0.43	0.49	0.71	0.64
CaO	17.42	15.90	13.71	17.03	17.08
Na_2O	1.05	1.99	3.21	1.43	1.57
K_2O	<0.20	<0.20	<0.20	<0.20	<0.20
Cl	<0.20	<0.20	<0.20	<0.20	<0.20
Total	98.93	99.16	99.72	100.11	100.42
Number of atoms per formula unit (32 oxygens)					
Si	8.62	8.99	9.46	8.69	8.61
Ti	<0.20	<0.20	<0.20	<0.20	<0.20
Al	7.22	6.83	6.32	7.12	7.21
Fe^{2+}	0.08	0.09	0.15	0.10	0.10
Mn	-	-	-	-	-
Mg	0.17	0.12	0.13	0.20	0.17
Ca	3.48	3.15	2.69	3.35	3.36
Na	0.38	0.71	1.14	0.51	0.56
K	-	-	-	-	-
Cl	-	-	-	-	-
Total	19.97	19.98	19.96	20.01	20.07
An	0.90	0.82	0.70	0.87	0.86
Ab	0.10	0.18	0.30	0.13	0.14
Or	0.00	0.00	0.00	0.00	0.00

	Gabbro										Gabbroic Diorite		
Sample No.	57	57	57	57	57	57	57	57	57	57	87	87	87
Analysis No.	1r	1c	2r	2c	3c	4r	4c	5r	6r	6c	1c	1r	2c
Oxide Weight Percent													
SiO_2	51.09	52.58	51.79	54.81	64.47	53.88	52.78	53.04	52.54	50.35	51.49	52.85	50.41
TiO_2	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Al_2O_3	30.39	29.04	29.10	27.60	21.44	28.34	29.27	28.51	28.50	30.02	29.62	29.09	30.64
Fe_2O_3(T)	0.76	0.76	0.88	0.80	0.37	0.65	0.69	0.75	0.81	0.42	0.72	0.82	0.72
MnO	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
MgO	0.44	0.52	0.29	0.47	<0.20	0.27	0.68	<0.20	0.63	0.28	0.60	0.63	0.66
CaO	13.78	12.27	12.56	10.57	3.20	11.09	12.46	11.93	12.31	14.19	12.77	12.98	15.01
Na_2O	3.63	4.03	4.25	5.34	10.06	5.17	4.30	4.52	4.37	3.28	3.13	3.83	2.73
K_2O	0.21	0.23	0.23	0.48	0.31	0.25	0.23	0.26	0.26	<0.20	0.60	<0.20	<0.20
Cl	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Total	100.34	99.45	99.26	100.25	100.07	99.81	100.48	99.35	99.77	98.81	99.20	100.51	100.50
Number of atoms per formula unit (32 oxygens)													
Si	9.31	9.61	9.52	9.92	11.41	9.80	9.56	9.71	9.61	9.31	9.46	9.58	9.19
Ti	-	-	-	-	-	-	-	-	-	-	-	-	-
Al	6.53	6.25	6.30	5.89	4.47	6.07	6.25	6.15	6.14	6.54	6.42	6.21	6.58
Fe^{2+}	0.11	0.12	0.13	0.12	0.05	0.10	0.10	0.11	0.12	0.06	0.11	0.12	0.11
Mn	-	-	-	-	-	-	-	-	-	-	-	-	-
Mg	0.12	0.14	0.08	0.13	-	0.07	0.18	-	0.17	0.08	0.16	0.17	0.18
Ca	2.69	2.40	2.47	2.05	0.60	2.16	2.42	2.34	2.41	2.81	2.51	2.52	2.93
Na	1.28	1.42	1.51	1.87	3.45	1.82	1.51	1.60	1.55	1.18	1.12	1.34	0.96
K	0.05	0.05	0.05	0.11	0.07	0.06	0.05	0.06	0.06	-	0.14	-	-
Cl	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	20.11	20.00	20.11	20.13	20.12	20.10	20.10	20.04	20.12	20.04	19.99	20.01	20.00
An	0.67	0.62	0.61	0.51	0.15	0.53	0.61	0.58	0.60	0.71	0.67	0.65	0.75
Ab	0.32	0.37	0.37	0.46	0.84	0.45	0.38	0.40	0.39	0.29	0.30	0.35	0.25
Or	0.01	0.01	0.01	0.03	0.02	0.01	0.01	0.02	0.01	0.00	0.04	0.00	0.00

r = analysis at grain rim; c = analysis at grain core; <0.20 = below detection limit; - = below detection limit

Feldspar analyses cont.

	Palaeogene Igneous Units														Miocene Barren Intrusive Units							
	Hbl Diorite						Hbl Microdiorite			Basaltic Andesite					Hbl Diorite				Hbl-Bt Qtz Diorite			
Sample No.	31	31	31	31	31	31	46	46	46	32	32	32	32	32	11	11	11	11	59	59	59	59
Analysis No.	1c	2c	2r	2r1	2r2	3r	1c	2r	2c	1c	2c	3c	4r	4r	1r	1c	2r	2c	1c	2c	2r	3c
SiO_2	58.64	59.51	59.07	67.14	58.19	59.52	54.22	51.82	48.70	49.10	53.41	50.43	53.82	52.91	55.64	56.81	55.33	55.98	58.52	57.60	57.94	57.66
TiO_2	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Al_2O_3	25.84	25.33	25.24	20.47	25.90	24.22	27.14	29.81	31.18	31.89	27.96	30.13	27.75	27.95	26.99	26.16	27.09	26.77	25.39	25.27	25.78	26.22
Fe_2O_3(T)	0.41	0.37	0.47	0.35	0.41	0.70	0.29	0.27	0.49	0.55	0.51	0.43	0.64	0.70	<0.20	<0.20	0.32	0.33	<0.20	<0.20	<0.20	<0.20
MnO	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
MgO	0.45	0.52	0.37	0.44	0.40	0.38	0.59	0.57	0.37	0.28	0.20	0.36	0.20	0.59	<0.20	0.23	0.21	0.45	0.47	0.43	0.51	0.46
CaO	8.13	7.78	7.71	1.39	7.91	6.76	10.55	13.13	15.04	15.23	11.37	13.63	11.20	12.09	9.57	8.85	9.91	9.11	8.83	8.33	8.78	8.88
Na_2O	6.67	6.74	6.84	10.44	6.94	7.16	5.48	3.77	2.92	2.32	4.38	3.13	4.68	4.45	5.43	5.93	5.25	5.93	6.43	6.22	5.84	5.73
K_2O	0.41	0.28	0.38	0.31	0.40	0.49	<0.20	<0.20	<0.20	<0.20	0.35	<0.20	0.34	0.36	0.27	0.25	0.26	0.26	0.20	0.32	0.36	0.32
Cl	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Total	100.65	100.54	100.25	100.75	100.22	99.28	98.53	99.68	98.90	99.58	98.39	98.41	98.80	99.21	98.39	98.50	98.51	98.85	100.36	98.47	99.48	99.59
Si	10.46	10.58	10.56	11.72	10.43	10.73	9.95	9.46	9.03	9.02	9.83	9.33	9.87	9.71	10.16	10.34	10.11	10.18	10.46	10.48	10.43	10.37
Ti	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Al	5.43	5.31	5.31	4.21	5.47	5.14	5.87	6.41	6.81	6.91	6.06	6.57	6.00	6.05	5.81	5.61	5.83	5.74	5.35	5.42	5.47	5.56
Fe^{2+}	0.06	0.05	0.07	0.05	0.06	0.10	0.05	0.04	0.08	0.08	0.08	0.07	0.10	0.11	-	-	0.05	0.05	-	-	-	-
Mn	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mg	0.12	0.14	0.10	0.11	0.11	0.10	0.16	0.16	0.10	0.08	0.06	0.10	0.06	0.16	-	0.06	0.06	0.12	0.12	0.12	0.14	0.12
Ca	1.55	1.48	1.48	0.26	1.52	1.30	2.07	2.57	2.99	3.00	2.24	2.70	2.20	2.38	1.87	1.72	1.94	1.77	1.69	1.62	1.69	1.71
Na	2.30	2.32	2.37	3.53	2.41	2.50	1.95	1.33	1.05	0.82	1.56	1.12	1.66	1.58	1.92	2.09	1.86	2.09	2.22	2.19	2.04	2.00
K	0.09	0.06	0.09	0.07	0.09	0.11	-	-	-	-	0.08	-	0.08	0.08	0.06	0.06	0.06	0.06	0.04	0.07	0.08	0.07
Cl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	20.03	19.95	19.99	20.00	20.09	20.00	20.11	20.03	20.11	19.97	19.95	19.95	20.00	20.10	19.91	19.92	19.93	20.02	19.98	19.97	19.90	19.89
An	0.39	0.38	0.38	0.07	0.38	0.33	0.52	0.66	0.74	0.78	0.58	0.71	0.56	0.59	0.49	0.45	0.50	0.45	0.43	0.42	0.44	0.45
Ab	0.58	0.60	0.60	0.92	0.60	0.64	0.48	0.34	0.26	0.22	0.40	0.29	0.42	0.39	0.50	0.54	0.48	0.53	0.56	0.56	0.53	0.53
Or	0.02	0.02	0.02	0.02	0.02	0.03	0.00	0.00	0.00	0.00	0.02	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02

Feldspar analyses cont.

	Early-Mid Miocene Mineralised Intrusive Centres																						
	Hbl-Bt Diorite																	Hbl-Bt Diorite					
Sample No.	Chail	Chail	Chail	Chail	Chail	Chail	Chail	Chail	Chail	Chail	Chail	Chail	Chail	Chail	Chail	Chail	Chail	H22	H22	H22	H22	H22	H22
Analysis No.	1r	1c	2r	2c	3r	3c	3r	4r	4c	5r	5c	6r	6c	7r	7c	7c1	7c2	1c	2c	3c	3r	4r	4c
SiO_2	55.80	57.16	56.82	56.18	58.17	58.58	57.52	58.60	57.12	57.42	57.18	55.86	57.58	58.23	56.11	54.09	56.53	59.16	58.00	56.56	57.60	58.59	59.24
TiO_2	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Al_2O_3	27.05	26.07	26.40	26.76	25.60	25.30	26.11	25.71	26.38	26.28	26.22	27.13	26.01	25.48	26.81	27.80	26.58	26.06	25.99	27.36	26.29	25.97	25.76
Fe_2O_3(T)	0.25	0.33	0.21	0.30	0.36	0.35	0.25	<0.20	0.24	0.19	0.28	0.26	0.35	0.22	0.32	0.43	<0.20	<0.20	<0.20	<0.20	0.24	0.42	<0.20
MnO	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
MgO	0.54	0.40	0.41	0.39	0.20	0.30	0.38	0.43	0.22	0.59	0.46	0.25	0.48	0.42	0.35	0.51	0.22	0.63	0.61	0.41	0.61	0.46	0.44
CaO	9.54	8.79	8.89	9.57	8.14	7.77	8.47	8.35	9.00	8.62	8.79	9.82	8.93	8.11	9.42	10.68	9.14	8.76	8.81	10.39	9.33	8.92	8.34
Na_2O	5.73	6.41	6.00	5.65	6.36	6.97	6.35	6.18	5.99	6.26	6.33	5.33	6.09	6.49	5.80	5.23	5.97	6.07	5.96	5.27	5.78	6.09	6.04
K_2O	0.23	0.23	0.29	0.32	0.29	0.36	0.29	0.32	0.21	0.25	0.31	0.21	0.38	0.27	0.28	<0.20	0.34	0.32	0.43	<0.20	0.28	0.31	0.44
Cl	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Total	99.18	99.52	99.12	99.22	99.24	99.91	99.52	99.83	99.29	99.75	99.76	98.97	99.87	99.55	99.24	99.11	99.02	101.30	100.14	100.40	100.42	100.87	100.53
Si	10.12	10.32	10.29	10.19	10.49	10.52	10.36	10.50	10.32	10.33	10.30	10.15	10.34	10.48	10.17	9.87	10.24	10.46	10.39	10.13	10.31	10.42	10.53
Ti	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Al	5.78	5.55	5.63	5.72	5.44	5.35	5.54	5.43	5.61	5.57	5.56	5.81	5.51	5.40	5.73	5.98	5.67	5.43	5.49	5.78	5.54	5.45	5.40
Fe^{2+}	0.04	0.05	0.03	0.05	0.05	0.05	0.04	-	0.04	0.03	0.04	0.04	0.05	0.03	0.05	0.07	-	-	-	-	0.04	0.06	-
Mn	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mg	0.14	0.11	0.11	0.10	0.05	0.08	0.10	0.11	0.06	0.16	0.12	0.07	0.13	0.11	0.09	0.14	0.06	0.17	0.16	0.11	0.16	0.12	0.12
Ca	1.85	1.70	1.72	1.86	1.57	1.49	1.63	1.60	1.74	1.66	1.70	1.91	1.72	1.56	1.83	2.09	1.77	1.66	1.69	1.99	1.79	1.70	1.59
Na	2.01	2.24	2.11	1.99	2.22	2.43	2.22	2.14	2.10	2.18	2.21	1.87	2.12	2.26	2.04	1.85	2.09	2.08	2.07	1.83	2.00	2.10	2.08
K	0.05	0.05	0.07	0.07	0.07	0.08	0.07	0.07	0.05	0.06	0.07	0.05	0.09	0.06	0.06	-	0.08	0.07	0.10	-	0.07	0.07	0.10
Cl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	20.01	20.04	19.98	19.98	19.92	20.05	19.98	19.89	19.93	20.01	20.03	19.91	19.96	19.97	20.00	20.08	19.95	19.92	19.96	19.92	19.96	19.95	19.87
An	0.47	0.43	0.44	0.47	0.41	0.37	0.42	0.42	0.45	0.43	0.43	0.50	0.44	0.40	0.47	0.53	0.45	0.44	0.44	0.52	0.46	0.44	0.42
Ab	0.51	0.56	0.54	0.51	0.58	0.61	0.57	0.56	0.54	0.56	0.56	0.49	0.54	0.58	0.52	0.47	0.53	0.55	0.54	0.48	0.52	0.54	0.55
Or	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.02	0.01	0.02	0.02	0.02	0.00	0.02	0.02	0.03	0.00	0.02	0.02	0.03

Feldspar analyses cont.

Early-Mid Miocene Mineralised Intrusive Centres	Hbl-Bt Diorite				Hbl-Bt Diorite						
Sample No.	T1 Gal	T1 Gal	T1 Gal	T1 Gal	T2 Gal	T2 Gal	T2 Gal	T2 Gal	T2 Gal	T2 Gal	T2 Gal
Analysis No.	1r	1c	2c	3c	1r	1c	2r	2c	2c	3c	3r
SiO_2	58.84	60.04	59.09	58.78	58.58	59.51	54.41	59.37	55.64	59.55	58.28
TiO_2	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Al_2O_3	24.88	24.31	24.59	24.14	25.24	24.30	27.03	24.20	26.06	24.40	24.99
Fe_2O_3(T)	<0.20	<0.20	<0.20	<0.20	<0.20	0.26	<0.20	0.32	0.28	<0.20	0.23
MnO	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
MgO	<0.20	<0.20	<0.20	<0.20	0.26	<0.20	0.24	0.27	<0.20	0.25	<0.20
CaO	8.86	8.49	8.47	8.75	9.13	8.13	12.38	8.37	10.90	8.09	8.92
Na_2O	5.46	5.73	5.55	5.73	5.75	5.94	4.46	5.93	4.85	5.84	5.32
K_2O	0.30	0.38	0.32	0.26	0.20	0.38	0.27	0.46	0.20	0.45	0.29
Cl	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Total	98.80	99.31	98.30	98.12	99.36	98.72	99.15	99.04	98.15	98.89	98.21
Si	10.63	10.78	10.71	10.70	10.55	10.75	9.94	10.72	10.22	10.74	10.59
Ti	-	-	-	-	-	-	-	-	-	-	-
Al	5.30	5.15	5.23	5.18	5.35	5.17	5.82	5.15	5.64	5.18	5.35
Fe^{2+}	-	-	-	-	-	0.04	-	0.05	0.04	-	0.03
Mn	-	-	-	-	-	-	-	-	-	-	-
Mg	-	-	-	-	0.07	-	0.07	0.07	-	0.07	-
Ca	1.71	1.64	1.69	1.71	1.76	1.57	2.43	1.62	2.14	1.56	1.74
Na	1.91	2.04	1.92	2.02	2.00	2.08	1.58	2.07	1.72	2.04	1.87
K	0.07	0.09	0.09	0.06	0.05	0.09	0.06	0.11	0.05	0.10	0.07
Cl	-	-	-	-	-	-	-	-	-	-	-
Total	19.70	19.80	19.72	19.74	19.82	19.75	19.96	19.80	19.85	19.75	19.69
An	0.46	0.43	0.46	0.45	0.46	0.42	0.60	0.43	0.55	0.42	0.47
Ab	0.52	0.54	0.52	0.53	0.53	0.56	0.39	0.55	0.44	0.55	0.51
Or	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.03	0.01	0.03	0.02

Early-Mid Miocene Mineralised Intrusive Centres	Hbl-Bt Qtz Diorite						Hbl-Bt Diorite							
Sample No.	T3 Gal	T3 Gal	T3 Gal	T3 Gal	T3 Gal	T3 Gal	T4 Gal	T4 Gal	T4 Gal	T4 Gal	T4 Gal	T4 Gal	T4 Gal	T4 Gal
Analysis No.	1c	1r	2r	2c	3c	3r	1c	1r	2c	2r	3r	3c	4r	4c
SiO_2	58.55	58.72	57.58	58.63	57.98	57.05	57.37	57.46	57.32	54.45	55.71	56.29	58.05	55.82
TiO_2	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Al_2O_3	25.18	24.62	25.34	24.68	24.71	25.37	25.44	25.33	25.70	27.81	25.49	25.16	24.97	26.35
Fe_2O_3(T)	0.20	0.23	<0.20	0.29	<0.20	<0.20	<0.20	0.43	0.20	0.32	0.30	0.21	<0.20	0.30
MnO	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
MgO	0.39	<0.20	0.23	0.29	<0.20	<0.20	0.32	0.33	0.44	0.39	0.20	<0.20	0.29	0.45
CaO	8.76	8.67	10.07	8.96	9.48	9.71	8.47	8.19	8.43	11.17	9.13	8.95	7.95	9.54
Na_2O	5.28	5.77	5.23	5.59	5.58	5.03	6.29	6.52	6.35	4.74	5.79	5.88	6.44	5.69
K_2O	0.40	0.41	0.36	0.45	0.31	0.40	0.41	0.50	0.44	0.26	0.39	0.38	0.35	0.36
Cl	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Total	98.84	98.81	99.12	98.97	98.63	97.92	98.53	98.91	99.03	99.49	97.16	97.13	98.26	98.63
Si	10.57	10.63	10.43	10.60	10.54	10.44	10.44	10.44	10.39	9.90	10.32	10.41	10.57	10.20
Ti	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Al	5.36	5.25	5.41	5.26	5.30	5.47	5.46	5.42	5.49	5.96	5.56	5.48	5.36	5.67
Fe^{2+}	0.03	0.03	-	0.04	-	-	-	0.07	0.03	0.05	0.05	0.03	-	0.05
Mn	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mg	0.10	-	0.06	0.08	-	-	0.09	0.09	0.12	0.10	0.06	-	0.08	0.12
Ca	1.69	1.68	1.95	1.74	1.85	1.90	1.65	1.59	1.64	2.18	1.81	1.77	1.55	1.87
Na	1.85	2.02	1.83	1.96	1.97	1.79	2.22	2.29	2.23	1.67	2.08	2.10	2.27	2.02
K	0.09	0.09	0.08	0.10	0.07	0.09	0.10	0.12	0.10	0.06	0.09	0.09	0.08	0.08
Cl	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	19.72	19.79	19.82	19.80	19.84	19.77	19.99	20.05	20.02	19.99	19.99	19.96	19.93	20.02
An	0.47	0.44	0.50	0.46	0.48	0.50	0.42	0.40	0.41	0.56	0.45	0.45	0.40	0.47
Ab	0.51	0.53	0.47	0.52	0.51	0.47	0.56	0.57	0.56	0.43	0.52	0.53	0.58	0.51
Or	0.03	0.02	0.02	0.03	0.02	0.02	0.02	0.03	0.03	0.02	0.02	0.02	0.02	0.02

Feldspar analyses cont.

	Miocene Volcanic Units											
	Hbl Basaltic Andesite						Hbl-Bt Andesite					
Sample No.	64	64	64	64	64	64	63	63	63	63	63	63
Analysis No.	1r	1c	2c	2r	3c	3r	1r	1c	2c	2r	3r	3c
SiO_2	55.78	55.90	59.46	60.27	59.79	57.99	58.41	58.56	58.16	58.27	59.11	58.00
TiO_2	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Al_2O_3	27.50	27.87	25.38	25.26	25.28	26.24	24.94	26.10	25.29	25.79	25.69	26.36
Fe_2O_3(T)	0.49	0.79	0.25	0.26	0.42	0.38	0.43	0.25	0.56	<0.20	0.47	0.13
MnO	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
MgO	0.45	0.48	0.53	0.44	0.52	0.54	<0.20	0.40	0.54	0.42	0.39	0.50
CaO	11.21	11.19	8.30	7.73	8.04	9.09	8.21	8.91	8.25	8.90	8.28	9.54
Na_2O	4.52	4.86	5.45	6.09	6.43	5.61	6.02	5.46	5.73	5.67	5.98	5.33
K_2O	0.26	<0.20	0.75	0.81	0.80	0.47	0.64	0.53	0.81	0.49	0.54	0.35
Cl	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Total	100.31	101.33	100.10	101.04	101.43	100.34	99.12	100.23	99.45	99.73	100.71	100.38
Si	10.03	9.98	10.61	10.66	10.58	10.37	10.57	10.45	10.50	10.46	10.52	10.35
Ti	-	-	-	-	-	-	-	-	-	-	-	-
Al	5.83	5.86	5.33	5.26	5.27	5.53	5.32	5.49	5.38	5.45	5.39	5.55
Fe^{2+}	0.07	0.12	0.04	0.04	0.06	0.06	0.07	0.04	0.08	-	0.07	0.02
Mn	-	-	-	-	-	-	-	-	-	-	-	-
Mg	0.12	0.13	0.14	0.12	0.13	0.14	-	0.10	0.14	0.11	0.10	0.13
Ca	2.16	2.14	1.59	1.46	1.52	1.74	1.59	1.70	1.59	1.71	1.58	1.82
Na	1.57	1.68	1.88	2.08	2.20	1.94	2.11	1.89	2.00	1.97	2.06	1.84
K	0.06	-	0.17	0.18	0.18	0.11	0.15	0.12	0.19	0.11	0.12	0.08
Cl	-	-	-	-	-	-	-	-	-	-	-	-
Total	19.86	19.95	19.75	19.84	19.98	19.89	19.91	19.80	19.91	19.85	19.88	19.83
An	0.57	0.56	0.44	0.39	0.39	0.46	0.41	0.46	0.42	0.45	0.42	0.49
Ab	0.42	0.44	0.52	0.56	0.56	0.51	0.55	0.51	0.53	0.52	0.55	0.49
Or	0.02	0.00	0.05	0.05	0.05	0.03	0.04	0.03	0.05	0.03	0.03	0.02

Electron microprobe analyses of hornblende grains

	Gabbroic Dyke			Palaeogene Igneous Units																							
	Sth Galeno			Co Montana - Hbl Diorite														East Minas Conga - Hbl Microdiorite									
Sample No.	55	55	55	31	31	31	31	31	31	31	31	31	31	31	31	31	31	46	46	46	46	46	46	46	46	46	46
Analysis No.	1r	1r	1c	1r	1c	1c1	2r	2c	2r1	2c1	2c2	2c3	3c	4r	4c	4r1	4r2	1c	1r	2c	3c	4r	4c	Stk 1c	Stk 2c	Stk 2r	Stk 3c
	Oxide Weight Percent																										
SiO_2	42.46	42.16	41.94	42.23	42.46	42.10	42.12	40.49	44.03	40.37	40.56	42.64	42.75	43.18	43.02	43.82	43.83	49.85	50.47	41.89	46.01	48.12	47.14	45.06	43.22	49.42	48.03
TiO_2	2.15	2.65	2.68	2.45	2.56	2.65	2.68	2.64	2.22	2.66	2.57	2.49	2.36	2.53	3.14	1.99	2.44	1.46	1.21	2.23	2.07	1.60	1.99	1.60	1.97	1.60	2.08
Al_2O_3	13.07	13.44	13.45	12.61	11.91	11.98	12.41	14.39	9.73	14.45	14.41	11.59	11.67	10.67	10.45	9.05	9.66	5.99	5.15	12.72	8.70	5.76	6.68	9.55	10.41	6.01	6.86
Fe_2O_3(T)	11.92	12.16	11.68	15.02	14.78	15.87	14.43	14.62	17.26	14.90	15.14	14.75	16.41	18.64	15.51	20.21	19.69	12.15	12.09	13.87	13.87	12.65	11.89	15.61	15.64	11.95	12.42
MnO	0.31	0.20	<0.20	0.39	0.34	0.36	0.29	<0.20	0.29	<0.20	0.33	0.22	0.49	0.40	0.33	0.69	0.75	0.47	0.60	0.33	0.47	0.46	0.57	0.73	0.39	0.59	0.56
MgO	13.67	13.10	13.31	12.29	12.81	12.56	13.14	12.03	11.90	12.22	11.69	13.00	11.77	10.92	12.58	10.42	10.92	14.36	15.00	11.69	12.49	14.43	14.79	11.38	11.26	14.68	14.39
CaO	11.01	10.92	10.83	10.85	10.98	10.73	11.05	11.02	10.20	11.10	11.17	10.62	10.59	10.28	10.56	10.22	9.97	11.06	11.03	11.10	11.93	11.05	10.86	10.83	10.99	10.81	10.60
Na_2O	2.20	2.45	2.94	2.22	2.39	2.65	2.55	2.80	1.98	2.42	2.23	2.39	2.12	2.33	2.29	2.01	2.52	1.37	1.32	2.21	1.61	1.25	1.38	1.61	2.06	1.43	1.71
K_2O	0.38	0.49	0.47	0.52	0.56	0.51	0.51	0.51	0.52	0.42	0.56	0.53	0.51	0.54	0.47	0.64	0.51	0.57	0.44	0.66	0.76	0.57	0.57	0.59	0.70	0.59	0.51
Cl	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.25	<0.20	<0.20	<0.20	<0.20	0.20	<0.20	0.32	0.22	0.22	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
O=Cl									0.06					0.05		0.07	0.05	0.05									
Total	97.24	97.66	97.37	98.71	98.82	99.51	99.24	98.78	98.30	98.68	98.72	98.25	98.82	99.61	98.51	99.29	100.46	97.43	97.48	96.73	98.04	96.04	96.04	97.09	96.79	97.22	97.28
	Number of atoms per formula unit (23 oxygens)																										
Si	6.26	6.20	6.18	6.13	6.05	5.88	6.24	6.26	6.21	6.18	5.99	6.57	5.97	6.01	6.31	6.34	6.42	7.26	7.34	6.28	6.79	7.16	7.00	6.75	6.53	7.22	7.04
Ti	0.24	0.29	0.30	0.40	0.44	0.40	0.27	0.28	0.29	0.30	0.29	0.25	0.30	0.29	0.28	0.26	0.28	0.16	0.13	0.25	0.23	0.18	0.22	0.18	0.22	0.17	0.23
Al	2.27	2.33	2.34	2.14	2.27	2.51	2.19	2.07	2.08	2.15	2.51	1.71	2.52	2.52	2.02	2.04	1.87	1.03	0.88	2.25	1.51	1.01	1.17	1.68	1.85	1.03	1.19
Fe^{2+}	1.47	1.50	1.44	1.80	1.72	1.73	1.85	1.82	1.96	1.77	1.81	2.15	1.84	1.87	1.83	2.03	2.32	1.48	1.47	1.74	1.71	1.57	1.48	1.95	1.98	1.46	1.52
Mn	0.04	0.02	-	0.03	0.02	0.03	0.05	-	0.05	-	0.02	0.04	0.02	0.04	0.03	0.06	0.05	0.06	0.07	0.04	0.06	0.06	0.07	0.09	0.05	0.07	0.07
Mg	3.00	2.87	2.92	2.66	2.66	2.61	2.70	2.81	2.76	2.87	2.65	2.64	2.69	2.58	2.87	2.60	2.42	3.11	3.25	2.61	2.74	3.20	3.27	2.54	2.53	3.19	3.14
Ca	1.74	1.72	1.71	1.80	1.82	1.85	1.72	1.73	1.69	1.74	1.75	1.63	1.76	1.77	1.68	1.68	1.64	1.72	1.72	1.78	1.88	1.76	1.73	1.74	1.78	1.69	1.66
Na	0.63	0.70	0.84	0.66	0.65	0.71	0.63	0.68	0.76	0.72	0.80	0.57	0.69	0.64	0.69	0.61	0.67	0.39	0.37	0.64	0.46	0.36	0.40	0.47	0.60	0.40	0.48
K	0.07	0.09	0.09	0.19	0.18	0.22	0.10	0.10	0.10	0.10	0.10	0.10	0.08	0.11	0.10	0.10	0.10	0.11	0.08	0.13	0.14	0.11	0.11	0.11	0.13	0.11	0.10
Cl	-	-	-	-	-	-	-	-	0.03	-	-	-	-	0.02	-	0.04	0.05	0.05	-	-	-	-	-	-	-	-	-
Total	15.73	15.76	15.83	15.84	15.82	15.94	15.80	15.82	15.91	15.88	15.94	15.72	15.86	15.84	15.80	15.77	15.80	15.37	15.36	15.73	15.56	15.44	15.48	15.55	15.72	15.39	15.46
# Mg	67.13	65.76	67.01	59.72	60.66	60.05	59.32	60.70	58.51	61.87	59.45	55.12	59.37	57.92	61.10	56.11	51.07	67.81	68.85	60.02	61.58	67.02	68.90	56.51	56.19	68.64	67.37
Al^{VI}	1.74	1.80	1.82	1.87	1.95	2.12	1.76	1.74	1.79	1.82	2.01	1.43	2.03	1.99	1.69	1.66	1.58	0.74	0.66	1.72	1.21	0.84	1.00	1.25	1.47	0.79	0.96

r = analysis at grain rim; c = analysis at grain core; <0.20 = below detection limit; - = below detection limit

Hornblende analyses cont.

	Cruz Conga - Basaltic Andesite						Carpa - Hbl Andesite				
Sample No.	32	32	32	32	32	32	21	21	21	21	21
Analysis No.	1c	2c	3c	3r	4c	5c	1c	2c	2r	3c	4c
SiO_2	41.34	40.84	40.87	41.73	41.00	39.52	39.32	41.61	40.93	40.28	42.86
TiO_2	3.65	3.93	3.86	3.65	3.94	3.56	2.08	2.41	2.37	2.11	1.84
Al_2O_3	12.23	12.84	12.62	12.38	13.06	14.34	14.17	10.97	11.24	13.07	10.17
Fe_2O_3(T)	14.76	13.29	14.64	14.62	13.99	13.94	16.40	18.12	19.30	13.35	16.29
MnO	0.26	0.33	0.23	0.25	<0.20	0.21	<0.20	0.75	1.01	<0.20	1.07
MgO	12.24	12.29	11.94	12.16	12.10	11.76	10.95	9.95	9.34	12.18	10.83
CaO	11.30	11.54	11.59	11.44	11.50	11.58	11.33	10.68	10.88	13.00	12.35
Na_2O	2.33	2.44	2.25	2.33	2.28	2.45	2.51	2.15	1.90	2.38	2.05
K_2O	0.93	0.98	0.98	0.99	0.96	1.14	0.81	0.99	1.06	0.88	0.95
Cl	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
O=Cl											
Total	99.08	98.54	99.00	99.64	99.05	98.54	97.77	97.70	98.13	97.39	98.44
Si	6.11	6.18	6.05	6.13	6.05	5.88	5.95	6.34	6.26	6.05	6.45
Ti	0.41	0.45	0.43	0.40	0.44	0.40	0.24	0.28	0.27	0.24	0.21
Al	2.13	2.29	2.20	2.14	2.27	2.51	2.52	1.97	2.03	2.32	1.80
Fe^{2+}	1.83	1.68	1.81	1.80	1.72	1.73	2.07	2.31	2.47	1.68	2.05
Mn	0.03	0.04	0.03	0.03	-	0.03	-	0.10	0.13	-	0.14
Mg	2.69	2.77	2.63	2.66	2.66	2.61	2.47	2.26	2.13	2.73	2.42
Ca	1.79	1.87	1.84	1.80	1.82	1.85	1.84	1.74	1.78	2.09	1.99
Na	0.67	0.71	0.64	0.66	0.65	0.71	0.74	0.63	0.56	0.69	0.60
K	0.18	0.19	0.19	0.19	0.18	0.22	0.16	0.19	0.21	0.17	0.18
Cl	-	-	-	-	-	-	-	-	-	-	-
Total	15.84	16.21	15.84	15.84	15.82	15.94	16.02	15.83	15.87	15.99	15.85
# Mg	59.62	62.23	59.23	59.72	60.66	60.05	54.34	49.46	46.32	61.91	54.21
Al^{VI}	1.89	1.82	1.95	1.87	1.95	2.12	2.05	1.66	1.74	1.95	1.55

Miocene Barren Intrusive Units

	Michiquillay Region - Hbl-Bt Qtz Diorite										
Sample No.	59	59	59	59	59	59	59	59	59	59	59
Analysis No.	1c	2c	3c	4c	4r	5c	5r	6c	6r	7c	7r
SiO_2	41.09	43.03	42.15	44.33	44.60	43.65	44.19	43.50	43.58	42.07	43.15
TiO_2	1.24	1.22	1.05	1.21	1.17	1.88	1.95	1.57	1.45	1.18	1.31
Al_2O_3	12.27	11.19	12.38	10.11	10.18	11.21	10.68	11.38	11.21	12.05	11.43
Fe_2O_3(T)	19.21	19.01	20.03	17.32	18.35	16.00	15.76	16.63	16.76	19.88	20.69
MnO	0.79	0.59	0.43	0.53	0.52	0.21	0.22	0.31	0.57	0.51	0.53
MgO	8.52	9.48	9.99	10.39	9.59	11.29	11.08	10.78	10.13	8.37	8.56
CaO	12.65	12.15	10.59	10.95	10.78	10.81	11.00	10.63	10.47	10.97	10.82
Na_2O	1.27	1.57	2.10	1.84	1.43	2.23	2.57	2.04	1.78	1.50	1.75
K_2O	1.31	1.01	1.14	0.72	0.74	0.63	0.73	0.61	0.85	1.33	1.12
Cl	0.24	<0.20	0.27	<0.20	<0.20	0.30	0.22	<0.20	<0.20	<0.20	<0.20
O=Cl	0.05		0.06			0.07	0.05				
Total	98.51	99.36	100.05	97.48	97.42	98.11	98.33	97.47	97.00	98.00	99.44
Si	6.27	6.45	6.30	6.68	6.73	6.50	6.57	6.52	6.59	6.42	6.49
Ti	0.14	0.14	0.12	0.14	0.13	0.21	0.22	0.18	0.16	0.13	0.15
Al	2.21	1.98	2.18	1.79	1.81	1.97	1.87	2.01	2.00	2.17	2.03
Fe^{2+}	2.45	2.38	2.50	2.18	2.32	1.99	1.96	2.08	2.12	2.53	2.60
Mn	0.10	0.07	0.05	0.07	0.07	0.03	0.03	0.04	0.07	0.07	0.07
Mg	1.94	2.12	2.22	2.33	2.16	2.50	2.45	2.41	2.28	1.90	1.92
Ca	2.07	1.95	1.70	1.77	1.74	1.72	1.75	1.71	1.69	1.79	1.74
Na	0.38	0.45	0.61	0.54	0.42	0.64	0.74	0.59	0.52	0.44	0.51
K	0.25	0.19	0.22	0.14	0.14	0.12	0.14	0.12	0.16	0.26	0.22
Cl	0.06	-	0.07	-	-	0.08	0.05	-	-	-	-
Total	15.86	15.78	15.97	15.65	15.53	15.76	15.77	15.66	15.65	15.76	15.74
# Mg	44.13	47.05	47.06	51.65	48.21	55.70	55.61	53.61	51.86	42.87	42.44
Al^{VI}	1.73	1.55	1.70	1.32	1.27	1.50	1.43	1.48	1.41	1.58	1.51

	Aurora Patricia - Hbl Diorite					Carpa - Hbl Qtz Diorite		
Sample No.	11	11	11	11	11	38	38	38
Analysis No.	1c	2c	3r	3c	4c	1c	2c	3c
SiO_2	43.02	42.91	42.59	41.85	41.82	41.17	41.51	41.37
TiO_2	1.00	1.03	1.10	1.06	1.15	1.46	1.15	1.24
Al_2O_3	10.69	10.84	11.14	11.84	12.07	12.31	11.56	11.96
Fe_2O_3(T)	19.41	20.00	19.72	20.50	20.42	18.24	19.68	18.69
MnO	0.39	0.70	0.61	0.64	0.45	0.41	0.57	0.62
MgO	9.52	9.79	9.94	9.16	9.23	9.06	8.71	8.76
CaO	10.77	10.75	10.78	10.75	10.57	12.49	12.60	12.67
Na_2O	1.23	1.54	1.22	1.17	1.64	1.48	1.79	1.81
K_2O	0.59	0.66	0.73	0.94	0.85	1.21	1.20	1.28
Cl	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
O=Cl								
Total	96.72	98.30	97.93	97.93	98.30	97.94	98.86	98.46
Si	6.58	6.50	6.46	6.38	6.36	6.27	6.32	6.30
Ti	0.11	0.12	0.13	0.12	0.13	0.17	0.13	0.14
Al	1.93	1.93	1.99	2.13	2.16	2.21	2.07	2.15
Fe^{2+}	2.48	2.53	2.50	2.61	2.59	2.32	2.50	2.38
Mn	0.05	0.09	0.08	0.08	0.06	0.05	0.07	0.08
Mg	2.17	2.21	2.25	2.08	2.09	2.06	1.98	1.99
Ca	1.76	1.74	1.75	1.76	1.72	2.04	2.05	2.07
Na	0.37	0.45	0.36	0.35	0.48	0.44	0.53	0.53
K	0.12	0.13	0.14	0.18	0.16	0.23	0.23	0.25
Cl	-	-	-	-	-	-	-	-
Total	15.60	15.73	15.69	15.70	15.78	15.82	15.92	15.90
# Mg	46.63	46.57	47.31	44.34	44.60	46.96	44.10	45.49
Al^{VI}	1.42	1.50	1.54	1.62	1.64	1.73	1.68	1.70

Hornblende analyses cont.

	Early-Mid Miocene Mineralised Intrusive Centres																							
	Minas Conga - Hbl-Bt Diorite										Michiquillay Prospect - Hbl-Bt Diorite										Galeno - Hbl-Bt Diorite			
Sample No.	Chail	Chail	Chail	Chail	Chail	Chail	Chail	Chail	Chail	Chail	H22	H22	H22	H22	H22	H22	H22	H22	H22	H22	T4	T4	T4	T4
Analysis No.	1r	1c	2r	2c	3r	3c	4r	4c	4r1	5c	1c	1r	2c	2r	3c	3r	4c	4r	5r	5c	1r	1c	2r	2c
SiO_2	45.34	44.80	46.61	45.97	45.13	45.66	45.62	44.92	45.73	44.88	47.47	46.15	45.88	47.32	45.54	47.44	44.81	46.19	45.38	45.72	42.93	43.69	43.74	43.45
TiO_2	1.41	1.29	1.20	1.31	1.34	1.11	1.40	1.41	1.54	1.31	1.07	1.17	1.23	0.94	1.26	1.07	1.14	1.19	1.34	1.26	1.35	1.22	1.26	1.25
Al_2O_3	8.78	9.01	8.59	8.59	8.56	8.14	9.01	9.27	9.11	9.66	8.65	9.26	9.68	8.73	9.66	7.89	9.94	9.10	10.45	9.28	10.25	10.16	9.86	10.07
Fe_2O_3(T)	15.71	15.72	14.48	15.03	14.25	15.86	13.13	17.03	13.75	13.19	15.84	15.90	16.54	15.83	16.84	15.21	16.51	15.92	14.79	16.89	17.92	17.13	17.08	17.38
MnO	0.51	0.56	0.66	0.78	0.75	0.52	0.67	0.64	0.55	0.64	0.43	0.42	0.38	0.39	0.50	0.57	0.57	0.45	0.49	0.42	0.64	0.65	0.57	0.35
MgO	12.62	12.79	13.80	13.57	13.76	12.80	13.94	11.74	13.68	13.88	11.93	11.82	11.67	12.20	11.57	12.37	11.43	11.78	11.27	11.36	10.48	11.16	10.42	10.38
CaO	10.75	10.78	10.69	11.03	11.26	10.93	11.24	10.91	10.79	10.81	11.05	10.98	10.83	10.84	10.98	10.59	10.92	10.92	10.83	10.87	11.08	11.09	11.19	11.01
Na_2O	2.13	2.25	1.97	2.18	2.05	1.92	1.97	1.90	2.28	1.87	1.40	1.75	2.02	1.80	1.75	1.48	2.01	1.40	1.88	1.47	1.79	1.71	1.74	1.66
K_2O	0.66	0.74	0.63	0.76	0.81	0.68	0.92	0.93	0.83	0.78	0.69	0.66	0.67	0.66	0.70	0.48	0.81	0.75	0.79	0.80	0.90	0.98	0.95	0.91
Cl	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.23	0.21	<0.20	<0.20	<0.20	0.20	<0.20	<0.20
O=Cl																	0.05	0.05				0.05		
Total	98.10	98.08	98.79	99.33	98.00	97.67	98.05	98.85	98.43	97.18	98.64	98.31	99.05	98.81	98.89	97.22	98.33	97.85	97.35	98.25	97.45	97.95	96.86	96.59
Si	6.74	6.67	6.82	6.74	6.70	6.81	6.71	6.67	6.72	6.66	6.96	6.82	6.75	6.93	6.73	7.03	6.68	6.85	6.74	6.80	6.57	6.65	6.63	6.58
Ti	0.16	0.14	0.13	0.14	0.15	0.12	0.15	0.16	0.17	0.15	0.12	0.13	0.14	0.10	0.14	0.12	0.13	0.13	0.15	0.14	0.14	0.14	0.14	0.11
Al	1.54	1.58	1.48	1.48	1.50	1.43	1.56	1.62	1.58	1.69	1.49	1.61	1.68	1.51	1.68	1.38	1.74	1.59	1.83	1.63	1.80	1.76	1.81	1.93
Fe^{2+}	1.95	1.96	1.77	1.84	1.77	1.98	1.61	2.11	1.69	1.64	1.94	1.97	2.04	1.94	2.08	1.88	2.06	1.97	1.84	2.10	2.16	2.17	2.22	2.48
Mn	0.06	0.07	0.08	0.10	0.09	0.07	0.08	0.08	0.07	0.08	0.05	0.05	0.05	0.05	0.06	0.07	0.07	0.06	0.06	0.05	0.08	0.07	0.04	0.05
Mg	2.79	2.84	3.01	2.96	3.04	2.85	3.06	2.60	2.99	3.07	2.61	2.60	2.56	2.66	2.55	2.73	2.54	2.60	2.50	2.51	2.50	2.36	2.36	2.17
Ca	1.71	1.72	1.67	1.73	1.79	1.75	1.77	1.73	1.70	1.72	1.74	1.74	1.71	1.70	1.74	1.68	1.74	1.73	1.72	1.73	1.79	1.82	1.80	1.76
Na	0.62	0.65	0.56	0.62	0.59	0.56	0.56	0.55	0.65	0.54	0.40	0.50	0.58	0.51	0.50	0.43	0.58	0.40	0.54	0.42	0.50	0.51	0.49	0.37
K	0.13	0.14	0.12	0.14	0.15	0.13	0.17	0.18	0.15	0.15	0.13	0.12	0.13	0.12	0.13	0.09	0.15	0.14	0.15	0.15	0.19	0.18	0.18	0.12
Cl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06	0.05	-	-	-	0.01	-	-
Total	15.74	15.80	15.68	15.79	15.80	15.70	15.72	15.72	15.76	15.72	15.47	15.60	15.66	15.55	15.63	15.45	15.75	15.54	15.57	15.58	15.78	15.69	15.70	15.60
# Mg	58.87	59.18	62.93	61.67	63.26	58.99	65.43	55.13	63.93	65.21	57.31	56.99	55.69	57.86	55.03	59.18	55.22	56.87	57.58	54.49	53.73	52.10	51.56	46.63
Al^{VI}	1.26	1.33	1.18	1.26	1.30	1.19	1.29	1.33	1.28	1.34	1.04	1.18	1.25	1.07	1.27	0.97	1.32	1.15	1.26	1.20	1.43	1.35	1.37	1.42

Hornblende analyses cont.

	Miocene Volcanic Units													
	Regalado Voclanic Sequence - Hbl Basaltic Andesite									Huambos Fm - Hbl-Bt Andesite				
Sample No.	64	64	64	64	64	64	64	64	64	63	63	63	63	63
Analysis No.	1r	1c	2c	2r	3r	3c	4r	4c	5c	1r	1c	2c	2r	3c
SiO_2	45.10	43.97	44.53	44.69	43.67	45.64	45.65	45.51	43.34	44.44	44.16	45.11	44.61	43.98
TiO_2	1.71	1.86	1.93	1.89	2.13	1.87	2.05	1.98	2.08	2.40	1.80	1.72	1.76	1.85
Al_2O_3	12.11	13.56	11.92	11.98	11.20	9.94	9.62	9.35	12.99	11.32	11.77	9.58	9.64	11.75
Fe_2O_3(T)	12.37	11.91	9.73	9.56	12.39	15.39	15.01	14.56	11.31	10.57	9.85	15.37	16.02	14.02
MnO	0.48	<0.20	0.25	0.22	<0.20	0.37	0.31	0.32	<0.20	<0.20	0.21	0.61	0.40	0.52
MgO	13.40	13.52	14.39	14.95	13.67	12.06	12.56	12.67	13.96	14.48	15.06	11.66	11.67	11.97
CaO	10.95	11.45	11.22	11.29	11.37	10.70	10.67	10.74	11.29	11.09	11.08	10.64	10.59	10.96
Na_2O	2.01	2.20	2.33	2.47	2.72	1.65	2.00	2.04	2.34	2.15	2.61	1.47	1.65	2.01
K_2O	0.37	0.57	0.62	0.62	0.54	0.96	0.89	1.00	0.56	0.47	0.56	1.05	1.01	0.65
Cl	<0.20	<0.20	<0.20	<0.20	<0.20	0.24	0.24	<0.20	<0.20	<0.20	<0.20	0.22	<0.20	<0.20
O=Cl						0.06	0.05					0.05		
Total	98.51	99.19	96.93	97.73	97.99	98.74	98.92	98.32	97.86	97.07	97.16	97.38	97.53	97.83
Si	6.53	6.33	6.50	6.48	6.42	6.71	6.70	6.71	6.32	6.50	6.45	6.74	6.68	6.50
Ti	0.19	0.20	0.21	0.21	0.24	0.21	0.23	0.22	0.23	0.26	0.20	0.19	0.20	0.21
Al	2.07	2.30	2.05	2.05	1.94	1.72	1.66	1.62	2.23	1.95	2.03	1.69	1.70	2.05
Fe^{2+}	1.50	1.43	1.19	1.16	1.52	1.89	1.84	1.79	1.38	1.29	1.20	1.92	2.01	1.73
Mn	0.06	-	0.03	0.03	-	0.05	0.04	0.04	-	-	0.03	0.08	0.05	0.07
Mg	2.89	2.90	3.13	3.23	3.00	2.64	2.74	2.78	3.03	3.15	3.28	2.59	2.60	2.64
Ca	1.70	1.77	1.76	1.75	1.79	1.68	1.67	1.70	1.76	1.74	1.73	1.70	1.70	1.73
Na	0.56	0.61	0.66	0.69	0.77	0.47	0.57	0.58	0.66	0.61	0.74	0.43	0.48	0.58
K	0.07	0.10	0.12	0.11	0.10	0.18	0.17	0.19	0.10	0.09	0.11	0.20	0.19	0.12
Cl	-	-	-	-	-	0.06	0.06	-	-	-	-	0.06	-	-
Total	15.57	15.68	15.65	15.72	15.84	15.61	15.67	15.68	15.72	15.62	15.77	15.59	15.66	15.65
# Mg	65.88	66.90	72.49	73.59	66.29	58.26	59.85	60.80	68.73	70.94	73.15	57.47	56.48	60.33
Al^{VI}	1.47	1.67	1.50	1.52	1.58	1.29	1.30	1.29	1.68	1.50	1.55	1.26	1.32	1.50

Electron microprobe analyses of pyroxene grains

Gabbroic Dyke — South Galeno - Hbl Gabbro

Sample No.	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Analysis No.	1r	1c	1r	1r1	2c	3c	3r	4r	4c	4r2	5c	5r	7r	7c	7r2
Oxide Weight Percent															
SiO_2	51.48	50.46	50.05	49.14	51.41	51.02	51.86	50.50	52.56	50.87	51.95	50.73	49.90	51.24	50.47
TiO_2	0.53	0.61	0.87	0.96	0.62	0.61	0.60	0.76	0.24	0.54	0.39	0.81	0.88	0.72	0.96
Al_2O_3	1.54	3.86	3.60	4.22	2.61	2.95	1.83	3.99	1.75	2.56	2.04	3.70	4.69	3.32	3.68
Fe_2O_3(T)	10.89	9.45	10.56	10.34	9.62	10.03	10.12	10.97	10.26	10.14	10.28	11.06	9.71	9.57	10.78
MnO	<0.20	0.28	0.39	0.27	0.38	0.20	<0.20	<0.20	0.30	0.30	0.45	<0.20	<0.20	0.31	0.30
MgO	14.40	13.99	13.20	13.41	14.44	13.73	14.45	13.55	14.91	13.87	14.39	13.30	13.58	13.75	13.40
CaO	20.10	20.72	20.61	20.46	20.11	20.40	20.33	20.12	20.12	19.95	19.98	20.34	21.54	20.50	20.30
Na_2O	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40
K_2O	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Cl	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Total	99.12	99.83	99.75	98.85	99.30	99.06	99.47	100.44	100.58	98.36	99.97	100.41	100.80	99.86	100.32
Number of atoms per formula unit (6 oxygens)															
Si	1.95	1.89	1.89	1.87	1.93	1.92	1.95	1.89	1.95	1.93	1.94	1.90	1.86	1.92	1.89
Ti	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.01	0.02	0.01	0.02	0.02	0.02	0.03
Al	0.07	0.17	0.16	0.19	0.12	0.13	0.08	0.18	0.08	0.11	0.09	0.16	0.21	0.15	0.16
Fe^{2+}	0.34	0.30	0.33	0.33	0.30	0.32	0.32	0.34	0.32	0.32	0.32	0.35	0.30	0.30	0.34
Mn	-	0.01	0.01	0.01	0.01	0.01	-	-	0.01	0.01	0.01	-	-	0.01	0.01
Mg	0.81	0.78	0.74	0.76	0.81	0.77	0.81	0.75	0.83	0.79	0.80	0.74	0.75	0.77	0.75
Ca	0.81	0.83	0.83	0.83	0.81	0.82	0.82	0.81	0.80	0.81	0.80	0.81	0.86	0.82	0.81
Na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
K	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	4.01	4.03	4.02	4.01	4.00	4.00	4.00	4.02	4.02	4.00	4.02	4.01	4.03	4.01	4.02
En	41.18	40.73	38.64	39.36	41.83	40.23	41.59	39.65	42.25	40.72	41.38	38.98	39.34	40.40	39.17
Fs	17.48	15.91	17.99	17.47	16.26	16.81	16.34	18.01	16.79	17.19	17.32	18.17	15.79	16.29	18.18
Wo	41.34	43.36	43.37	43.17	41.91	42.96	42.06	42.34	40.96	42.09	41.30	42.84	44.88	43.31	42.64
# Mg	70.21	72.51	69.02	69.81	72.78	70.93	71.79	68.77	72.15	70.92	71.38	68.20	71.36	71.92	68.91

Gabbroic Dyke — South Galeno - Hbl Gabbro

Sample No.	55	55	55	55	55	55
Analysis No.	1r	1c	2c	2r	3c	3r
Oxide Weight Percent						
SiO_2	51.44	50.23	52.21	51.83	51.49	50.71
TiO_2	0.71	0.65	0.52	0.63	0.71	0.81
Al_2O_3	3.89	5.12	2.58	3.70	3.95	4.65
Fe_2O_3(T)	8.46	8.55	8.22	8.17	8.00	8.50
MnO	0.36	0.29	0.41	0.20	0.23	0.29
MgO	13.54	13.28	14.54	13.92	13.88	13.59
CaO	20.50	20.06	19.82	20.67	21.05	21.37
Na_2O	0.64	0.63	0.72	0.63	0.74	0.58
K_2O	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Cl	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Total	99.59	98.87	99.09	99.84	100.08	100.56
Number of atoms per formula unit (6 oxygens)						
Si	1.92	1.89	1.95	1.92	1.91	1.88
Ti	0.02	0.02	0.01	0.02	0.02	0.02
Al	0.17	0.23	0.11	0.16	0.17	0.20
Fe^{2+}	0.26	0.27	0.26	0.25	0.25	0.26
Mn	0.01	0.01	0.01	0.01	0.01	0.01
Mg	0.75	0.74	0.81	0.77	0.77	0.75
Ca	0.82	0.81	0.79	0.82	0.84	0.85
Na	0.05	0.05	0.05	0.05	0.05	0.04
K	-	-	-	-	-	-
Cl	-	-	-	-	-	-
Total	4.00	4.01	4.01	4.00	4.01	4.02
En	40.76	40.65	43.24	41.57	41.26	40.10
Fs	14.89	15.18	14.40	14.03	13.75	14.58
Wo	44.35	44.17	42.36	44.40	44.99	45.32
# Mg	74.05	73.46	75.92	75.23	75.54	74.01

Gabbroic Dyke — East Galeno - Gabbroic Diorite

Sample No.	57	57	57	57	57	57	57	57	57	57
Analysis No.	1r	1c	1r1	1c1	2r	2c	2r1	3r	3c	4c
Oxide Weight Percent										
SiO_2	51.67	51.31	52.29	51.56	51.64	51.64	51.43	51.24	51.31	51.49
TiO_2	0.78	0.80	0.41	0.64	0.76	0.71	0.75	0.75	0.65	0.72
Al_2O_3	2.47	2.23	1.93	2.17	1.66	1.84	2.03	2.07	2.18	1.80
Fe_2O_3(T)	10.65	10.54	12.04	11.37	11.18	10.66	10.95	10.99	10.69	10.77
MnO	0.31	<0.20	0.35	0.30	0.29	0.34	0.38	0.46	0.38	0.33
MgO	13.84	14.14	13.43	14.10	13.86	14.22	13.99	14.17	13.81	14.29
CaO	19.72	19.67	19.37	19.39	19.85	20.03	19.69	19.25	19.45	19.40
Na_2O	<0.40	<0.40	<0.40	<0.40	<0.40	0.52	<0.40	0.45	<0.40	<0.40
K_2O	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Cl	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Total	99.73	99.30	99.89	99.89	99.52	100.02	99.44	99.41	98.61	98.88
Number of atoms per formula unit (6 oxygens)										
Si	1.94	1.93	1.96	1.94	1.95	1.94	1.94	1.93	1.95	1.95
Ti	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Al	0.11	0.10	0.09	0.10	0.07	0.08	0.09	0.09	0.10	0.08
Fe^{2+}	0.33	0.33	0.38	0.36	0.35	0.33	0.35	0.35	0.34	0.34
Mn	0.01	-	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Mg	0.77	0.79	0.75	0.79	0.78	0.79	0.79	0.80	0.78	0.81
Ca	0.79	0.79	0.78	0.78	0.80	0.80	0.79	0.78	0.79	0.79
Na	-	-	-	-	-	0.04	-	-	-	-
K	-	-	-	-	-	-	-	-	-	-
Cl	-	-	-	-	-	-	-	-	-	-
Total	4.00	4.01	3.99	4.01	4.01	4.02	4.00	4.02	3.99	4.00
En	40.50	41.36	39.15	40.78	40.08	40.86	40.54	41.16	40.61	41.45
Fs	18.00	17.30	20.27	18.93	18.62	17.75	18.43	18.67	18.27	18.08
Wo	41.50	41.35	40.58	40.29	41.29	41.40	41.03	40.18	41.12	40.47
# Mg	69.85	70.51	66.53	68.86	68.83	70.39	69.47	69.68	69.72	70.27

r = analysis at grain rim; c = analysis at grain core; <0.20 = below detection limit; - = below detection limit

Pyroxene analyses cont.

	Palaeogene Igneous Units															Miocene Barren Intrusions						Miocene Volcanic Units							
	North Galeno - Gabbroic Diorite					East M Conga - Hbl MD			Cruz Conga - Basltic Andesite							Michiquillay Region - Hbl-Bt Qtz Diorite						Regalado Voclanic Sequence - Hbl Basaltic Andesite						Huambos Fm	
Sample No.	87	87	87	87	87	46	46	46	32	32	32	32	32	32	32	59	59	59	59	59	59	64	64	64	64	64	64	63	63
Analysis No.	1c	1r	1c1	2r	2c	1r	1c	2c	1c	2c	3c	4c	5c	6c	7c	1c	2c	3c	3r	4c	5c	1c	2c	2r	3c	3r	4r	1c	1r
SiO_2	52.09	50.14	51.90	51.02	52.62	51.79	51.35	52.48	50.06	50.36	49.97	49.73	49.01	47.79	50.05	51.13	50.89	50.23	50.64	53.13	50.79	52.62	54.22	54.15	54.94	52.58	54.09	54.54	53.77
TiO_2	0.21	1.02	0.23	0.93	0.28	0.27	0.20	<0.20	1.22	0.91	1.03	0.86	1.26	1.71	1.10	0.60	0.69	0.82	0.60	0.35	0.77	0.53	0.30	0.34	0.32	0.57	0.40	0.24	<0.20
Al_2O_3	0.64	3.58	0.62	3.50	0.88	1.60	1.34	0.64	4.44	3.78	4.12	4.47	4.92	6.02	3.66	5.39	5.35	5.90	5.37	2.85	5.19	2.28	0.97	1.13	1.24	2.47	1.31	1.35	1.10
Fe_2O_3(T)	18.20	12.27	17.88	11.56	16.16	9.16	9.73	8.00	9.38	9.78	10.47	12.01	9.35	9.94	9.54	5.23	5.18	5.71	5.30	4.43	4.95	8.19	8.93	7.86	8.50	7.94	9.09	9.34	9.26
MnO	0.40	0.46	0.36	0.28	0.56	0.84	1.11	0.89	0.46	0.31	0.49	0.97	0.21	<0.20	0.42	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.36	0.55	0.36	0.50	0.36	0.37	0.69	0.94
MgO	9.81	11.27	10.07	12.04	10.82	13.15	12.70	14.25	12.88	13.34	11.59	10.86	12.43	12.02	13.00	13.94	14.39	13.85	14.23	15.36	14.26	14.78	15.50	15.87	16.02	14.63	15.55	13.60	13.35
CaO	17.72	19.74	18.03	19.58	18.58	21.35	21.37	21.88	21.97	21.81	21.81	21.60	22.05	21.97	21.78	22.41	22.31	22.21	21.65	21.93	22.17	20.64	19.08	19.04	19.23	20.26	18.54	20.52	20.42
Na_2O	<0.40	<0.40	0.60	0.72	0.87	0.83	0.60	0.46	0.49	0.64	0.61	0.65	0.47	0.53	<0.40	<0.40	0.91	0.54	0.61	<0.40	0.79	0.83	0.55	<0.40	0.57	<0.40	0.62	0.56	<0.40
K_2O	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Cl	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Total	99.44	98.94	99.77	99.69	100.81	99.04	98.50	98.76	101.02	100.98	100.13	101.29	99.81	100.13	99.83	99.24	99.85	99.50	98.59	98.52	99.08	100.30	100.18	99.14	101.40	99.20	100.09	100.87	99.50
Si	2.02	1.92	2.00	1.92	2.00	1.96	1.96	1.98	1.86	1.88	1.88	1.87	1.85	1.80	1.88	1.89	1.87	1.86	1.88	1.96	1.88	1.95	2.00	2.01	2.00	1.96	1.99	2.01	2.01
Ti	0.01	0.03	0.01	0.03	0.01	0.01	0.01	-	0.03	0.03	0.03	0.02	0.04	0.05	0.03	0.02	0.02	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.01	0.01	-
Al	0.03	0.16	0.03	0.16	0.04	0.07	0.06	0.03	0.19	0.17	0.18	0.20	0.22	0.27	0.16	0.23	0.23	0.26	0.24	0.12	0.23	0.10	0.04	0.05	0.05	0.11	0.06	0.06	0.05
Fe^{2+}	0.59	0.39	0.58	0.36	0.51	0.29	0.31	0.25	0.29	0.30	0.33	0.38	0.29	0.31	0.30	0.16	0.16	0.18	0.16	0.14	0.15	0.25	0.28	0.24	0.26	0.25	0.28	0.29	0.29
Mn	0.01	0.01	0.01	0.01	0.02	0.03	0.04	0.03	0.01	0.01	0.02	0.03	0.01	-	0.01	-	-	-	-	-	-	0.01	0.02	0.01	0.02	0.01	0.01	0.02	0.03
Mg	0.57	0.64	0.58	0.68	0.61	0.74	0.72	0.80	0.71	0.74	0.65	0.61	0.70	0.67	0.73	0.77	0.79	0.76	0.79	0.85	0.79	0.81	0.85	0.88	0.87	0.81	0.85	0.75	0.74
Ca	0.73	0.81	0.75	0.79	0.76	0.87	0.88	0.89	0.88	0.87	0.88	0.87	0.89	0.89	0.88	0.89	0.88	0.88	0.86	0.87	0.88	0.82	0.75	0.76	0.75	0.81	0.73	0.81	0.82
Na	-	-	0.05	0.05	0.06	0.06	0.04	0.03	0.04	0.05	0.04	0.05	0.03	0.04	-	-	0.07	0.04	0.04	-	0.06	0.06	0.04	-	0.04	-	0.04	0.04	-
K	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	3.98	3.99	4.00	4.00	4.01	4.03	4.03	4.02	4.03	4.04	4.02	4.03	4.03	4.04	4.02	3.99	4.03	4.01	4.01	3.98	4.01	4.02	3.99	3.98	3.99	3.99	3.99	3.98	3.98
En	29.74	34.55	30.28	36.74	32.23	38.53	37.19	40.74	37.64	38.46	34.67	32.23	36.95	35.99	37.96	42.25	43.16	41.94	43.43	45.69	43.24	42.93	44.87	46.45	45.90	43.21	45.46	40.02	39.55
Fs	31.64	21.93	30.76	20.29	27.96	16.47	17.83	14.29	16.16	16.32	18.41	21.65	15.94	16.70	16.33	8.91	8.72	9.70	9.08	7.40	8.41	13.95	15.41	13.49	14.48	13.75	15.53	16.57	16.97
Wo	38.62	43.52	38.96	42.98	39.81	45.00	44.99	44.97	46.20	45.22	46.92	46.12	47.11	47.31	45.72	48.85	48.12	48.35	47.49	46.91	48.35	43.12	39.72	40.06	39.62	43.04	39.01	43.41	43.48
# Mg	48.99	62.06	50.11	64.97	54.39	71.88	69.94	76.04	70.97	70.85	66.35	61.69	70.32	68.30	70.83	82.59	83.19	81.21	82.71	86.06	83.71	76.27	75.56	78.27	77.06	76.65	75.30	72.18	71.99

APPENDIX C2

Raw whole rock geochemical data

ANALYTICAL TECHNIQUES FOR X-RAY FLUORESCENCE

Samples selected for X-ray fluorescence (XRF) were crushed in a clean tungsten-carbide bowl using a Rocklabs tema mill. Splits of the samples were analysed by the Advanced Analytical Centre (AAC) at James Cook University. Approximately 10 g of each sample was weighed into a porcelain crucible and heated at 1000^{o}C for 10 hours to determine the loss on ignition (LOI). Approximately 0.6 g of the heated samples were then pressed into disks and analysed using the Siemens SRS-3000 X-ray fluorescence (XRF) spectrometer. Two duplicate samples of S-59 were run to establish variance and analytical error. One of these (S-59 Duplicate 1) was also crushed in a tungsten-carbide bowl, whereas the other (S-59 Duplicate 2) was crushed in a chromium-steel bowl. Duplicate samples show minimal variations and are within analytical error.

Suite	Gabbroic Dykes						Palaeocene-Eocene Intrusions				Eocene - Llama Volcanic					
Locality	S Galeno	S Galeno	S Galeno	N Galeno	E Galeno	N Galeno	Cerro Montana		East Minas Conga		La Carpa	Cruz Conga	Aurora Patricia	La Carpa		
Sample No.	S-16	S-55	S-57	S-18	S-26	S-87	S-28	S-31	S-46	S-50	S-21	S-32	S-11	S-38	S-35	S-36
Rock Type	Hbl Gabbro	Hbl Gabbro	Gabbro	Gabbro	Gab Diorite	Gab Diorite	Hbl Diorite	Hbl Diorite	Hbl MD	Hbl MD	Hbl Andesite	Basaltic Andesite	Hbl Diorite	Hbl Qtz Diorite	Hbl-Bt Diorite	Hbl-Bt Diorite
wt.%																
SiO_2	46.49	44.37	49.67	43.17	50.70	51.13	57.80	56.70	55.80	53.34	56.16	54.90	61.30	63.52	59.38	60.85
TiO_2	1.20	1.07	1.28	1.19	1.51	1.09	0.57	0.64	0.71	0.69	0.64	1.10	0.52	0.48	0.60	0.55
Al_2O_3	18.15	16.89	19.90	16.39	16.87	18.14	17.35	18.54	17.82	17.50	18.54	18.43	17.43	16.61	17.09	16.29
Fe_2O_3(T)	11.59	12.21	9.93	10.19	11.09	10.12	6.93	7.46	7.39	7.69	6.45	6.88	4.83	3.88	5.39	4.68
MnO	0.16	0.21	0.20	0.12	0.64	0.15	0.29	0.26	0.17	0.16	0.21	0.24	0.11	0.07	0.11	0.11
MgO	4.86	4.71	3.82	6.23	3.80	3.32	1.83	2.00	3.68	3.90	2.06	1.62	1.80	1.79	2.43	1.90
CaO	9.41	10.03	9.47	8.04	6.92	9.18	5.34	5.01	8.19	7.52	6.75	6.42	5.70	4.50	6.44	5.99
Na_2O	2.15	2.22	3.25	2.88	3.13	3.23	3.80	4.73	3.81	3.82	4.40	4.55	3.68	3.73	3.67	3.20
K_2O	0.94	0.73	0.94	0.19	2.11	0.94	2.05	1.67	2.06	1.09	2.04	2.79	1.90	2.44	1.93	2.11
P_2O_5	0.17	0.20	0.18	0.34	0.52	0.26	0.39	0.36	0.23	0.24	0.31	0.46	0.23	0.20	0.23	0.23
LOI	5.66	7.71	2.60	11.31	3.10	3.18	3.94	2.89	0.92	4.65	2.06	3.15	3.08	2.92	2.22	5.08
Total	100.78	100.35	101.24	100.06	100.39	100.74	100.29	100.26	100.78	100.60	99.61	100.54	100.58	100.14	99.49	100.99
ppm																
Cr	19	9	5	39	36	3	9	19	31	10	0	0	26	21	29	12
Ni	13	13	14	32	28	8	9	6	15	16	6	5	6	11	12	8
Co	40	33	29	30	32	24	12	11	27	22	19	17	13	17	24	15
Sc	25	18	21	25	22	18	6	7	18	18	8	5	7	7	10	8
V	332	291	222	247	185	184	42	62	174	187	114	82	70	79	103	95
Rb	35	14	24	<1	67	18	61	39	62	27	59	74	60	76	58	64
Cs	8	1	2	<1	8	<1	<1	1	6	1	2	<1	1	3	<1	2
Ba	375	366	621	829	701	373	1228	580	803	648	902	1073	827	864	708	893
Sr	514	582	711	625	472	571	898	799	635	816	775	967	584	623	793	625
Ga	17	17	23	18	21	16	16	16	20	19	20	23	21	21	20	18
Ta	<1.0	<1.0	1.0	<1.0	1.8	<1.0	<1.0	1.1	<1.0	<1.0	<1.0	2.2	<1.0	<1.0	<1.0	<1.0
Nb	1.0	2.0	9.0	11.0	21.0	4.0	3.0	7.0	5.0	4.0	5.0	29.0	5.0	5.0	5.0	6.0
Hf	1.9	1.8	2.1	2.4	5.1	3.5	3.6	3.3	2.9	2.6	3.6	5.0	3.1	3.0	2.5	2.9
Zr	51.0	57.0	81.0	88.0	241.0	128.0	112.0	97.0	86.0	83.0	111.0	189.0	110.0	92.0	78.0	82.0
Y	19.0	19.0	17.0	18.0	37.0	27.0	73.0	27.0	21.0	19.0	25.0	28.0	17.0	16.0	12.0	11.0
Th	1.5	1.7	3.4	3.5	9.6	3.0	3.2	4.7	6.9	5.5	7.3	12.0	4.6	3.0	4.2	4.3
U	<2.0	<2.0	<2.0	<2.0	3.1	<2.0	<2.0	<2.0	<2.0	<2.0	2.1	2.4	<2.0	2.2	<2.0	2.7
La	10.60	12.70	18.40	24.30	43.20	20.00	34.00	25.80	25.90	23.60	34.10	58.40	20.70	15.00	15.90	16.70
Ce	22.70	25.30	36.10	47.10	82.40	46.00	60.70	51.00	48.00	44.30	65.10	106.00	37.30	26.70	36.10	32.90
Nd	13.10	13.00	16.90	na	35.10	na	32.20	25.30	23.00	na	26.60	41.50	18.00	14.70	na	na
Sm	3.15	3.26	3.39	4.32	7.14	5.07	7.54	5.42	4.09	3.96	5.50	7.26	3.66	3.40	3.82	3.54
Eu	1.11	1.02	1.33	1.26	1.71	1.42	2.50	1.74	1.17	0.84	1.58	2.07	1.03	0.75	1.23	1.06
Tb	0.62	0.54	0.65	0.60	1.10	0.88	1.32	0.90	0.69	0.64	0.78	0.94	0.51	0.48	0.53	0.52
Ho	0.74	0.69	0.77	na	1.28	na	1.78	1.07	0.85	na	0.98	1.13	0.58	na	na	na
Yb	1.77	1.67	1.60	1.48	3.16	2.64	4.45	2.59	2.05	1.88	2.70	2.42	1.27	0.86	0.86	0.91
Lu	0.24	0.23	0.22	0.21	0.45	0.40	0.66	0.35	0.29	0.28	0.34	0.31	<0.20	<0.20	<0.20	<0.20
Rb/Sr	0.07	0.02	0.03	0.00	0.14	0.03	0.07	0.05	0.10	0.03	0.08	0.08	0.10	0.12	0.07	0.10
Sr/Y	27.05	30.63	41.82	34.72	12.76	21.15	12.30	29.59	30.24	42.95	31.00	34.54	34.35	38.94	66.08	56.82
La_N/Yb_N	4.00	5.09	7.69	10.98	9.14	5.07	5.11	6.66	8.45	8.39	8.45	16.14	10.90	11.66	12.36	12.27

<2.0 = below detection limit; na = not analysed

Gab Diorite = Gabbroic Diorite; MD = Microdiorite; Bas Andesite = Basaltic Andesite; Hbl = Hornblende; Bt = Biotite

Suite	Miocene Barren Intrusive Units							Miocene Mineralised Centres							
Locality	Michiquillay Region						Galeno Prospect	Michiquillay Prospect			Minas Conga Prospect		Galeno Prospect		
Sample No.	S-54	S-58	S-59	S-59 (Duplicate 1)	S-59 (Duplicate 2)	S-60	S-T4	S-H22(244)	S-H22(176)	S-H22(180)	S-Chail	S-Hualy	S-T1	S-T2	S-T3
Rock Type	Hbl-Bt Diorite	Hbl-Bt Diorite	Hbl-Bt Qtz Diorite	Hbl-Bt Qtz Diorite	Hbl-Bt Qtz Diorite	Hbl-Bt Diorite	Hbl-Bt Diorite	Hbl-Bt Diorite	Hbl-Bt Diorite	Hbl-Bt Diorite	Hbl-Bt Diorite	Hbl-Bt Diorite	Hbl-Bt Diorite	Hbl-Bt Diorite	Hbl-Bt Qtz Diorite
wt.%															
SiO_2	60.58	58.51	59.77	59.50	59.84	61.09	58.20	59.51	61.90	63.00	62.50	59.70	64.00	65.80	63.90
TiO_2	0.54	0.62	0.65	0.63	0.64	0.55	0.60	0.52	0.56	0.56	0.50	0.55	0.48	0.47	0.46
Al_2O_3	16.13	16.75	17.14	17.06	17.17	17.26	16.17	16.80	16.95	16.46	17.19	16.33	17.47	17.15	16.47
Fe_2O_3(T)	4.58	5.56	5.62	5.59	5.73	4.91	7.79	4.50	5.17	5.64	4.72	4.86	3.51	2.28	4.40
MnO	0.10	0.12	0.12	0.12	0.12	0.12	0.07	0.23	0.08	0.00	0.09	0.17	0.00	0.00	0.10
MgO	1.86	2.64	2.68	2.66	2.69	1.55	4.40	0.91	2.26	2.27	1.72	2.33	1.64	1.35	1.57
CaO	5.63	6.08	6.18	6.17	6.16	5.71	4.65	4.73	5.48	4.35	5.00	5.65	0.59	2.30	4.20
Na_2O	3.11	3.94	4.03	3.97	3.88	3.78	3.54	2.44	3.69	3.67	4.27	3.41	2.64	3.43	3.32
K_2O	2.17	1.97	1.99	1.97	1.98	1.86	2.10	2.57	2.34	2.38	2.45	1.16	5.88	3.64	3.32
P_2O_5	0.22	0.22	0.23	0.22	0.22	0.22	0.20	0.22	0.23	0.23	0.23	0.21	0.17	0.23	0.21
				0.01	0.00										
LOI	5.63	4.47	2.50	2.45	2.46	3.62	2.12	7.80	1.40	1.84	1.32	5.06	4.31	3.83	2.60
Total	100.54	100.87	100.91	100.33	100.89	100.67	99.84	100.22	100.06	100.40	99.99	99.43	100.69	100.48	100.55
ppm															
Cr	7	43	28	24	103	7	175	5	45	42	33	41	35	35	46
Ni	7	20	12	13	14	6	46	4	13	12	9	11	10	5	8
Co	19	17	22	32	12	15	23	24	23	22	21	14	21	20	21
Sc	8	13	13	13	13	7	18	10	10	10	8	8	6	6	6
V	93	123	118	119	117	87	146	79	90	94	72	116	80	79	68
Rb	66	60	60	60	60	52	90	100	51	75	72	33	165	81	88
Cs	4	3	2	1	2	<1	3	3	1	2	<1.0	1	4	5	2
Ba	1065	622	671	660	658	766	344	529	668	582	723	473	630	606	794
Sr	580	619	708	711	705	774	532	230	690	600	643	615	295	491	528
Ga	19	19	19	18	19	20	20	21	18	20	19	20	18	18	20
Ta	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.5	1.2	1.2	<1.0	<1.0	1.3	<1.0
Nb	5.0	4.0	4.0	4.0	5.0	6.0	4.0	6.0	7.0	7.0	5.0	6.0	6.0	7.0	7.0
Hf	3.4	2.3	2.7	2.3	3.2	2.8	2.5	3.0	3.0	3.1	3.4	3.0	2.7	3.2	2.4
Zr	89.0	84.0	81.0	87.0	84.0	87.0	67.0	95.0	70.0	82.0	93.0	63.0	99.0	85.0	62.0
Y	16.0	12.0	15.0	14.0	15.0	11.0	16.0	16.0	14.0	12.0	13.0	13.0	13.0	11.0	10.0
Th	4.1	3.7	4.5	4.3	4.1	4.1	3.8	6.2	5.8	6.1	6.1	5.8	3.8	4.6	5.1
U	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
La	19.90	15.10	17.20	16.80	16.00	17.50	14.70	17.50	16.90	16.90	19.30	17.20	14.40	19.60	16.40
Ce	37.60	31.40	36.40	35.40	32.20	37.10	29.70	37.40	35.60	33.90	37.70	33.90	30.40	39.90	32.50
Nd	na	na	16.90	na	na	na	15.60	na	16.90	15.80	17.40	16.30	16.20	20.10	15.50
Sm	4.16	3.41	3.49	3.47	3.59	4.01	3.46	3.56	3.40	2.91	3.28	3.18	3.40	3.77	2.97
Eu	1.23	1.03	0.98	0.92	0.99	1.16	1.17	0.94	1.03	0.89	0.95	0.80	0.98	0.96	0.89
Tb	0.60	0.50	0.53	0.59	0.57	0.53	0.55	0.52	0.45	0.38	0.47	0.48	0.48	0.48	0.43
Ho	na	na	0.62	na	na	na	0.65	na	0.49	0.45	0.57	0.54	0.48	0.46	0.44
Yb	1.14	1.12	1.21	1.14	1.32	0.88	1.32	1.21	0.96	0.93	1.20	1.11	0.91	0.79	0.78
Lu	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Rb/Sr	0.11	0.10	0.08	0.08	0.09	0.07	0.17	0.43	0.07	0.13	0.11	0.05	0.56	0.16	0.17
Sr/Y	36.25	51.58	47.20	50.79	47.00	70.36	33.25	14.38	49.29	50.00	49.46	47.31	22.69	44.64	52.80
La_N/Yb_N	11.67	9.02	9.51	9.85	8.11	13.30	7.45	9.67	11.77	12.15	10.75	10.36	10.58	16.59	14.06

Suite			Regalado Volcanic Units (M-L Mio)				Huambos Volcanics (L Mio)	
Locality	Minas Carpa	Yanacocha			North Cajamarca			W M Conga
Sample No.	S-M Carpa	S-CLL5	S-61	S-64	S-66	S-68	S-63	S-MC4
Rock Type	Hbl-Bt Diorite	Hbl-Bt Diorite	Hbl Andesite	Hbl Andesite	Hbl Andesite	Hbl Andesite	Hbl-Bt Andesite	Hbl-Bt Andesite
wt.%								
SiO_2	62.62	67.90	57.18	60.53	58.57	56.57	59.82	61.77
TiO_2	0.49	0.38	0.71	0.57	0.68	0.74	0.71	0.54
Al_2O_3	16.41	16.85	18.29	16.91	17.76	17.96	17.91	16.80
Fe_2O_3(T)	5.66	2.05	6.37	5.29	5.87	6.67	5.76	4.99
MnO	0.07	0.00	0.14	0.11	0.10	0.20	0.10	0.15
MgO	1.74	1.12	3.31	1.91	2.79	2.62	2.46	2.23
CaO	2.88	2.68	7.20	5.66	6.55	7.42	6.49	5.10
Na_2O	3.42	4.68	4.07	3.56	3.85	3.71	4.23	4.01
K_2O	2.78	2.88	1.51	2.10	1.74	1.59	1.87	2.34
P_2O_5	0.22	0.18	0.25	0.23	0.26	0.28	0.27	0.22
LOI	4.06	1.18	1.18	3.95	1.58	2.55	1.21	2.72
Total	100.35	99.90	100.20	100.81	99.75	100.32	100.83	100.88
ppm								
Cr	35	44	22	13	10	11	25	0
Ni	6	5	16	10	12	11	14	9
Co	22	26	23	20	19	18	19	21
Sc	8	5	17	13	13	13	10	9
V	87	68	132	102	120	129	123	101
Rb	87	83	33	64	46	42	47	70
Cs	3	<1	<1	<1	<1	<1	2	<1
Ba	617	895	620	610	534	488	560	1973
Sr	433	805	838	660	718	759	820	594
Ga	20	20	21	19	22	21	22	20
Ta	<1.0	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nb	7.0	2.0	1.0	4.0	3.0	3.0	3.0	5.0
Hf	3.2	3.6	2.7	2.9	3.2	3.2	2.8	2.5
Zr	93.0	94.0	83.0	86.0	101.0	95.0	105.0	84.0
Y	14.0	7.0	18.0	20.0	15.0	14.0	16.0	12.0
Th	6.3	6.1	2.5	3.7	3.8	3.2	5.9	6.3
U	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.2	2.2
La	18.30	20.20	18.20	20.50	18.60	17.90	22.30	18.20
Ce	36.80	39.00	36.10	42.00	37.80	38.40	41.60	35.50
Nd	17.10	16.50	17.60	na	na	na	19.70	na
Sm	3.28	2.62	3.81	4.00	4.00	3.98	3.90	3.41
Eu	1.06	0.78	1.11	1.05	1.01	0.81	1.15	0.57
Tb	0.45	0.33	0.62	0.61	0.62	0.50	0.60	<0.50
Ho	0.52	0.35	0.77	na	na	na	0.74	na
Yb	1.12	0.62	1.65	1.23	1.37	1.29	1.56	0.99
Lu	<0.20	<0.20	0.21	<0.20	0.20	<0.20	0.22	<0.20
Rb/Sr	0.20	0.10	0.04	0.10	0.06	0.06	0.06	0.12
Sr/Y	30.93	115.00	46.56	33.00	47.87	54.21	51.25	49.50
La_N/Yb_N	10.93	21.79	7.38	11.14	9.08	9.28	9.56	12.29

APPENDIX C3

Partial melting modelling calculations and partition coefficients

Starting composition and partition coefficents used for partial melting models.

Element	Basaltic Source* (ppm)	Olv[1]	Opx[1]	Cpx[1]	Grt[1]	Amp[1]	Kfs[1]	Ilm[1]	Mag[1]
La	10.60	0.0004	0.002	0.10	0.04	0.2	0.10	0.005	0.22
Ce	22.70	0.0005	0.003	0.20	0.08	0.3	0.06	0.006	0.26
Nd	13.10	0.0010	0.007	0.40	0.20	0.8	0.04	0.008	0.30
Sm	3.15	0.0013	0.010	0.60	1.00	1.1	0.04	0.010	0.35
Eu	1.11	0.0016	0.013	0.60	0.98	1.3	4.60	0.007	0.26
Tb	0.62	0.0016	0.019	0.70	7.50	2.0	0.06	0.022	0.28
Yb	1.77	0.0015	0.049	0.60	21.00	1.7	0.04	0.077	0.18
Lu	0.24	0.0015	0.058	0.60	21.00	1.5	0.03	0.100	0.18
Rb	35	0.0100	0.022	0.03	0.03	0.2	2.40		
Sr	514	0.0140	0.017	0.20	0.01	0.4	5.10		
Zr	51	0.4000	0.100	0.35	0.50	0.5	0.02		
Y	19	0.0015	0.030	0.03	16.00	1.9			

* Data from this study (Sample S16)

[1] Martin (1987)

Olv = Olivine; Opx = Orthopyroxene; Cpx = Clinopyroxene; Grt = Garnet; Amp = Amphibole

Kfs = K-feldspar; Ilm = Ilmenite; Mag = Magnetite

Mantle Melting Model To Generate S-16

%	Residual mineralogy	
4	0.04	Amphibole
15	0.15	Clinopyroxene
23	0.23	Orthopyroxene
55	0.55	Olivine
3	0.03	Garnet
0	0.00	Plagioclase

Mantle KD Values for partial melting calculation (Martin, 1987)

	Olivine	Orthopyroxene	Clinopyroxene	Garnet	Amphibole	Plagioclase
La	0.0004	0.002	0.070	0.015	0.20	0.130
Ce	0.0005	0.003	0.098	0.021	0.30	0.110
Nd	0.0010	0.007	0.210	0.087	0.80	0.070
Sm	0.0013	0.010	0.260	0.217	1.10	0.050
Eu	0.0016	0.013	0.310	0.320	1.30	1.300
Tb	0.0016	0.019	0.315	0.779	2.00	0.037
Yb	0.0015	0.049	0.280	4.030	1.70	0.024
Lu	0.0015	0.058	0.270	5.050	1.50	0.023
Rb	0.0100	0.022	0.030	0.040	0.22	0.060
Sr	0.0140	0.017	0.120	0.012	0.36	2.000
Zr	0.4000	0.100	0.350	0.500	0.45	0.250
Y	0.0015	0.030	0.300	2.000	1.90	0.600

Prim. Mantle (McDonough et al. 1992)		Calculated bulk partition coefficient	
La	0.71	La	0.01963
Ce	1.83	Ce	0.02830
Nd	1.37	Nd	0.06822
Sm	0.44	Sm	0.09253
Eu	0.17	Eu	0.11197
Tb	0.11	Tb	0.15587
Yb	0.48	Yb	0.24300
Lu	0.07	Lu	0.26617
Rb	0.64	Rb	0.02506
Sr	21.10	Sr	0.04437
Zr	11.20	Zr	0.32850
Y	4.55	Y	0.18873

1% Batch Melt		2% Batch Melt		5% Batch Melt		S-16	6% Batch Melt		10% Batch Melt		20% Batch Melt		35% Batch Melt		50% Melt	
La	24.05	La	18.04	La	10.31	10.60	La	9.02	La	6.02	La	3.28	La	1.95	La	1.39
Ce	48.22	Ce	38.40	Ce	23.84	22.70	Ce	21.17	Ce	14.61	Ce	8.23	Ce	4.98	Ce	3.57
Nd	17.62	Nd	15.73	Nd	11.90	13.10	Nd	11.00	Nd	8.46	Nd	5.37	Nd	3.46	Nd	2.56
Sm	4.37	Sm	4.01	Sm	3.22	3.15	Sm	3.02	Sm	2.42	Sm	1.62	Sm	1.08	Sm	0.81
Eu	1.39	Eu	1.29	Eu	1.07	1.11	Eu	1.02	Eu	0.84	Eu	0.58	Eu	0.40	Eu	0.30
Tb	0.66	Tb	0.63	Tb	0.55	0.62	Tb	0.52	Tb	0.45	Tb	0.33	Tb	0.24	Tb	0.19
Yb	1.92	Yb	1.86	Yb	1.71	1.77	Yb	1.67	Yb	1.51	Yb	1.22	Yb	0.95	Yb	0.77
Lu	0.27	Lu	0.26	Lu	0.24	0.24	Lu	0.24	Lu	0.22	Lu	0.18	Lu	0.14	Lu	0.12
Rb	18.24	Rb	14.25	Rb	8.60	35.00	Rb	7.60	Rb	5.18	Rb	2.89	Rb	1.73	Rb	1.24
Sr	391.27	Sr	332.37	Sr	228.97	514.00	Sr	207.46	Sr	150.79	Sr	89.60	Sr	55.70	Sr	40.41
Zr	33.41	Zr	32.76	Zr	30.93	51.00	Zr	30.37	Zr	28.31	Zr	24.20	Zr	19.87	Zr	16.86
Y	23.12	Y	22.20	Y	19.84	19.00	Y	19.17	Y	16.86	Y	12.96	Y	9.63	Y	7.66

Batch Melting Model To Generate S-46

%	Residual mineralogy	
15	0.15	Olivine
20	0.20	Orthopyroxene
42	0.42	Clinopyroxene
1.5	0.02	Garnet
10	0.10	Amphibole
11	0.11	K-Feldspar
0	0.00	Ilmenite
0	0.00	Magnetite
0	0.00	Quartz

Archean Tholeiitic KD Values for partial melting calculation (Martin, 1987)

	Olivine	Orthopyroxene	Clinopyroxene	Garnet	Amphibole	K feldspar	Ilmenite	Magnetite	Quartz
La	0.0004	0.002	0.10	0.04	0.20	0.10	0.005	0.22	0.018
Ce	0.0005	0.003	0.20	0.08	0.30	0.06	0.006	0.26	0.014
Nd	0.0010	0.007	0.40	0.20	0.80	0.04	0.008	0.30	0.016
Sm	0.0013	0.010	0.60	1.00	1.10	0.04	0.010	0.35	0.017
Eu	0.0016	0.013	0.60	0.98	1.30	4.60	0.007	0.26	0.080
Tb	0.0016	0.019	0.70	7.50	2.00	0.06	0.022	0.28	0.019
Yb	0.0015	0.049	0.60	21.00	1.70	0.04	0.077	0.18	0.017
Lu	0.0015	0.058	0.60	21.00	1.50	0.03	0.100	0.18	0.011
Rb	0.0100	0.022	0.03	0.03	0.22	2.40			
Sr	0.0140	0.017	0.20	0.01	0.36	5.10			
Zr	0.4000	0.100	0.35	0.50	0.45	0.02			
Y	0.0015	0.030	0.03	16.00	1.90				

Primitive Basaltic Source (S16)		Calculated bulk partition coefficient	
La	10.60	La	0.07406
Ce	22.70	Ce	0.12248
Nd	13.10	Nd	0.25691
Sm	3.15	Sm	0.38360
Eu	1.11	Eu	0.90554
Tb	0.62	Tb	0.61714
Yb	1.77	Yb	0.75143
Lu	0.24	Lu	0.73213
Rb	35.00	Rb	0.30501
Sr	514.00	Sr	0.68670
Zr	51.00	Zr	0.28170
Y	19.00	Y	0.44883

1% Batch Melt		2% Batch Melt		5% Batch Melt		10% Batch Melt		25% Batch Melt		29% Batch Melt		40% Batch Melt		Sample 46	50% Melt	
La	127.22	La	114.50	La	88.07	La	63.60	La	34.69	La	30.94	La	23.85	25.90	La	19.74
Ce	172.95	Ce	162.11	Ce	136.46	Ce	107.98	Ce	66.40	Ce	60.22	Ce	47.94	48.00	Ce	40.45
Nd	49.56	Nd	48.20	Nd	44.55	Nd	39.55	Nd	29.59	Nd	27.73	Nd	23.64	23.00	Nd	20.84
Sm	8.08	Sm	7.96	Sm	7.60	Sm	7.07	Sm	5.86	Sm	5.60	Sm	5.00	4.09	Sm	4.55
Eu	1.22	Eu	1.22	Eu	1.22	Eu	1.21	Eu	1.19	Eu	1.19	Eu	1.18	1.17	Eu	1.17
Tb	1.00	Tb	0.99	Tb	0.97	Tb	0.95	Tb	0.87	Tb	0.85	Tb	0.80	0.69	Tb	0.77
Yb	2.35	Yb	2.34	Yb	2.32	Yb	2.28	Yb	2.18	Yb	2.15	Yb	2.08	2.05	Yb	2.02
Lu	0.33	Lu	0.33	Lu	0.32	Lu	0.32	Lu	0.30	Lu	0.30	Lu	0.29	0.29	Lu	0.28
Rb	112.19	Rb	109.75	Rb	103.01	Rb	93.46	Rb	73.11	Rb	69.09	Rb	60.03	62.00	Rb	53.64
Sr	745.11	Sr	741.74	Sr	731.82	Sr	715.85	Sr	671.88	Sr	661.05	Sr	632.99	635.00	Sr	609.48
Zr	176.54	Zr	172.26	Zr	160.57	Zr	144.26	Zr	110.56	Zr	104.08	Zr	89.63	86.00	Zr	79.58
Y	41.82	Y	41.32	Y	39.88	Y	37.70	Y	32.39	Y	31.22	Y	28.39	21.00	Y	26.23

Batch Melting Model To Generate Chail

%	Residual Mineralogy	
36	0.36	Clinopyroxene
4	0.04	Garnet
50	0.50	Amphibole
7	0.07	K-Feldspar
2	0.02	Ilmenite
1	0.01	Magnetite
0	0.00	Quartz

Archean Tholeiitic KD Values for partial melting calculation (Martin, 1986)

	Olivine	Orthopyroxene	Clinopyroxene	Garnet	Amphibole	K feldspar	Ilmenite	Magnetite	Quartz
La	0.0004	0.002	0.10	0.04	0.20	0.10	0.005	0.22	0.018
Ce	0.0005	0.003	0.20	0.08	0.30	0.06	0.006	0.26	0.014
Nd	0.0010	0.007	0.40	0.20	0.80	0.04	0.008	0.3	0.016
Sm	0.0013	0.010	0.60	1.00	1.10	0.04	0.010	0.35	0.017
Eu	0.0016	0.013	0.60	0.98	1.30	4.60	0.007	0.26	0.080
Tb	0.0016	0.019	0.70	7.50	2.00	0.06	0.022	0.28	0.019
Yb	0.0015	0.049	0.60	21.00	1.70	0.04	0.077	0.18	0.017
Lu	0.0015	0.058	0.60	21.00	1.50	0.03	0.100	0.18	0.011
Rb	0.0100	0.022	0.03	0.03	0.22	2.40			
Sr	0.0140	0.017	0.20	0.01	0.36	5.10			
Zr	0.4000	0.100	0.35	0.50	0.45	0.02			
Y	0.0015	0.030	0.03	16.00	1.90				

Primitive Basaltic Source (S-16)		Calculated bulk partition coefficient	
La	10.60	La	0.14690
Ce	22.70	Ce	0.23212
Nd	13.10	Nd	0.55796
Sm	3.15	Sm	0.81250
Eu	1.11	Eu	1.22994
Tb	0.62	Tb	1.55944
Yb	1.77	Yb	1.91214
Lu	0.24	Lu	1.81190
Rb	35.00	Rb	0.29016
Sr	514.00	Sr	0.60952
Zr	51.00	Zr	0.37240
Y	19.00	Y	1.60080

1% Batch Melt		2% Batch Melt		5% Batch Melt		10% Batch Melt		20% Batch Melt		35% Batch Melt		50% Melt		Sample Chail
La	68.20	La	64.65	La	55.92	La	45.65	La	33.38	La	23.79	La	19.05	19.30
Ce	94.66	Ce	91.73	Ce	83.91	Ce	73.48	Ce	58.85	Ce	45.32	Ce	37.79	37.70
Nd	23.29	Nd	23.11	Nd	22.58	Nd	21.75	Nd	20.27	Nd	18.38	Nd	17.01	17.40
Sm	3.87	Sm	3.86	Sm	3.83	Sm	3.79	Sm	3.71	Sm	3.59	Sm	3.49	3.28
Eu	0.90	Eu	0.91	Eu	0.91	Eu	0.92	Eu	0.94	Eu	0.97	Eu	0.99	0.95
Tb	0.40	Tb	0.40	Tb	0.40	Tb	0.41	Tb	0.43	Tb	0.45	Tb	0.48	0.47
Yb	0.93	Yb	0.93	Yb	0.95	Yb	0.97	Yb	1.02	Yb	1.11	Yb	1.20	1.20
Lu	0.13	Lu	0.13	Lu	0.14	Lu	0.14	Lu	0.15	Lu	0.16	Lu	0.17	-0.20
Rb	117.74	Rb	115.00	Rb	107.48	Rb	96.91	Rb	80.99	Rb	64.98	Rb	55.48	72.00
Sr	837.92	Sr	832.62	Sr	817.11	Sr	792.52	Sr	747.51	Sr	688.83	Sr	644.96	643.00
Zr	134.68	Zr	132.48	Zr	126.31	Zr	117.20	Zr	102.43	Zr	86.14	Zr	75.71	93.00
Y	11.91	Y	11.96	Y	12.10	Y	12.33	Y	12.83	Y	13.66	Y	14.48	13.00

Batch Melting Model To Generate S-59

%	Residual mineralogy	
0	0.00	Olivine
0	0.00	Orthopyroxene
50	0.50	Clinopyroxene
5	0.05	Garnet
40	0.40	Amphibole
3	0.03	K-Feldspar
1	0.01	Ilmenite
1	0.01	Magnetite
0	0.00	Quartz

Archean Tholeiitic KD Values for partial melting calculation (Martin, 1987)

	Olivine	Orthopyroxene	Clinopyroxene	Garnet	Amphibole	K feldspar	Ilmenite	Magnetite	Quartz	Kfs	Plag
La	0.0004	0.002	0.10	0.04	0.20	0.10	0.005	0.22	0.018	0.10	0.140
Ce	0.0005	0.003	0.20	0.08	0.30	0.06	0.006	0.26	0.014	0.06	0.100
Nd	0.0010	0.007	0.40	0.20	0.80	0.04	0.008	0.30	0.016	0.04	0.069
Sm	0.0013	0.010	0.60	1.00	1.10	0.04	0.010	0.35	0.017	0.04	0.052
Eu	0.0016	0.013	0.60	0.98	1.30	4.60	0.007	0.26	0.080	4.60	0.790
Tb	0.0016	0.019	0.70	7.50	2.00	0.06	0.022	0.28	0.019	0.06	0.060
Yb	0.0015	0.049	0.60	21.00	1.70	0.04	0.077	0.18	0.017	0.04	0.012
Lu	0.0015	0.058	0.60	21.00	1.50	0.03	0.100	0.18	0.011	0.03	0.009
Rb	0.0100	0.022	0.03	0.03	0.22	2.40				2.40	2.400
Sr	0.0140	0.017	0.20	0.01	0.36	5.10				5.10	2.000
Zr	0.4000	0.100	0.35	0.50	0.45	0.02				0.02	0.010
Y	0.0015	0.030	0.03	16.00	1.90						

Basaltic Source (S16)		Calculated bulk partition coefficient	
La	10.60	La	0.13725
Ce	22.70	Ce	0.22846
Nd	13.10	Nd	0.53428
Sm	3.15	Sm	0.79480
Eu	1.11	Eu	1.00967
Tb	0.62	Tb	1.52982
Yb	1.77	Yb	2.03377
Lu	0.24	Lu	1.95370
Rb	35.00	Rb	0.17670
Sr	514.00	Sr	0.39765
Zr	51.00	Zr	0.38060
Y	19.00	Y	1.57500

1% Batch Melt		2% Batch Melt		5% Batch Melt		10% Batch Melt		20% Batch Melt		35% Batch Melt		55% Melt		S-59
La	72.66	La	68.61	La	58.76	La	47.42	La	34.22	La	24.13	La	17.33	17.20
Ce	96.12	Ce	93.07	Ce	85.01	Ce	74.28	Ce	59.30	Ce	45.54	Ce	34.77	36.40
Nd	24.31	Nd	24.10	Nd	23.49	Nd	22.55	Nd	20.88	Nd	18.79	Nd	16.57	16.90
Sm	3.95	Sm	3.94	Sm	3.91	Sm	3.86	Sm	3.77	Sm	3.63	Sm	3.47	3.49
Eu	1.10	Eu	1.10	Eu	1.10	Eu	1.10	Eu	1.10	Eu	1.10	Eu	1.11	0.98
Tb	0.41	Tb	0.41	Tb	0.41	Tb	0.42	Tb	0.44	Tb	0.46	Tb	0.50	0.53
Yb	0.87	Yb	0.88	Yb	0.89	Yb	0.92	Yb	0.97	Yb	1.06	Yb	1.21	1.21
Lu	0.12	Lu	0.12	Lu	0.13	Lu	0.13	Lu	0.14	Lu	0.15	Lu	0.17	-0.20
Rb	189.26	Rb	181.19	Rb	160.65	Rb	135.12	Rb	102.53	Rb	75.29	Rb	55.60	60.00
Sr	1273.31	Sr	1254.59	Sr	1201.59	Sr	1122.55	Sr	992.05	Sr	844.74	Sr	705.13	708.00
Zr	131.85	Zr	129.77	Zr	123.92	Zr	115.24	Zr	101.09	Zr	85.37	Zr	70.71	81.00
Y	12.11	Y	12.15	Y	12.29	Y	12.52	Y	13.01	Y	13.83	Y	15.09	15.00

Batch Melting Model To Generate S-61

%	Residual mineralogy	
0	0.00	Olivine
0	0.00	Orthopyroxene
55	0.55	Clinopyroxene
1	0.01	Garnet
38	0.38	Amphibole
3	0.03	K-Feldspar
2	0.02	Ilmenite
1	0.01	Magnetite
0	0.00	Quartz

Archean Tholeiitic KD Values for partial melting calculation (Martin, 1987)

	Olivine	Orthopyroxene	Clinopyroxene	Garnet	Amphibole	K feldspar	Ilmenite	Magnetite	Quartz	Kfs	Plag
La	0.0004	0.002	0.10	0.04	0.20	0.10	0.005	0.22	0.018	0.10	0.140
Ce	0.0005	0.003	0.20	0.08	0.30	0.06	0.006	0.26	0.014	0.06	0.100
Nd	0.0010	0.007	0.40	0.20	0.80	0.04	0.008	0.30	0.016	0.04	0.069
Sm	0.0013	0.010	0.60	1.00	1.10	0.04	0.010	0.35	0.017	0.04	0.052
Eu	0.0016	0.013	0.60	0.98	1.30	4.60	0.007	0.26	0.080	4.60	0.790
Tb	0.0016	0.019	0.70	7.50	2.00	0.06	0.022	0.28	0.019	0.06	0.060
Yb	0.0015	0.049	0.60	21.00	1.70	0.04	0.077	0.18	0.017	0.04	0.012
Lu	0.0015	0.058	0.60	21.00	1.50	0.03	0.100	0.18	0.011	0.03	0.009
Rb	0.0100	0.022	0.03	0.03	0.22	2.40				2.40	2.400
Sr	0.0140	0.017	0.20	0.01	0.36	5.10				5.10	2.000
Zr	0.4000	0.100	0.35	0.50	0.45	0.02				0.02	0.010
Y	0.0015	0.030	0.03	16.00	1.90						

Basaltic Source (S16)		Calculated bulk partition coefficient	
La	10.60	La	0.13670
Ce	22.70	Ce	0.22932
Nd	13.10	Nd	0.53036
Sm	3.15	Sm	0.76290
Eu	1.11	Eu	0.97454
Tb	0.62	Tb	1.22504
Yb	1.77	Yb	1.19054
Lu	0.24	Lu	1.11470
Rb	35.00	Rb	0.17244
Sr	514.00	Sr	0.39993
Zr	51.00	Zr	0.36910
Y	19.00	Y	0.89850

1% Batch Melt		2% Batch Melt		5% Batch Melt		10% Batch Melt		20% Batch Melt		35% Batch Melt		50% Melt		Sample 61
La	72.94	La	68.85	La	58.93	La	47.53	La	34.26	La	24.15	La	18.65	18.20
Ce	95.77	Ce	92.75	Ce	84.75	Ce	74.09	Ce	59.20	Ce	45.49	Ce	36.93	36.10
Nd	24.48	Nd	24.27	Nd	23.65	Nd	22.69	Nd	20.98	Nd	18.86	Nd	17.12	17.60
Sm	4.12	Sm	4.10	Sm	4.07	Sm	4.00	Sm	3.89	Sm	3.72	Sm	3.57	3.81
Eu	1.14	Eu	1.14	Eu	1.14	Eu	1.14	Eu	1.13	Eu	1.13	Eu	1.12	1.11
Tb	0.51	Tb	0.51	Tb	0.51	Tb	0.52	Tb	0.53	Tb	0.54	Tb	0.56	0.62
Yb	1.49	Yb	1.49	Yb	1.50	Yb	1.51	Yb	1.54	Yb	1.57	Yb	1.62	1.65
Lu	0.22	Lu	0.22	Lu	0.22	Lu	0.22	Lu	0.22	Lu	0.22	Lu	0.23	0.21
Rb	193.67	Rb	185.19	Rb	163.69	Rb	137.15	Rb	103.57	Rb	75.74	Rb	59.70	33.00
Sr	1266.23	Sr	1247.78	Sr	1195.53	Sr	1117.54	Sr	988.57	Sr	842.69	Sr	734.32	838.00
Zr	135.85	Zr	133.61	Zr	127.29	Zr	118.00	Zr	102.97	Zr	86.45	Zr	74.50	83.00
Y	21.12	Y	21.10	Y	21.03	Y	20.91	Y	20.68	Y	20.34	Y	20.02	18.00

Batch Melting Model To Generate Yana

%	Residual mineralogy	
30	0.30	Clinopyroxene
17	0.17	Garnet
50	0.50	Amphibole
0	0.00	K-Feldspar
2	0.02	Ilmenite
1	0.01	Magnetite
0	0.00	Quartz

Archean Tholeiitic KD Values for partial melting calculation (Martin, 1987)

	Olivine	Orthopyroxene	Clinopyroxene	Garnet	Amphibole	K feldspar	Ilmenite	Magnetite	Quartz
La	0.0004	0.002	0.10	0.04	0.20	0.10	0.005	0.22	0.018
Ce	0.0005	0.003	0.20	0.08	0.30	0.06	0.006	0.26	0.014
Nd	0.0010	0.007	0.40	0.20	0.80	0.04	0.008	0.30	0.016
Sm	0.0013	0.010	0.60	1.00	1.10	0.04	0.010	0.35	0.017
Eu	0.0016	0.013	0.60	0.98	1.30	4.60	0.007	0.26	0.080
Tb	0.0016	0.019	0.70	7.50	2.00	0.06	0.022	0.28	0.019
Yb	0.0015	0.049	0.60	21.00	1.70	0.04	0.077	0.18	0.017
Lu	0.0015	0.058	0.60	21.00	1.50	0.03	0.100	0.18	0.011
Rb	0.0100	0.022	0.03	0.03	0.22	2.40			
Sr	0.0140	0.017	0.20	0.01	0.36	5.10			
Zr	0.4000	0.100	0.35	0.50	0.45	0.02			
Y	0.0015	0.030	0.03	16.00	1.90				

Basaltic Source (S16)		Calculated bulk partition coefficient	
La	10.60	La	0.13910
Ce	22.70	Ce	0.22632
Nd	13.10	Nd	0.55716
Sm	3.15	Sm	0.90370
Eu	1.11	Eu	0.99934
Tb	0.62	Tb	2.48824
Yb	1.77	Yb	4.60334
Lu	0.24	Lu	4.50380
Rb	35.00	Rb	0.12478
Sr	514.00	Sr	0.24221
Zr	51.00	Zr	0.41500
Y	19.00	Y	3.67900

1% Batch Melt		2% Batch Melt		5% Batch Melt		10% Batch Melt		20% Batch Melt		45% Batch Melt		S-Yana	50% Melt	
La	71.76	La	67.81	La	58.20	La	47.07	La	34.05	La	20.13	20.20	La	18.61
Ce	96.99	Ce	93.88	Ce	85.66	Ce	74.75	Ce	59.57	Ce	39.51	39.00	Ce	37.02
Nd	23.33	Nd	23.14	Nd	22.61	Nd	21.78	Nd	20.29	Nd	17.32	16.50	Nd	16.83
Sm	3.48	Sm	3.48	Sm	3.47	Sm	3.45	Sm	3.41	Sm	3.33	2.62	Sm	3.31
Eu	1.11	Eu	1.11	Eu	1.11	Eu	1.11	Eu	1.11	Eu	1.11	0.78	Eu	1.11
Tb	0.25	Tb	0.25	Tb	0.26	Tb	0.27	Tb	0.28	Tb	0.34	0.33	Tb	0.36
Yb	0.39	Yb	0.39	Yb	0.40	Yb	0.42	Yb	0.46	Yb	0.59	0.62	Yb	0.63
Lu	0.05	Lu	0.05	Lu	0.06	Lu	0.06	Lu	0.06	Lu	0.08	-0.20	Lu	0.09
Rb	262.11	Rb	245.99	Rb	207.66	Rb	164.86	Rb	116.74	Rb	67.49	83.00	Rb	62.23
Sr	2057.75	Sr	1997.16	Sr	1835.06	Sr	1616.41	Sr	1305.34	Sr	881.32	805.00	Sr	827.56
Zr	121.18	Zr	119.52	Zr	114.80	Zr	107.71	Zr	95.86	Zr	75.19	94.00	Zr	72.08
Y	5.20	Y	5.24	Y	5.36	Y	5.57	Y	6.04	Y	7.68	7.00	Y	8.12

APPENDIX C4

Fractional crystallisation modelling using partition coefficients

Fractional Crystallisation Modelling Using Partition Coefficients

	Opx	Cpx	Hbl	Plag	Bt
Sm	0.100	0.750	2.000	0.110	2.117
Th	0.050	0.010	0.150	0.010	0.997

Partition Coefficients taken from Gill (1981), Sm in Hbl from Green and Pearson (1985) and Bt from Nash and Creecraft (1985)

Initial Composition (S-46)					
Sm	4.09				
Th	6.90				
5% fractional crystallisation					
Sm	4.28	4.14	3.89	4.28	3.86
Th	7.24	7.26	7.21	7.26	6.90
10% fractional crystallisation					
Sm	4.50	4.20	3.68	4.49	3.64
Th	7.63	7.66	7.55	7.66	6.90
20% fractional crystallisation					
Sm	5.00	4.32	3.27	4.99	3.19
Th	8.53	8.61	8.34	8.61	6.90
30% fractional crystallisation					
Sm	5.64	4.47	2.86	5.62	2.75
Th	9.68	9.82	9.34	9.82	6.91
50% fractional crystallisation					
Sm	7.63	4.86	2.05	7.58	1.89
Th	13.33	13.70	12.44	13.70	6.91