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PETROGRAPHIC REPORT ON 22 POLISHED THIN SECTIONS

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Samples submitted: 95-16-77.2, 232.2; 17-276.7; 19-163.6, 247.8, 266.8; 20-123.2; 23- 25.5, 72.3, 102.5, 110.1; 25- 40.3, 143.4, 214.8, 239.1, 345.8, 382.4; 26-48.3, 247.7, 263.5; 30-A; DH-N-95-32-76.7

SUMMARY:

This suite of altered intrusive rocks appears to come from a porphyry copper deposit of the "diorite clan", with attendant mafic potassic (biotite-amphibole-magnetite-alkali feldspar, including both albitic and true K-feldspar) alteration. The original rock types are generally deducible through the alteration, and may be classified as belonging to a gradational series as follows:

Quartz diorite to diorite (16-77.2, 19-123.2, 163.6, 26-48.3) composed of almost equigranular plagioclase (50-60%, 1-2 mm) and relict amphibole crystals (10-15%, 1-2 mm) with interstitial quartz;

Hornblende diorite porphyry (or porphyritic hornblende quartz diorite to rarely quartz monzonite* in places: 16-232.2, 19-247.8, 23-102.5, 110.1, 25-40.3, 345.8, 382.4*, 26-263.5) composed of 40-50% 1-3 mm plagioclase and 15-20% 1-2 mm ?hornblende phenocrysts in 10-30% phaneritic (0.2 mm) quartzx-feldspathic groundmass;

Biotite-hornblende dacite (25-239.1) to **rhyodacite** (19-266.8, 25-143.4) or **rhyolite** (25-214.8) **porphyries**, composed of 5-10% 1 mm biotite, 5-15% 1-2 mm hornblende, and 25-30% plagioclase phenocrysts (rare 1 mm quartz) in an aphanitic (0.01-0.05 mm) quartzofeldspathic groundmass;

Fragmental volcanics (23-25.5, 72.3) composed of smaller plagioclase and hornblende phenocrysts, and **?hydrothermal breccia** (17-276.7, 30-A, 32-76.7) composed of variably altered clasts in a matrix of secondary minerals (quartz, tourmaline, biotite, K-feldspar, pyrite, magnetite).

Alteration ranges from weak or moderate to intense **mafic potassic** (secondary biotite and/or amphibole, K-feldspar and/or albitic alkali feldspar, quartz, magnetite; rarely tourmaline) (16-232.2, 17-276.7, 19-163.6, 247.8, 20-123.2, 23-25.5, 72.3, 25-40.3, 345.8, 25-239.1, 26-48.3, 247.7, 263.5, 30-A, 32-76.7) variably overprinted by chlorite, sericite and carbonate or **phyllic** (19-266.8, 23-102.5, 25-143.4, 214.8) or **argillic** (clay-carbonate, generally dolomitic-pyrite) (16-77.2, 23-110.1) to **advanced argillic** (clay-sericite-dolomite-quartz) (25-382.4). Tourmaline is generally a dark blue-green to khaki-coloured schorl, and occurs in veins and breccia matrix. The types and intensity of mafi potassic alteration (and the overprint) is similar in many respects to other diorite clan porphyry copper deposits such as Island Copper on Vancouver Island, or Tanama or Taysan in the Phillipines.

Mineralization ranges from magnetite with traces of chalcopyrite and/or bornite to significant chalcopyrite or bornite, mainly disseminated or along microfractures. Pyrite is generally notable by its absence, i.e. a high chalcopyrite:pyrite, low total sulfide system that is also typical of diorite clan porphyry coppers. Late planar quartz-chlorite-calcite-pyrite veinlets, some with minor chalcopyrite, tend to cut early, irregular quartz-k-feldspar+/-amphibole, biotite and chalcopyrite/bornite veinlets.

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95-16-72.2: ARGILLIC-CARBONATE-QUARTZ ALTERED ?QUARTZ DIORITE WITH MINOR PYRITE, TRACE CHALCOPYRITE

Buff-white, fine to medium grained, fairly even textured intrusive with local glomeratic feldspar. Mainly softer than steel; no stain for K-feldspar, non-magnetic, no reaction to cold dilute HCl. Modal mineralogy in polished thin section is roughly:

Clay (?) (after feldspar, mafics)	40%
Carbonate (dolomite or ankerite)	25%
Relict feldspar	15%
Quartz (partly secondary)	15%
Rutile, leucoxene	1-2%
Pyrite	1%
Sericite	1%
Apatite, trace zircon	1%
Chalcopyrite	<1%

This slide consists essentially of intensely altered feldspar and mafic relics, with lesser interstitial and minor secondary quartz. It probably originally consisted of about 60% feldspar (likely mostly plagioclase), 25% mafics, and 15% quartz with accessory Fe-Ti oxides, apatite and zircon.

Feldspar originally formed sub- to anhedral crystals up to about 3 mm in diameter (5 mm where glomeratic). It is almost completely pseudomorphed by very fine (5-10 micron) ?clay and lesser 25-50 micron carbonate, with only remnants of feldspar in cores of crystals. This likely was mainly plagioclase.

Mafic crystals originally were ragged, subhedral and interstitial to the feldspar, up to 2 mm long. They are now pseudomorphed by subhedral carbonate to 0.1 mm, fine (5-15 micron) ?clay, and minor quartz to 0.15 mm diameter. Scattered, fine aggregates of rutile and leucoxene up to 0.1 mm across are likely after ?ilmenite. Euhedral crystals of apatite to 100 microns and zircon to 70 microns may be relict accessories.

Quartz forms subhedral to anhedral crystals up to 1.5 mm diameter with minor undulose extinction and sub-grain development indicating strain. Part of the quartz is probably primary, interstitial to the feldspar and mafics, but part of it is in the form of narrow veinlets up to 0.5 mm thick; this is secondary silicification. The quartz veinlets are accompanied by minor pyrite (euhedral, to 0.25 mm) and chalcopyrite (subhedral elongate blebs to 0.25 mm long); the quartz veinlets cut by narrow veinlets of ?clay.

In summary, this appears to have been an intermediate intrusive rock composed of feldspar, mafics (possibly amphibole to judge by the elongate shapes), and minor quartz. It may have been about a quartz diorite in composition; it has undergone intense argillic (clay) and carbonate alteration, with minor silicification and sulfide mineralization (including trace copper).

95-16-232.2: BIOTITE-AMPHIBOLE-MINOR KSPAR ALTERED ?HORNBLENDE QUARTZ DIORITE PORPHYRY WITH MINOR MAGNETITE, TRACE CHALCOPYRITE

Dark grey-green, medium-grained intrusive rock with vague (altered?) texture, minor sulfides; strongly magnetic, very minor yellow stain for K-feldspar apparently along hairline fractures. There is no reaction to cold dilute HCl; modal mineralogy in polished thin section is approximately:

Plagioclase (phenocrysts and groundmass)	55%
Secondary biotite	15%
Secondary amphibole	10%
Quartz (groundmass)	10%
K-feldspar (secondary)	5%
Clay-sericite	2%
Magnetite (partly hematized)	1-2%
Sphene	1%
Chalcopyrite	<1%
Apatite, trace zircon	<1%

This sample consists essentially of fresh feldspar and intensely biotite altered mafics set in about 20-30% phaneritic quartz-feldspar groundmass. Feldspar is mainly plagioclase, forming euhedral to subhedral crystals up to 2 mm in length displaying primary oscillatory compositional zoning. The composition is about andesine (An30-50) based on extinction angles Y^010 of 10-25 degrees and relief slightly above that of quartz. There is very minor alteration of feldspar to clay-sericite (5-10 micron sized flakes, in patches up to 0.25 mm across). In places the plagioclase crystals are traversed by narrow veinlets of a lower relief mineral, likely K-feldspar, up to 50 microns thick. Traces of biotite also occur in these veinlets, but they do not generally contain sulfides.

Mafics appear to have been amphibole, likely hornblende; they have somewhat ragged to subhedral outlines up to 2 mm long, and are pseudomorphed by fine (25-50 micron) fibrous green secondary amphibole and similar-sized greenish brown secondary biotite, plus opaques and accessory aptite, sphene and rare zircon. Minor sphene is found as 25-50 micron sized subhedral crystals intimately mixed with biotite and magnetite; apatite and zircon form euhedral prisms to 0.1 mm and 50 microns long respectively.

Magnetite is common as fine to very fine (to 80 micron) subhedral crystals, mainly in altered mafic sites but occasionally also in narrow veinlets. Most of the magnetite shows slight to modest alteration to hematite. In places magnetite is accompanied by minor chalcopyrite, as subhedral blebs mainly less than 50 microns but up to 0.1 mm. Pyrite is notable by its absence, making this a low total sulfide but high chalcopyrite to pyrite ratio sample.

The groundmass consists of small (0.1 mm) subhedral crystals of plagioclase, likely of similar composition to the phenocrysts, and interstitial quartz (10-25 microns), biotite and amphibole plus minor magnetite and rare chalcopyrite.

In summary, this sample, likely originally hornblende quartz diorite porphyry, displays moderate "mafic potassic" alteration (secondary amphibole, biotite and magnetite after mafics with trace K-feldspar after plagioclase; seen at diorite clan porphyry coppers such as Island Copper), associated with weak chalcopyrite mineralization.

95-17 276.7: POTASSIC (ALKALI FELDSPAR-QUARTZ-BIOTITE-KSPAR-AMPHIBOLE-MAGNETITE-TOURMALINE-APATITE-CHALCOPYRITE ALTERED) FELSIC ?BRECCIA

Grey, siliceous rock (harder than steel) with vague fragmental texture caused by ghost-like clasts of varied lithology and subrounded outlines up to 2 cm long. Some clasts contain very fine sulfides, likely chalcopyrite; rare veinlets of magnetite and biotite are present. The rock does not react to cold dilute HCl, and shows only minor diffuse yellow stain for K-feldspar, mainly around margins of fragments. Mineralogy in polished thin section is approximately:

Alkali feldspar (?albitic)	50%
Quartz (partly secondary)	20%
Secondary biotite (partly chloritized)	10%
Clay (?)	10%
K-feldspar (secondary)	5%
Amphibole (secondary)	1%
Magnetite, partly hematized	1%
Chalcopyrite, trace bornite	1%
Apatite	1%
Tourmaline	1%
Epidote, ?molybdenite	tr

Fragments appear to consist of ?clay altered alkali feldspar; the matrix, mainly fine quartz and alkali feldspar. Both are cut by a network of fine alkali feldspar-biotite-minor opaques-apatite veinlets, in places with diffuse envelopes of secondary biotite.

Fragments are composed of altered feldspar relict crystals of about 0.2 mm length that appear to be partly altered to fine flakes of ?clay (5-10 microns). Most of the alkali feldspar is probably albitic (some is vaguely twinned) although the alteration makes it difficult to be sure. There is also very fine (1-50 micron) opaque, mostly magnetite. Some fragments are composed of coarser (up to 1 mm sized) alkali feldspar, and others of fine aggregates of anhedral 25-50 micron feldspar, lesser biotite and minor amphibole.

The matrix consists of very fine (10-30 micron) quartz/alkali feldspar and considerable biotite, magnetite and chalcopyrite plus minor amphibole and dark tourmaline (schorl). Again, most of the alkali feldspar appears to be albitic, although some may be K-feldspar. Amphibole forms ragged fibrous crystals to 50 microns long; the biotite forms dark greeny brown flakes to 20 microns that in places are partly chloritized. Tourmaline crystals up to 50 microns are anhedral to ragged and poikilitically enclose quartz and feldspar.

Veinlets are diffuse and irregular, up to 0.5 mm thick where best developed. They contain the same minerals as in the matrix, but coarser and better developed (quartz to 0.15 mm; true K-feldspar to 50 micron; tourmaline and chalcopyrite to 0.2 mm; biotite to 0.1 mm). Rare euhedral crystals of epidote up to 0.2 mm are enclosed by or associated with chalcopyrite. This suggests that the matrix is largely secondary, or is more altered than the fragments, and that this alteration is related to the veinlets. Most chalcopyrite is intergrown with lesser bornite (subhedral, to 0.1 mm; especialy along the veins) and partly hematized magnetite. There are rare 50 micron flakes of ?molybdenite. As in the previous sample, pyrite is notable by its absence.

In summary, this appears to be a strongly mafic potassic altered (quartz, alkali feldspar, biotite, amphibole, magnetite) felsic fragmental or ?breccia, well mineralized with fine chalcopyrite.

95-19 163.6: MAFIC POTASSIC (K-FELDSPAR-AMPHIBOLE-MAGNETITE-QUARTZ-CARBONATE ALTERED) ?HORNBLENDE DIORITE; VIRTUALLY NO CHALCOPYRITE

Dark grey, medium-grained intrusive cut by magnetite-rich zones (?fracture envelopes) and pink planar fractures with green centres and minor chalcopyrite. There is abundant K-feldspar, mainly interstitial to the feldspar and mafic crystal relicts, but no reaction to cold dilute HCl. Modal mineralogy in the polished thin section is:

Plagioclase (andesine)	45%
Amphibole (largely secondary)	15%
K-feldspar (largely secondary)	15%
Quartz (partly secondary)	10%
Clay, sericite	5%
Carbonate (dolomite or ankerite)	5%
Magnetite (partly hematized)	5%
Sphene, trace rutile	<1%
Chalcopyrite	tr

This is a relatively equigranular rock, composed of about 50% plagioclase with 20-25% interstitial mafics (relict amphibole) and lesser quartz. It could have been the precursor to the argillic altered specimen of 16-77.2. Plagioclase forms subhedral crystals with corroded outlines, mainly due to alteration around the rims by K-feldspar. Although part of this K-spar is likely a result of overgrowth on primary K-spar (clear, cleaved, to 0.2 mm) that was interstitial to the plagioclase, much of it appears to be secondary (anhedral, with many sub-domains, to 0.1 mm). In some cases almost the entire plagioclase crystal is replaced by K-spar, accompanied by magnetite. Most plagioclase, which appears to be about andesine in composition, shows relict compositional zoning and is altered to minor flecks of sericite and carbonate, or in some cases secondary quartz.

Quartz is not abundant in this sample, forming subhedral crystals to 0.3 mm diameter in certain of the larger interstitial areas, with magnetite and needle-like secondary amphibole partly altered to carbonate. Lack of reaction of the carbonate to acid suggests it is largely dolomite or ankerite.

Mafic crystals include both major ragged, anhedral amphibole (heavily replaced by magnetite and lesser sphene) and rare brown biotite. Former amphibole crystals were up to 2 mm long; biotite to 0.5 mm diameter. Most of the amphibole is replaced by fibrous secondary amphibole, partly in parallel position, abundant magnetite-hematite, and minor carbonate (anhedral, to 0.1 mm) and quartz (anhedral, to 0.1 mm); there are traces of chlorite.

Magnetite occurs as subhedral crystals to 0.25 mm diameter, in places aggregating to several mm, and in most cases slightly altered to hematite at grain margins and along partings. Sphene occurs as subhedral crystals to 0.3 mm diameter commonly intergrown or associated with magnetite-hematite; rarely, 25-50 micron rutile is included in sphene. Chalcopyrite is extremely rare (less than 0.1 mm diameter). The heaviest magnetite replacement is esentially interstitial to the plagioclase, forming a "groundmass" with K-feldspar that leaves plagioclase as islands.

This appears to be a mafic potassic (K-feldspar-amphibole-quartz-magnetite-minor carbonate) altered ?hornblende-biotite diorite, but there is no significant copper mineralization.

95-19 247.8: WEAKLY MAFIC POTASSIC (K-FELDSPAR-AMPHIBOLE-MAGNETITE-QUARTZ-CHLORITE-CALCITE) ALTERED ?HORNBLENDE DIORITE PORPHYRY

Light grey, faintly porphyritic intrusive rock with fine disseminated magnetite; modest reaction to cold dilute HCl, moderate yellow stain for K-feldspar. Modal mineralogy in polished thin section is approximately:

Plagioclase (phenocrysts and groundmass)	60%
Amphibole (partly secondary)	10%
K-feldspar (groundmass; partly secondary)	10%
Quartz	5%
Chlorite	5%
Carbonate (calcite)	5%
Clay-sericite	2%
Magnetite (partly hematized)	2%
Sphene/rutile, apatite, trace zircon	1%
Epidote	<1%

This sample is composed of about 15-20 % plagioclase and 5-10 % smaller amphibole phenocrysts in a groundmass of plagioclase and minor quartz, K-feldspar, and amphibole plus trace magnetite.

Feldspar crystals are euhedral and up to 2 mm long, with corroded margins against the groundmass. The crystals are zoned, particularly at the rims, with composition close to oligoclase-andesine (An_{35} cores to An_{28} rims, based on extinction angles X^001 of 6 to -2 degrees). Most crystals are slightly altered to veinlets of carbnate and flecks of fine sericite as well as minor K-feldspar attack by the groundmass.

Mafic crystals are altered to chlorite and minor sphene (rare epidote as subhedral crystals to 0.1 mm). They appear to have mostly been amphibole (?hornblende) as euhedral to subhedral, ragged crystals up to 1.5 mm long. In the larger crystals, minor carbonate, quartz and sphene as ragged, anhedral crystals are up to 0.15 mm across; magnetite forms subhedral crystals rarely over 100 microns in diameter, in places rimming or replacing almost the entire crystal. Rare biotite as pale washed-out relict crystals to 0.1 mm and apatite (+/-rare zircon) to 75 microns included in the amphibole are likely primary. Magnetite crystals (partly altered to hematite) commonly aggregate up to 0.5 mm, surrounding areas of sphene cored by minor rutile (25-30 microns). The only chalcopyrite present occurs as rare minute (1-5 micron) inclusions in magnetite.

The groundmass consists of fine plagioclase microlites in random orientation, of about 0.1-0.2 mm size, with lesser interstitial quartz and K-feldspar (50-100 microns), and fine amphibole (to 0.3 mm), magnetite (0.1 mm), chlorite (0.1 mm), sphene (50 microns), and carbonate (0.2 mm); epidote to 50 microns is rare. Feldspars are slightly clay altered.

This sample likely was a hornblende-plagioclase porphyritic diorite or quartz diorite; it is only weakly mafic potassic altered, to K-feldspar, amphibole, magnetite, quartz, and calcite. The coarseness of the groundmass suggests a slightly deeper emplacement than the porphyry in 95-16 77.2m.

95-19 266.8: MODERATELY PHYLLIC (SERICITE-QUARTZ-CARBONATE-CHLORITE-MINOR ?K-FELDSPAR) ALTERED BIOTITE-HORNBLENDE RHYODACITE PORPHYRY

Light grey-buff, felsic porphyry characterized by 20-25% fine pale green altered plagioclase and 5% black biotite crystals in an aphanitic matrix that stains strongly for K-feldspar. There is no reaction to cold dilute HCl and the rock is not magnetic; sulfides are absent. In polished thin section, the modal mineralogy is approximately:

Sericite, clay	25%
K-feldspar (groundmass; ?partly secondary)	25%
Quartz (groundmass)	15%
Relict plagioclase (?albitic)	15%
Carbonate	10%
Biotite	5%
Chlorite	5%
Hematite (likely after magnetite)	<1%
Rutile, sphene, zircon	<1%

This is a finely porphyritic rock composed of altered plagioclase, fairly freshs biotite and rare relict amphibole crystals in a quartzo-feldspathic matrix. Plagioclase crystals have euhedral outlines and are strongly altered to fine (15-25 micron) sericite and lesser 50 micron carbonate (many have been entirely pseudomorphed, and have been plucked out during section preparation). It is not possible to determine the original plagioclase composition, but it was likely more calcic than it is now (possibly now albitic).

Biotite phenocrysts are euhedral books up to 1 mm in diameter; they are pleochroic in yellowish to greenish brown, and relatively fresh. Elongate ?amphibole relics up to 1.5 mm long were at least as abundant as biotite but have been pseudomorphed by chlorite (subhedral flakes to 100 microns), carbonate (subhedral, iron-stained, likely ankerite to 50 microns) and minor sphene and opaques (see next paragraph).

Minor hematite occurs as sub- to euhedral flakes to 75 microns diameter, likely after ?magnetite; these are mixed with or surround rutile (eu- to subhedral, to 50 microns) and euhedral zircon to 45 microns; in places, sphene to 0.15 mm is mixed with or contained in larger crystals of carbonate to 0.3 mm across.

The groundmass consists largely of fine (0.1-0.2 mm) subhedral altered plagioclase microlites set in finer (50-100 micron) subhedral K-feldspar and quartz; in places it is altered to a mosaic of secondary quartz, carbonate and minor apatite up to 0.2 mm in diameter. This carbonate may be ?dolomite (does not react to HCl). Although part of the K-feldspar may be secondary (attacking the edges of plagioclase phenocrysts, with quartz), most is likely primary.

This appears to be a moderately phyllic (sericite-carbonate-chlorite) altered, biotite-hornblende dacite or more likely rhyodacite porphyry (or porphyritic quartz diorite to quartz monzonite). It does not contain any sulfide mineralization.

95-20 123.2: SECONDARY ALKALI FELDSPAR (?ALBITIC)-QUARTZ-CARBONATE-MINOR CLAY/SERICITE ALTERED, HORNBLENDE QUARTZ DIORITE

Siliceous, light grey-green, medium-grained intrusive (harder than steel; no reaction to cold dilute HCl) composed of grey plagioclase and pale green mafic relicts containing buff-coloured sphene/rutile. Very rare stain for K-feldspar and no sulfides; weakly magnetic. Modal mineralogy in polished thin section is approximately:

Plagioclase (oligoclase; partly ?albitized)	40%
Secondary alkali feldspar (?albitic)	20%
Quartz	15%
Amphibole	15%
Carbonate (dolomite or ankerite)	5%
Clay, sericite	3%
Sphene/rutile	1%
K-feldspar (secondary)	1%
Apatite	<1%
Magnetite (partly hematized)	<1%

This sample consists of mainly plagioclase, with interstitial amphibole and quartz (akin to the intensely argillic alteredsample from 95-16 at 77.2 m, possibly a precursor to such a rock). Plagioclase is mainly fresh and finely twinned, but shows only traces of relict compositional zoning, and abundant overgrowth by a feldspar with little or no relief difference, suggesting it is mostly albite overgrowth (composition of the cores is about oligoclase, based on extinction angles Y^010 about 7 degrees, and relief close to that of quartz). THis secondary alkali feldspar looks like K-feldspar in its habit (sub-grains, clearly secondary) but the lack of yellow stain in the hand specimen shows that it is not. This type of alteration (albitic alkali feldspar) is common at certain "diorite clan" porphyry coppers such as the Island Copper deposit; see also Leitch, CIM Bull. July 1981. Minor clay-sericite flecking (10-25 micron diameter) of both primary and secondary feldspars is common; carbonate forms anhedral to subhedral crystals up to 0.1 mm in the plagioclase.

Plagioclase crystals are also attacked at their margins (outboard of the albitization) by secondary quartz, in sub- to anhedral crystals up to 0.25 mm diameter growing outward from minor interstitial (?primary) quartz. The amount of primary quartz may have been about 5-10%, putting this rock on the boundary between hornblende quartz diorite and diorite.

Mafic crystals are subhedral amphibole to 1.5 mm long, mainly fairly fresh to moderately carbonate altered and associated with significant sub- to euhedral, often skeletal, crystals of sphene up to 1 mm across, most with cores of euhedral rutile (25-50 microns) and some poikilitically enclosing quartz. Alteration carbonte, likely dolomite or ankerite, forms sub- to anhedral crystals aggregating to 0.1 mm size. Fine euhedral prisms of apatite to 0.1 mm are found with the sphene/rutile and amphibole. Rare euhedral crystals of magnetite to 0.3 mm, partly oxidized to hematite, are likely primary accessories; there are no sulfides.

In summary, this appears to be a mainly holocrystalline intrusive of about hornblende quartz diorite composition, mildly altered to secondary alkali feldspar, quartz, carbonate and clay-sericite.

95-23 25.5: MAFIC POTASSIC (SECONDARY ALKALI FELDSPAR-KSPAR, BIOTITE-QUARTZ-TOURMALINE, OVERPRINTED BY SERICITE-CARBONTE-CHLORITE) ALTERED ?FELSIC FRAGMENTAL VOLCANIC; MINOR CHALCOPYRITE STRINGERS

Fine-grained, buff, strongly altered ?volcanic rock cut by fractures with cores of fine chalcopyrite and envelopes of pale-coloured ?sericite cutting brownish ?relict unaltered rock. Pale ghosts of ?plagioclase and mafic phenocrysts are visible. The rock is weakly magnetic but does not react to cold dilute HCl. It shows modest yellow stain for K-feldspar; modal mineralogy in polished thin section is:

Secondary alkali feldspar (albitic, minor Kspar)	50%
Quartz (at least partly secondary)	15%
Sericite, clay	15%
Carbonate (?dolomite or ankerite)	10%
Chlorite (mainly after secondary biotite)	7%
Tourmaline (schorl)	2%
Ilmenite, magnetite	<1%

This is a fine-grained, mainly altered rock composed of secondary alkali feldspar, quartz, carbonate, chorite, sericite and minor opaques. Relict phenocryst sites up to 1 mm long are only barely recognizable as anhedral patches of sericite or carbonate. Vague boundaries between coarse-grained and finer-grained areas may indicate fragments that were subrounded and up to 1 cm long. There are rare sub- to euhedral phenocrysts or shards of quartz to 0.3 mm. Scattered crystals of tourmaline (schorl; black in hand specimen, dark greeny-brown in thin section, to 0.5 mm) are likely secondary

Secondary alkali feldspar forms ragged, anhedral crystals rarely up to 0.1 mm diameter, with refractive index less than quartz but no yellow stain in hand specimen indicating mainly albitic compositions. In some places there is minor yellow stain, indicating more orthoclase-rich alkali feldspar (strongest along the veinlets with chalcopyrite, but weakly pervasive elsewhere). The secondary feldspar is itself partly altered to carbonate (probably dolomite or ankerite, largely anhedral, less than 0.1 mm) and fine sericite (flakes of 10-30 micron size). Quartz forms subhedral to anhedral crystals up to 0.1 mm diameter, also partly altered to (or ?mixed with) some sericite.

Relict plagioclase sites are pseudomorphed by 20 micron sericite and lesser carbonate; relic mafic sites are pseudomorphed by fine (25-50 micron) greeny-brown biotite, mainly partly chloritized. These minerals appear to be after former ragged anhedral amphibole crystals; rarely, ragged tourmaline crystals to 0.2 mm long also replace the mafic sites.

Ilmenite and lesser magnetite occur as disseminated crystals or aggregates of subhedral crystals up to 0.3 mm across, possibly as relict primary accessories. Chalcopyrite is found only along narrow (0.1 mm) stringers as 0.25 mm subhedral blebs with quartz, chlorite, and minor sericite.

Rare quartz and plagioclase shards, plus vague ?fragment outlines, suggest this is a crystal-lithic tuff of felsic (?dacite-rhyodacite) composition, strongly altered to alkali feldspar (partly K-spar, partly albitic), biotite, quartz and tourmaline, overprinted by sericite-chlorite-carbonate. The quartz veinlets carrying chalcopyrite may have originally contained either biotite or amphibole that is now chloritized by a later sericite-chlorite-carbonate overprint (SCC alteration at Island Copper, Taysan In the Phillipines, etc.).

95-23 72.3: STRONGLY SECONDARY ALKALI FELDSPAR-SERICITE-BIOTITE-CLAY-CARBONATE-TOURMALINE ALTERED ?FELSIC FRAGMENTAL; CHALCOPYRITE VEIN

Fine-grained, strongly altered volcanic rock with black tourmaline ?vein (surrounded by white, hard envelope, and both cut by a quartz-chalcopyrite veinlet). The bulk of the rock is distinguished by a fine wispy texture caused by alternating darker brownish and lighter buffish laminae. There is minor yellow stain for K-spar along hairline fractures particularly in the darker patches (not the lighter or white, which may therefore be albitic). There is no reaction to cold dilute HCl except along narrow late fractures; the rock is not magnetic. Modal mineralogy in polished thin section is:

Secondary alkali feldspar (albitic, minor K-spar)	40%
Sericite, muscovite	20%
Secondary biotite (chloritized)	15%
Carbonate (mainly dolomite or ankerite; minor calcite)	10%
Clay (?)	10%
Tourmaline (schorl)	3%
Chalcopyrite (veinlet, disseminated)	1%
Rutile, ilmenite, hematite	1%

The bulk of this rock is relatively homogeneous, with only slight variations in texture to indicate a possible tuffaceous origin. In contrast to the sample from 25.5m, fine quartz shards (subhedral, 0.1 mm) are common throughout the rock. Most of the rock appears to consist of very fine-grained (10-50 micron) alkali feldspar, possibly largely secondary. The lighter-coloured wispy areas are enriched in (?altered to) sericite; the darker areas are enriched in fine ?biotite (chloritized) and ?clay (mostly too fine, in the 5-10 micron size range, to identify with certainty). Fine opaques (5-15 microns, aggregating to 50 microns) are mainly rutile.

Tourmaline-rich areas (cores of highly irregular veinlets) consist of subhedral to euhedral bladed crystals up to 1 mm long, in radiating clusters. Dark green and blue pleochroism indicates schorl; the crystals are zoned, with narrow darker rims on paler cores; tourmaline is rimmed by coarse (to 0.35 mm) quartz that poikilitically encloses feldspar. The white envelope to tourmaline veinlets consists of ragged, highly interlocking feathery secondary alkali feldspar, likely albitic, strongly clouded by fine clay-sericite (5-10 microns) and partly altered by carbonate. The central area of the slide, and another zone nearby (buff or bleached in the hand sample) is strongly altered to carbonate, likely dolomite or ankerite to judge by the lack of reactivity in hand specimen, as ragged anhedral interlocking crystals to 0.05 mm, and lesser sericite as flakes to 25 microns. This alteration appears to accompany (envelope to) the main chalcopyrite-quartz-carbonate-minor sericite vein (sub- to euhedral quartz to 0.3 mm, carbonate to 0.15 mm, muscovite to 50 microns).

Chalcopyrite, forming coarse (several mm long) blebs, both cuts across and is associated with (?or replaces) the tourmaline. Narrow veinlets elsewhwere in the rock are composed of quartz, calcite, and sericite contain euhedral crystals of ilmenite to 0.4 mm diameter with minor exsolution laths of hematite, or rutile as euhedral 25-50 micron prisms. These veinlets are surrounded by the bleached carbonate-sericite envelopes; clearly TiO2 was mobilized during later carbonate-sericite-?clay alteration, which cuts mafic potassic (alkali feldspar, partly K-spar; biotite, quartz, tourmaline) alteration.

95-23 102.5: ANKERITIC CARBONATE-SERICITE ALTERED PLAGIOCLASE-AMPHIBOLE PORPHYRITIC QUARTZ DIORITE; BIOTITE ENVELOPES TO CHALCOPYRITE FRACTURES

Fine greenish buff ?feldspar-amphibole porphyry, intensely altered and cut by narrow stringers of quartz-chalcopyrite with dark (?biotite) envelopes. There is a faint yellow stain in the etched slab that may be due to sericite rather than K-feldspar; the rock shows no reaction to cold dilute HCl and is not magnetic. Modal mineralogy in polished thin section is:

Plagioclase (oligoclase phenocrysts, matrix)	60%
Carbonate (dolomite or ankerite)	15%
Quartz (?partly secondary)	10%
Sericite, clay	7%
Secondary biotite (chloritized)	3%
Relict amphibole	3%
Rutile, minor sphene	<1%
Apatite	<1%
Chalcopyrite	tr

This slide consists mainly of feldspar phenocrysts and smaller altered mafic relics set in a phaneritic groundmass of smaller plagioclase and quartz plus heavily altered mafic relicts. Plagioclase phenocrysts are euhedral, complexly compositionally zoned, and up to 2 mm long. They are likely about oligoclase (An_{25}) in composition (extinction angle Y^010 about 8 degrees, relief close to that of quartz). Most crystals are mildly altered to fine sericite and some carbonate, plus scalloping by quartz of the groundmass at the rims.

Mafic relics are pseudomorphed by carbonate, sphene (subhedral, to 0.2 mm), and rutile (euhedral, to 50 microns); rarely, remnants of the original (or fibrous secondary) amphibole occurs, and fine subhedral prisms of apatite are up to 0.1 mm long. The crystals were sub- to anhedral, up to about 1 mm long. Near a fracture at one end of the section, they are altered to fine greenish brown secondary biotite (partly chloritized) as subhedral flakes to about 40 microns diameter.

The groundmass consists of small subhedral plagioclase of about 0.2 mm size, intergrown with finer anhedral quartz of about 50-100 micron diameter and ragged fibrous amphibole to 0.15 mm long, mostly altered to fine (25 micron) carbonate, rutile (10-25 microns) and minor sphene (to 50 microns).

In and near the quartz vein at the very end of the section, there is minor chalcopyrite as subhedral crystals to 0.25 mm diameter. Elsewhere, chalcopyrite is rare, forming fine grains to 25 microns in altered mafic sites, where it accompanies rutile.

This sample appears to be moderately carbonate-sericite altered porphyritic plagioclase-hornblende quartz diorite with minor potassic alteration (secondary biotite along fractures) and trace chalcopyrite on quartz veinlets.

95-23 110.1: INTENSELY CLAY-CALCITE-MINOR QUARTZ ALTERED (ADVANCED ARGILLIC?) PLAGIOCLASE-?HORNBLENDE PORPHYRITIC QUARTZ DIORITE

Chalky white, intensely argillic altered finely porphyritic intrusive (sticks to the tongue; much softer than steel. Cut by narrow veinlets that are harder than steel. There is quite a strong reaction throughout to cold dilute HCl, but no stain for K-feldspar, and the rock is not magnetic. Modal mineralogy in polished thin section is approximately:

Clay (after feldspar)	35%
Carbonate (calcite; after mafics)	35%
Quartz (likely partly secondary)	25%
Rutile	1-2%
Radiating rosettes (?zeolite)	1%
Sericite	1%
Sphene, apatite	<1%
Pyrite, chalcopyrite, ?hematite	<1%

The mineralogy of this slide is simple; it is a thoroughly argillic (clay-calcite) altered rock, with lesser quartz either primary, left over from the original rock, or partly secondary.

Clay essentially replaces (pseudomorphs) all former feldspar, likely plagioclase, crystals in the original rock. The clay forms minute (5, rarely 10 micron) subhedral flakes that have low birefringence and relief lower than quartz; flakes appear to be length-slow. The clay mineral could be a member of the kaolinite family, but I caution that X-ray diffraction would be necessary to characterize it properly. The plagioclase relic sites have eu- to subhedral outlines up to 1.5 mm long.

Carbonate essentially replaces or pseudomorphs all former mafic crystals, which had elongate but ragged outlines up to 1.25 mm in length; they were likely amphibole, and so the original rock type was likely the same as in other porphyritic samples of this suite. Carbonate is likely mainly calcite, and forms fine anhedral crystals rarely over 50 microns in diameter, aggregating to 0.5 mm in places. Minor amounts are mixed with clay in the feldspar sites. Minor rutile, as 25-50 micron subhedral crystals, aggregating to 0.1 mm in places, is common in the relic mafic sites. In places, radiating rosettes of a low birefringence, low relief mineral up to 0.15 mm in diameter could be ?zeolite.

Quartz appears to largely be the remnant of a phaneritic groundmass that probably consisted of plagioclase, amphibole and quartz; the quartz forms subhedral crystals averaging about 0.1 mm. In places where there is a tendency for crystals to line up along irregular ?veinlets a tenth of a millimeter wide, it may be secondary. The prominent veinlets seen in hand specimen are principally quartz, as an- to subhedral crystals of 0.1-0.2 mm diameter, with a central parting of very fine clay and minor carbonate. There are no sulfides in the veins, but minor sulfides (pyrite as subhedral crystals to 0.15 mm diameter and rare chalcopyrite to 0.1 mm) plus rare ?hematite to 0.1 mm appear to be associated with secondary silica in the body of the rock, or in some cases with narrow calcite stringers and fractures.

In summary, this is an intensely argillic (or advanced argillic, if there is significant secondary quartz) altered ?porphyritic hornblende quartz diorite, similar to 95-23 102.5m in rock type.

95-25 40.3: MAFIC POTASSIC (CALCITE-BIOTITE-K-SPAR-CHLORITE-QUARTZ ALTERED) PORPHYRITIC HORNBLENDE DIORITE; BORNITE-CHALCOPYRITE-CALCITE-QUARTZ VEIN

Grey-green, altered intrusive rock cut by a major (3 mm) quartz-chalcopyrite-bornite vein. Minor K-feldspar (yellow stain in etched slab) is only weakly associated with fractures and veins; part of it could be primary. Minor buff carbonate along the vein and in the rock reacts slowly to cold dilute HCl; it may be Fe-calcite. In polished thin section, modal mineralogy is approximately:

Plagioclase (oligoclase-andesine)	45%
Carbonate (mainly ?Fe-calcite)	20%
Quartz (partly secondary)	10%
Secondary biotite	10%
K-feldspar (partly secondary)	5%
Chlorite	5%
Sericite, clay	3%
Bornite, chalcopyrite	1-2%
Rutile, apatite, zircon	<1%

This slide consists of plagioclase crystals and mafic relict sites with a little phaneritic groundmass composed of quartz and feldspar, cut by a major carbonate-quartz-sulfide-biotite vein with carbonate alteration envelope. Plagioclase feldspar forms euhedral crystals up to 2 mm long that are mostly mildly altered to fine sericite and carbonate and corroded around the margins by groundmass quartz and K-feldspar, or rarely converted to secondary alkali feldspar, possibly of albitic composition. Original composition of the plagioclase appears to be about oligoclas-andesine (An_{30}) based on extinction angle Y^010 about 15 degrees and relief close to that of quartz.

Mafic relics have ragged subhedral outlines up to 2.5 mm long; elongate outlines and fibrous character suggests they were formerly amphibole (?hornblende), now pseudomorphed by carbonate, secondary biotite (partly chloritized), minor quartz, K-spar and rutile. There are two carbonates, one fine and brownish (Fe-calcite or ankerite, up to 50 micron anhedral crystals) and one coarser, clear (calcite, up to 0.25 mm diameter) intergrown with quartz and ?K-feldspar of similar size. Biotite is greenish brown, and forms ragged flakes up to 0.3 mm size, in places intergrown with (?replaced by) a colourless ?chlorite forming subhedral flakes to about 0.1 mm diameter. Rutile is common though not abundant throughout, forming fine (25-30 micron) euhedral prisms, mainly in mafic sites with carbonate. Rare apatite and zircon form euhedral crystals to 80 microns long.

The (minor) groundmass consists of an- to subhedral quartz up to 0.2 mm diameter, with lesser interstitial K-feldspar (subhedral, to 0.1 mm), filling interstices between plagioclase and relict mafic crystals. In places both the groundmass minerals attack the plagioclase. Narrow fractures of secondary biotite and carbonate criss-cross the rock. The major vein consists of subhedral carbonate (1 mm), fibrous ?chalcedonic quartz to 0.5 mm, and rare biotite and chlorite (0.2 mm). In the vein, bornite is more abundant than chalcopyrite; both form eu- to subhedral crystals up to several mm across. Sulfides are rare outside the vein except for minor chalcopyrite and bornite blebs to 50 microns along hairline fractures, in places intergrown with rutile.

This appears to be a mafic potassic (biotite-carbonate-K-spar-quartz-chlorite altered) porphyritic ?hornblende quartz diorite.

95-25 143.4: INTENSELY CARBONATE-SERICITE-CLAY ALTERED ?RHYODACITE PORPHYRY (K-SPAR RICH GROUNDMASS); DISSEMINATED CHALCOPYRITE-BORNITE

Pale grey-buff plagioclase porphyry (rare fine mafic relics) with K-feldspar rich groundmass, disseminated chalcopyrite (probably replacing mafic sites). The rock is not magnetic and shows no reaction to cold dilute HCl; modal mineralogy in polished thin section is:

K-feldspar (groundmass)	35%
Sericite, clay (after plagioclase)	25%
Carbonate (?ankerite or dolomite)	25%
Quartz (?partly secondary)	5%
Relict plagioclase	5%
Muscovite (after mafics)	3%
Chalcopyrite	1%
Rutile	1%
Apatite	<1%

Under the microscope, this rock is a mass of secondary minerals: plagioclase phenocrysts and groundmass crystals are pseudomorphed by fine sericite and lesser ?clay plus variable carbonate; former mafic are replaced by coarser sericite (muscovite) and carbonate plus rutile. Plagioclase phenocrysts have euhedral outlines up to 3.5 mm diameter, and now consist of sericite flakes to 0.1 mm, with cores of very fine clay (5-10 micron flakes) and an- to subhedral carbonate crystals to 0.15 mm diameter, with minor relict plagioclase (likely albite).

Mafic relics are replaced by 0.25 mm carbonate, likely ankerite, and sulfide (mainly chalcopyrite, as subhedral crystals or aggregates up to 1 mm across). Most chalcopyrite is associated with or contains fine irregular inclusions of bornite (to 50 microns), as well as inclusions of rutile. These mafic crystals mostly appear to have been ?amphibole, as subhedral crystals up to 1.5 mm long, but some (replaced by muscovite flakes to 0.25 mm diameter) may have been biotite up to 0.5 mm diameter (as seen in 19 at 266.8m).

The groundmass consists of a highly interlocking aggregate of feathery K-feldspar and lesser quartz, both about 50-100 microns in size, surrounding small plagioclase relict crystals of about 0.2 mm size (most pseudomorphed as for the phenocrysts). It is not clear that the K-feldspar is exclusively primary; some may be secondary. Some of the quartz is clearly secondary, possibly replacing former plagioclase. Sericite and carbonate plus minor rutile, respectively after small plagioclase and mafics, are abundant. Fine euhedral prisms of apatite to 0.1 mm long are common.

This sample appears to have been a plagioclase-hornblende porphyry possibly of rhyodacite composition (if the K-feldspar is mainly primary) before significant alteration to carbonate, sericite, and quartz that accompanied minor copper mineralization.

95-25 214.8: SERICITE-CARBONATE-QUARTZ ALTERED ?RHYODACITE PORPHYRY (K-SPAR RICH GROUNDMASS); TRACE DISSEMINATED CHALCOPYRITE-BORNITE-RUTILE

Buff-coloured, similar porphyry to the previous sample but with sparser chalcopyrite and rutile in altered mafic sites; same K-feldspar rich groundmass. Not magnetic, only reacts to cold dilute HCl along narrow fractures; modal mineralogy in polished thin section is approximately:

K-feldspar (groundmass, ?mainly primary)	45%
Sericite	25%
Carbonate (?dolomite or ankerite)	20%
Quartz (?partly secondary)	7%
Rutile	1-2%
Apatite	1-2%
Chalcopyrite, trace bornite	<1%

This slide has a very fine (aphanitic) groundmass consisting of K-feldspar (likely mainly primary) and lesser quartz, plus mionr sericite and carbonate, rare rutile, all about 15-25 micron diameter. This is considerably finer than the groundmass in 95-25 110.1m, although in other respects the samples are similar. Apatite is scattered in the groundmass as slender euhedral prisms to 0.15 mm long.

Plagioclase relict crystals have euhedral outlines up to 2.5 mm diameter; they are pseudomorphed by 10-35 micron sericite and lesser anhedral carbonate (to 0.1 mm; likely ankerite or dolomite). In places there is minor quartz (anhedral, 50 microns).

Altered mafic sites consist of carbonate and sericite in roughly reversed proportions to the plagioclase crystals, with significant rutile and rare sulfide. Some crystals are also replaced by quartz to 50 microns diameter. As in the previous sample, chalcopyrite forms subhedral crystals to 1 mm size that are cracked/rimmed by minor bornite (25-50 micron blebs) and include or are associated with rutile (euhedral crystals to 100 microns long). It is not obvious what the original mafic crystals were, but amphibole and biotite are likely.

If the K-feldspar in the groundmass is primary, and there is over 10% (5% according to some classification schemes) this would classify as a rhyolite porphyry rather than a rhyodacite. The groundmass is very fine, but it is likely a high level intrusive rather than a flow. Alternately, the K-spar rich groundmass could be secondary, a product of potassic flooding, but the textures do not suggest this. Alteration therefore appears to be phyllic (sericite-carbonate-quartz) but with very little sulfide accompanying the alteration.

95-25 239.1: SERICITE-CARBONATE-CHLORITE-MINOR BIOTITE-QUARTZ-CLAY-K-FELDSPAR ALTERED BIOITE-HORNBLENDE ?DACITE PORPHYRY; MINOR BORNITE

Dark grey, relatively fresh porphyry similar to the altered porphyries at 143.4 and 214.8 m in this hole, characterized by white glomeratic feldspar and small black biotite/green altered ?amphibole phenocrysts in an aphanitic groundmass that does not stain for K-feldspar (although the plagioclase phenocrysts show minor yellow stain). Traces of magnetism in mafic crystals; no reaction to cold dilute HCl. Modal mineralogy in polished thin section is:

Relict plagioclase (phenocrysts and matrix)	30%
Sericite	20%
Carbonate (dolomite or ankerite)	15%
Chlorite	12%
Quartz (?partly secondary)	10%
Biotite (partly secondary)	5%
Clay (after plagioclase)	3%
K-feldspar (secondary)	3%
Rutile	1%
Bornite, chalcopyrite	<1%
Apatite, magnetite	tr

Plagioclase crystals are actually strongly altered in thin section, mainly pseudormorphed by 25-50 micron sericite and carobnate (likely dolomite; no reaction in hand specimen to HCl). They have euhedral outlines up to 2 mm diameter. In addition, some contain patches replaced by fine feathery K-feldspar to 100 microns long, or by very fine clay (5-10 microns).

Mafic relics are altered to carbonate (0.15 mm, anhedral), chlorite (two varieties, subhedral, 0.15 mm), opaques (see below) and rutile (euhedral, to 50 microns). In some there is very minor secondary biotite (greenish brown, 10-20 microns). Chlorite is either length-slow (Fe-rich) or length-fast (Mg-rich) that occur intergrown. Biotite phenocrysts are euhedral and up to 1.5 mm in diameter, with greenish brown pleochroism. They contain rare fine apatite crystals to 70 microns long, and are slightly altered to chlorite, carbonate and sericite. There is only minor chalcopyrite (subhedral, to 0.25 mm); actually, bornite is more common, forming rounded blebs to subhedral crystals to 0.7 mm diameter, in places mixed with chalcopyrite. Magnetite occurs as fine (0.1-0.2 mm) euhedra in the altered mafic sites, with rutile needles to 50 microns aggregating to 0.15 mm.

The groundmass consists of fine plagioclase crystals of 0.1-0.25 mm length, generally partly altered to sericite and carbonate, and lesser chlorite (0.1 mm, after fine mafic crystals), set in a matrix of very fine alkali feldspar, probable quartz, and carbonate, sericite, secondary biotite and chlorite (all about 10-30 microns in diameter).

Since there is no appreciable K-feldspar in the matrix, this sample appears to be distinct from the rhyodacite to ?rhyolite porphyries of samples 19-266.8, 25-143.4 and 214.8; it could be a dacite porphyry, with mild mafic potassic alteration (secondary biotite, K-feldspar) superimposed by stronger sericite-dolomitic carbonate-chlorite alteration.

95-25 345.8: MILD POTASSIC (K-FELDSPAR, QUARTZ, BIOTITE, SERICITE, CARBONATE ALTERED) PORPHYRITIC BIOTITE-HORNBLENDE QUARTZ DIORITE MINERALIZED WITH MINOR CHALCOPYRITE AND BORNITE

Grey, porphyryitic hihg-level intrusive rock marked by fine black biotite and large plagioclase phenocrysts; minor disseminated magnetite and chalcopyrite. Significant K-feldspar, mainly secondary, is present along fractures with bornite and chalcopyrite. There is minor reaction to cold dilute HCl along the fracture and in altered mafic sites. Mineralogy in polished thin section is approximately:

Plagioclase (oligoclase)	60%
Carbonate (?mainly calcite)	10%
K-feldspar (partly secondary)	7%
Quartz (partly secondary)	5%
Sericite, clay	5%
Biotite (phenocrysts)	5%
Secondary biotite, chlorite	5%
Chalcopyrite, minor bornite	1%
Magnetite (partly hematized)	<1%
Apatite	<1%

This is weakly porphyritic to almost holocrystalline intrusive of about biotite-?hornblende quartz diorite composition; biotite is notable in the phenocryst phase, in contrast to the majoritiy of the hornblende quartz diorites of this suite. The slide consists of major plagioclase and minor biotite, set in a minimum amount of groundmass. Plagioclase is probably about oligoclase in composition; relief is very close to that of quartz, as sub- to euhedral crystals up to 2 mm diameter (glomeratic to almost 1 cm locally). The crystals are zoned, ranging from almost labradorite at the cores to oligoclase at rims; they are mildly altered to fine sericite and minor carbonate. Rims of the crystals are also partly replaced by 0.1-0.2 mm K-feldspar and quartz, especially along quartz-sulfide stringers that are up to 0.5 mm thick.

Biotite phenocrysts are euhedral and up to 1 mm in diameter, with greenish brown pleochroism. Other subhedral, ragged mafic relics that likely represent hornblende crystals are pseudomorphed by chlorite (50 microns, pale green to almost colourless), carbonate (anhedral, 0.15 mm) and a little greenish-brown secondary biotite (subhedral, to 0.1 mm) as well as variable opaques (sulfides, magnetite) and rutile.

The groundmass consists of K-feldspar (to 0.2 mm, subhedral, clearly replacing small plagioclase crystals in places), lesser quartz (0.1 mm, anhedral), plus minor carbonate, sericite, biotite and opaques.

In the vein, bornite forms rounded blebs to 1 mm long, in places intermixed with subhedral chalcopyrite to 0.75 mm long. Disseminated chalcopyrite (with lesser bornite and associated magnetite, the latter partly altered to hematite) occur scattered in relict mafic sites throughout the rock. Magnetite crystals are euhedral, up to 0.25 mm diameter; chalcopyrite is generally subhedral and less than 0.15 mm in size.

The alteration in this sample is mild mafic potassic (K-feldspar and quartz; biotite and carbonate after hornblende), associated with rare stringers and microfractures of quartz-K-feldspar-chalcopyrite and bornite.

95-25 382.4: INTENSELY CLAY-SERICITE-CARBONATE-QUARTZ (ADVANCED ARGILLIC) ALTERED PLAGIOCLASE-HORNBLENDE QUARTZ MONZONITE PORPHRY

Grey, feldspar porphyritic intermediate intrusive with rare carbonate veins and abundant sulfide microfractures; the groundmass is rich in K-feldspar, but it is not clear (lacking a "fresh" specimen to compare with) whether the K-spar is primary or secondary. It is not obviously controlled along fractures; in this regard, it is similar to rhyodacite porphry in the Island Copper pit, which appears to be rich in primary groundmass K-feldspar (Leitch et al., GSC Current Research 1995-A, p.51-59). The rock is not magnetic and does not react to cold dilute HCl; modal mineralogy in polished thin section is roughly:

Clay (after plagioclase, hornblende)	30%
K-feldspar (groundmass)	25%
Carbonate (dolomite or ankerite)	15%
Quartz (partly secondary)	15%
Sericite	10%
Chlorite	3%
Chalcopyrite, trace ?arsenopyrite	1%
Rutile	<1%
Apatite	<1%

Plagioclase crystals are completely pseudomorphed by very fine (5 micron) clay and minor carbonate (10-30 micron, anhedral), sericite (25 micron flakes) and ?quartz (15-20 microns). The crystals have euhedral outlines up to 5 mm long (where glomeratic). Mafic relics are sparse, up to about 1 mm long; they are completely replaced by carbonate (to 0.1 mm, anhedral) and fine clay-chlorite (flakes to 15 microns) plus traces of quartz (10-15 microns) and rutile (subhedral, to 40 microns). They likely mainly represent former hornblende crystals to judge by their elongate outlines. Blebs of sulfide to 0.25 mm and rare subhedral apatite to 0.1 mm are associated with the mafic sites in places but are also found along microfractures separate from the mafic sites. Most carbonate microveinlets, however, are barren of sulfide (even although close to them and subparallel), suggesting they are later than the bulk of sulfide mineralization.

The groundmass is fairly coarse (phaneritic), composed of 0.2-0.3 mm sub- to anhedral K-feldspar (partly sericite-clay altered), lesser subhedral plagioclase (also clay-sericite-carbonate altered) and finer (to 0.1 mm) anhedral quartz. The K-feldspar is not obviously secondary (does not clearly attack margins of plagioclase) but admittedly there is so much overprinting by carbonate and sericite that it is hard to tell; there are some micrographic textures of quartz and K-feldspar, but these could be late magmatic rather than hydrothermal.

Sulfides include chalcopyrite (an- to subhedral blebs, to 0.25 mm diameter) and ?arsenopyrite as euhedral crystals to 0.15 mm, in places associated with or including some rutile crystals. The chalcopyrite occurs in 25-50 micron thick microveinlets in clay altered plagioclase or as much larger rounded blebs mainly in altered groundmass locations.

This is apparently an advanced argillic (clay-sericite-carbonate-quartz-minor chlorite) altered porphyritic ?hornblende quartz monzonite with minor chalcopyrite and trace arsenopyrite (check geochemistry for As to confirm this).

95-26 48.3: MAFIC POTASSIC (SECONDARY ALKALI FELDSPAR-QUARTZ-MAGNETITE-AMPHIBOLE ALTERED) BIOTITE-HORNBLENDE QUARTZ DIORITE; RARE CHALCOPYRITE

Dark grey, fine-grained, more mafic-looking; no stain for K-feldspar, very magnetic, trace reaction to HCl along fractures. Modal mineralogy in polished thin section is approximately:

Plagioclase (oligoclase)	35%
Secondary alkali feldspar (?albitic)	20%
Quartz (partly secondary)	20%
Biotite (?partly secondary)	10%
Chlorite	5%
Amphibole (partly secondary, in veinlets)	3%
Carbonate (partly calcite)	3%
Magnetite	3%
Sericite	2%
Sphene, rutile	<1%
Chalcopyrite, trace pyrite	<1%

This sample is more equigranular than porphyritic, although traces of a phenocrystic texture can be seen in the sizes of plagioclase crystals, which are subhedral and range up to 1.25 mm diameter. Most are partly altered to secondary alkali feldspar that is likely albitic or "anorabltite" with a little orthoclase molecule (see Leitch, CIM Bull. July 1981) since there is no stain in the etched slab. This secondary feldspar is controlled by microfractures and a has a slightly cloudy, sub- to anhedral, granular appearance compared to the clear, more euhedral primary plagioclase, which may be about oligoclase in composition (relief very close to that of quartz; extinction angle Y^010 8-15 degrees). In places whole plagioclase crystals are replaced, in places to myrmektic intergrowths with magnetite.

Quartz is abundant, forming sub- to anhedral crystals to about 0.75 mm diameter that also appear to be at least in part secondary, particularly where they form fine-grained (50-100 micron) intergrowths with plagioclase, magnetite and minor amphibole, or where anhedral, irregular veinlet-like areas cross or overprint plagioclase crystals.

Mafic minerals include brown biotite as subhedral flakes to 1 mm diameter (possibly primary) that are strongly poikilitic, including fine quartz. As well, there are fine greenish-brown (50-100 micron, anhedral) secondary biotite flakes with chlorite and carbonate possibly replacing some other former mafic mineral. These other relics have anhedral outlines up to about 0.5 mm, and were likely amphibole. Traces of relict amphibole are present in some of them, and fresher amphibole occurs in veinlets. Associated with the altered mafic sites are opaques (magnetite-hematite, sulfides; see below) and a little sphene that forms subhedral crystals to 0.15 mm, in places cored by rutile as euhedral prisms to 40 microns long.

Magnetite mostly occurs in altered mafic sites as sub- to euhedral crystals of about 0.1 mm diameter, mainly partly oxidized to hematite; in places aggregates to about 0.7 mm diameter occur. It is also present in a narrow, irregular quartz-amphibole veinlet 0.2 mm thick. Rare chalcopyrite forms subhedral crystals up to 0.1 mm size, mainly disseminated in quartz or feldspar areas; pyrite is even rarer, forming euhedral crystals <0.1 mm.

The albitic alkali feldspar-quartz-amphibole-magnetite alteration of this biotite-?hornblende quartz diorite is characteristic of mafic potassic alteration (e.g., Island Copper, Tanama in Phillipines, etc.)

95-26 247.7: MILDLY POTASSIC (ALKALI FELDSPAR-BIOTITE-CARBONATE-QUARTZ-CHLORITE-TOURMALINE) ALTERED BIOTITE-HORNBLENDE DACITE PORPHYRY WITH DISSEMINATED CHALCOPYRITE-TRACE BORNITE

Pale grey-brown, possibly similar intrusive to that at 48.3m but with flow texture (visible in etched slab, which shows only minor K-feldspar) caused by alignment of abundant biotite flakes. Cut by a dark ?tourmaline veinlet and a white ?calcite veinet; minor reaction to HCl throughout, not magnetic. Modal mineralogy in polished thin section is approximately:

Plagioclase (phenocrysts and groundmass)	55%
Biotite (phenocrysts, secondary)	15%
Carbonate (calcite and ?dolomite)	10%
Quartz (partly secondary)	5%
Chlorite	5%
Sericite	5%
Tourmaline (schorl; mostly veinlet)	1%
Chalcopyrite, minor bornite, trace chalcocite	1%
Rutile	1%
Sphene	<1%
Apatite	<1%

This is a fine-grained biotite-?hornblende dacite porphyry, characterized by large plagioclase phenocrysts and smaller, needle-like ?hornblende and biotite crystals in an aphanitic groundmass. Plagioclase crystals are euhedral and up to 2.5 mm long; they are mildly flecked by fine (25-50 micron) sericite and carbonate, and have a slighly cloudy, sub-granular, unzoned texture that suggests they have been altered to ?albite, particularly at the margins. Clusters of rutile crystals to 50 microns are included, in places with surrounding sphene.

Mafic crystals are mainly euhedral brown biotite to 1 mm, in places showing minor alteration to fine greenish-brown secondary biotite. Other, elongate lath-like relict mafic crystals up to 1.26 mm log are altered to similar fine (25-50 micron) secondary biotite and lesser carbonate, opaques and sphene/rutile, or rarely dark green tourmaline to 0.1 mm long. Carbonate is likely partly calcite and partly ?dolomite, forming elongated masses to 0.2 mm long. Opaques include mostly chalcopyrite (subhedral blebs to 0.5 mm) with lesser rutile (unusually coarse euhedra to 0.2 mm) and minor bornite (rounded blebs, mainly mixed with chalcopyrite, to 0.1 mm size). Rarely, 15-20 micron chalcocite mantles part of the bornite. Pyrite is notable by its absence (this is a low total sulfide, high Fe:Cu sample).

The groundmass consists of fine flow-aligned laths (to 0.15 mm) of altered plagioclase, very fine(10-25 micron) shreddy pale green biotite, chlorite and sericite. Quartz is relatively rare, scattered throughout as 0.1-0.2 mm sub- to anhedral crystals (possibly primary) or rarely replacing the edges of plagioclase (secondary).

The dark veinlèt consists of euhedral to radiating tourmaline to 1 mm long with pale green to khaki pleochroism (likely schorl) plus minor rutile (euhedral, to 0.1 mm); the tourmaline is fractured by calcite, which also occurs in other veinlets up to 0.2 mm thick. Traces of bornite and chalcopyrite occur in the tourmaline veinlet.

In summary, this is a mildly mafic potassic (albitic alkali feldspar-secondary biotite-carbonate-quartz-rutile-chalcopyrite-bornite tourmaline altered), biotite-hornblende ?dacite porphyry.

95-26 263.5: INTENSELY MAFIC POTASSIC (AMPHIBOLE-SECONDARY BIOTITE-K-FELDSPAR) ALTERED ?DIORITE PORPHYRY, OVERPRINTED BY CHLORITE-PYRITE

Dark grey to black, fine-grained rock that reveals a porphyritic texture when etched; minor yellow stain for K-feldspar. Irregular veinlets of dark material are cut by planar veinlets of pyrite and minor calcite with dark (chloritic) envelopes; the rest of the rock does not react to cold dilute HCl. The rock is magnetic; modal mineralogy in polished thin section is approximately:

Secondary green biotite	45%
Amphibole (?secondary)	15%
Chlorite	10%
Relict plagioclase (?albitic)	10%
Muscovite (sericite)	5%
Secondary alkali feldspar (albitic)	5%
(K-feldspar)	3%
Quartz (mainly secondary)	3%
Pyrite	3%
Chalcopyrite	1%
Magnetite	<1%
Calcite (late veinlets only)	<1%

This is a very mafic rock, composed mainly of secondary green biotite, secondary amphibole, relict feldspar, and lesser muscovite or sericite. Feldspar and quartz are minor and mainly veinlet-controlled, except for relict plagioclase (relicts of former phenocrysts). Most of the rock is a fine-grained aggregate of secondary biotite (pale greenish brown, sub- to euhedral, about 25-50 microns, rarely to 100 microns) and amphibole (almost colurless, ?tremolite-actinolite, subhedral laths about 0.1-0.2 mm long). In places, relict mafic sites up to 0.75 mm size are pseudomorphed by fibrous secondary amphibole, and scattered flakes of muscovite to 0.2 mm across (the latter possibly after ?biotite. There are also vestiges of former plagioclase crystals (originally subhedral crystals up to 1.5 mm size), almost obliterated by the intense mafic potassic alteration. In the area of the dark irregular veinlets, both secondary biotite and sulfides are more abundant, compared to the wallrock which is richer in amphibole. This suggests that the sulfide mineralization is associated with the biotite part rather than the amphibole part of mafic potassic alteration, as is the case at Island Copper. Also as at Island Copper, there is a major chlorite envelope (destroying both amphibole and secondary biotite) along the major pyrite-minor chalcopyrite-quartz veinlets.

Relict feldspar is mostly replaced by a twinned secondary alkali feldspar, probably albitic in composition. Secondary K-feldspar occurs as subhedral crystals up to 0.15 mm, aggregating to 0.3 mm in places. There are relatively rare, an- to subhedral crystals of quartz mixed with the secondary alkali feldspar (K-spar and albite). These are most abundant along the "irregular fracture" and of course in the veins.

In the veins, pyrite forms coarse euhedral crystals up to several mm long, mixed in places with lesser chalcopyrite (sub- to anhedral, to 1.2 mm) and sub- to euhedral quartz to 1 mm. The quartz is fractured and recrystallized in places, and cut by stringers of calcite. Earlier fractures are marked by swarms of fine euhedral pyrite (0.5 mm) and lesser subhedral chalcopyrite blebs (to 0.3 mm) as well as traces of magnetite (euhedral, to 0.1 mm). Away from these zones, there is only trace pyrite and chalcopyrite disseminated in relict mafic sites.

95-30A: INTENSELY MAFIC POTASSIC (BIOTITE-K-FELDSPAR-QUARTZ-TOURMALINE-MAGNETITE ALTERED; PYRITE OVERPRINTED) BRECCIA OF VOLCANIC FRAGMENTS

Dark blackish-brown, clearly fragmental rock, strongly magnetic; no reaction to cold dilute HCl, but minor yellow stain for K-feldspar in the dark but not the light-coloured fragments. Larger clasts look like altered volcanics, and are rounded to sub-rounded, up to 10 cm maximum dimension. The rock is cut by abundant veinlets/microfractures of pyrite. Modal mineralogy in polished thin section is approximately:

Secondary biotite	40%
Relict plagioclase	25%
Secondary K-feldspar	15%
Quartz	10%
Pyrite	5%
Tourmaline (schorlitic)	3%
Magnetite	1%
Chlorite	1%
Rutile	<1%

Clasts range from pale brown and biotitic (dominant) to clear (quartz- or K-feldspar rich) to rare tourmaline-pyrite rich. The most abundant clasts are composed of very fine, pale brown secondary biotite (10-20 micron), hosting quartz (anhedral, to 0.1 mm, looks secondary) and plagioclase (subhedral, to 0.2 mm, look like volcanic shards). Minor tourmaline (dark greeny-brown schorl, subhedral, to 0.1 mm; poikilitically including pyrite) occurs with the secondary quartz and sulfides, partly distributed along microfractures. These clasts look to have been ?dacitic crystal tuffs before intense mafic potassic (biotite-quartz-tourmaline-pyrite) alteration.

Clear clasts consist of either quartz (shards/phenocrysts to 1 mm) or aggregates of feldspar, mainly secondary K-feldspar as subhedral crystals to 0.1 mm diameter, and fine quartz to 50 microns. There are also shards (broken phenocrysts) of plagioclase to 1 mm diameter, in places partly to wholly replaced by secondary K-feldspar, minor pyrite and trace secondary biotite or rare tourmaline. These clasts grade to darker clasts that were once finely porphyritic ?volcanics (0.3 mm plagioclase), now highly altered to secondary alkalki feldspar, mainly K-feldspar, as subhedral 0.1 mm crystals full of 2-15 micron opaque (?mainly pyrite) inclusions and partly altered to 10-20 micron secondary biotite. In tourmaline-rich clasts, greenish-blue (Fe-rich, schorl) tourmaline crystals are subhedral and up to 0.1 mm; pyrite is subhedral and of similar size. The less altered rim of the clast shows fine relict plagioclase microlites.

The matrix (about 10-15% of the rock) consists mainly of secondary biotite (subhedral flakes to 50 microns) and pyrite (sub- to euhedral crystals to 0.5 mm), with variable tourmaline (subhedral crystals to 0.15 mm), quartz (anhedral, to 50 microns). Chalcopyrite is rare, fine (generally <20 microns; rarely 0.1 mm) and mainly associated with (or included in) magnetite, which forms eu- to subhedral crystals to 0.1 mm (aggregates to 0.5 mm). Magnetite also contains euehdral 20-30 micron inclusions of pyrite, but in general, pyrite appears to be surrounding and ?replacing magnetite. Fine (20-30 micron) rutile occurs with pyrite and tourmaline. Planar veinlets cutting both clasts and matrix are composed of pyrite (?replacing magnetite), quartz, and chlorite; in their narrow envelopes, secondary biotite is converted to chlorite and minor sericite.

N-95-32 76.7: INTENSELY CARBONATE-SERICITE-TOURMALINE-K-FELDSPAR-QUARTZ AND RUTILE ALTERED BRECCIA COMPOSED OF ?FELSIC VOLCANIC FRAGMENTS

Highly variegated fragmental rock with subrounded to rounded clasts to 1 cm diameter, mainly buff coloured and fairly hard, reacting to HCl (?quartz-calcite-sericite) but some pinkish (?hematite-stained) in a matrix of black ?tourmaline. Not magnetic, but strong yellow stain throughout for K-feldspar. Modal mineralogy in polished thin section is approximately:

Carbonate (largely calcite)	35%
Sericite	25%
Tourmaline (schorl)	15%
K-feldspar (secondary)	10%
Quartz (phenocrysts, secondary)	10%
Rutile	2-3%
Apatite (secondary)	1-2%
Secondary biotite	<1%
Chalcopyrite, trace ?tetrahedrite	<1%

The bulk of the clasts in this slide are altered to a very fine-grained (10-15 micron) mixture of carbonate and sericite, with vague relict texture in places suggesting a ?volcanic texture; there are scattered subhedral quartz shards to 0.5 mm in some clasts. Carbonate forms anhedral crystals and sericite subhedral flakes, commonly in patches up to 0.7 mm across that could represent former ?plagioclase. Other patches with more quartz and/or carbonate may represent former ?mafic mineral crystals, although it is not possible to be sure. Although K-feldspar appears to be abundant by the yellow stain in the etched slab, it is not at all obvious in thin section (part may be confused with quartz, as very fine, 10-15 micron anhedral crystals).

Large white altered clasts have similar mineralogy to the buff-coloured clasts, but perhaps with more sericite (and ?clay) and less carbonate. Tourmaline appears to be concentrated around their borders, but not in them. In one clast, there is minor secondary biotite (deep brown colour, high Mg content) as subhedral flakes to 50 microns.

The matrix is rich in tourmaline, mainly as extremely fine, sub- to anhedral stubby prismatic crystals up to about 10 microns long. However, in places the tourmaline is recrystallized to radiating sprays of 0.25 mm crystals with zoned pale purplish-blue (cores) to greenish-brown (rims) pleochroism, likely schorlitic in composition. In one area, large anhedral to subhedral apatite crystals up to 1 mm across poikilitically enclose other minerals (apatite is almost vein-like in its occurrence, and must be secondary).

Rutile is abundantly intergrown with tourmaline in places; it occurs as fine euhedral needles up to 35 microns long, aggregating in bunches up to 0.1 mm across or in narrow veinlets (a most unusual occurrence for rutile, demonstrating mobility of Ti). These are the pink stains seen in hand specimen. Other rare narrow veinlets contain quartz and green ?tourmaline (subhedral, to 0.1 mm long). These cut large (0.2 mm) brown subhedral tourmaline crystals in what look like vugs. Rare chalcopyrite (subhedral, to 0.25 mm) is associated with carbonate and contains intergrown trace ?tetrahedrite (25-35 microns).

This is a heavily carbonate-sericite-tourmaline-K-feldspar-quartz-rutile-apatite altered rock; the carbonate-sericite may be an overprint on an initially potassic altered rock, but the abundant rutile and apatite as part of the secondary assemblage are very unusual.