T6S → Island Copper

INTEROFFICE MEMORANDUM

Date: 02-Feb-1996 11:27am PST
From: David Lefebure of EMPR
DLEFEBURE
Dept: Energy, Mines & Petroleum Res.
Tel No: 952-0404

834394

TO: Distribution List suppressed (Current User: David Lefebure of EMPR )

Subject: Island Copper Core Archive File

I will circulate to you a short report and digital file compiled by Kika Ross while working with the Geological Survey of Canada on the Island Copper property and incorporates information collected by Kika, Craig Leitch and possibly other colleagues.

The information includes:
- cross-sections
- sample-descriptions
- thin section descriptions
- assays
- two recent published reports

After circulation, the oroginal report and digital file will be placed in the property files.

Okayed by BHP?

Cheers,
Dave

Andre Panteleyev —
Gib McArthur —
Tom Schroeter ✓
Robert Pinsent —

Return to Larry Jones for Property file.
David Lefebure

photocopy for ~~Dave~~

* Additional Reference CIM SV 46 (1995)

# Island Copper Core Library

This suite of rocks was collected in Nov. 1995 as part of the archiving of the Island Copper Mine that is due to be shut down Dec. 1995. Drill holes lying on or near five cross sections through the pit were selected, as well as several others of interest. Samples were taken to represent each significant change in alteration or lithology. Sample descriptions are based on visual inspection at the time of collection, but understanding of the alteration is based on a petrographic study of over 200 thin and polished sections completed early in 1995 by K. Ross and C. Leitch.

The diskette contains a file(Corelibr.xls, saved in Excel 5.0) listing the samples, organized by cross section, with the footage the sample was collected at and a brief description of the rock. Four matching suites were collected, multiple footage entries apply to samples in different suites.

The PLOT directory contains the five cross sections with drill hole traces and assays. They are saved in HPGL format and can be printed from DOS.

The THINSECT directory contains the unpublished thinsection descriptions of the alteration study completed earlier in the year, (saved in Excel 5.0). Footages will not match this rock suite, but may serve as a guide to comparing hand samples to the detailed petrography. These files have not been edited and contain typos, abbreviations and comments.

The ASSAY directory contains all assay information for the drill holes in the suite. The plot files contain some additional assay information for holes that were not sampled.

Photocopies of working sections with geological interpretations are also included.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| IS' ND COPPER CORE LIBRARY | | | | | | | |
| | | | | | | | |
| SECTION 139 W | | FOOTAGE** | | | | | |
| | D-71 | 50 | 55 | 60 | 70 | | early QFP, magnetite alteration |
| | | 82 | 86 | 87 | 88 | | quartz-sericite overprint of the same QFP |
| | | 125 | | 132 | 133 | | sheeted quartz-magnetite veins grading to breccia |
| | | 290 | 291 | 296 | 305 | 308 | sheeted quartz-magnetite veins grading to breccia |
| | | 296 | 317 | | | | chlorite-sericite overprint on the quartz-magnetite alteration QFP |
| | | 351 | 352 | 353 | 363 | | Bonanza volcanics intense magnetite-actinolite/biotite/chlorite alteration, quartz veins with chalcopyrite |
| | | 384 | 391 | 399 | 426 | | fine grained volcanics, magnetic |
| | | 488 | 587 | 589 | | | late zeolite-calcite veinlets overprinting volcanics |
| | | 551 | 543 | 559 | | | magnetite only veinlet in volcanics |
| | | 680 | | | | | late QFP dyklet with zeolite alteration in volcanics |
| | | 740 | | | | | zeolite alteration |
| | | 731 | 732 | 733 | 745 | | relatively fresh looking volcanics, mafic phenocrysts still visible but probably has pervasive actinolite-magnetite alteration |
| | | 816 | | | | | green pebble dyke/ breccia, matrix contains sulphides pyrite- chalcopyrite ?, quartz and tuffaceous clasts |
| | | 841 | 846 | | | | propylitically altered volcanics, disseminated and fracture controlled pyrite- calcite-epidote -chlorite |
| | | | | | | | |
| | D-75 | 20 | 24 | 25 | | | QFP with chlorite-magnetite alteration with a sericite- pyrite- clay overprint |
| | | 60 | 119 | | | | watery grey quartz veins in volcanics |
| | | 46 | | | 51 | | intensely altered volcanic, actinolite/chlorite-magnetite-albite alteration with sericite-pyrite overprint |
| | | 166 | | | | | intensely altered volcanics , clottyactinolite/chlorite-magnetite-albite alteration with sericite- pyrite overprint, watery quartz vein |
| | | 148 | | | | | quartz-magnetite veinlet |
| | | 149 | | | | | pyrite overprint and/or reopening of a quartz-magnetite veinlet |
| | | 187 | | | | | intense magnetite-actinolite alteration of volcanics with a cross cutting quartz vein |
| | | 192 | | | | | green pebble dyke |
| | | 225 | 227 | 230 | | | intense magnetite-actinolite alteration with abundant cross cutting magnetite-quartz and quartz veins |
| | | 458 | | | | | volcanics , disseminated magnetite and quartz veins with pervasive chlorite after actinolite or biotite |
| | | 517 | 520 | 527 | | | pervasive magnetite-biotite alteration, probably at least partially chloritized, some chalcopyrite mineralization |
| | | 591 | | | | | intense sericite- pyrite overprint |
| | | 596 | | | | | pervasive magnetite-actinolite with ghosty early quartz veins |
| | | 705 | | | | | pervasive biotite-magnetite with quartz-magnetite veinlets in volcanics with late calcite-zeolite veins/stockwork |
| | | 860 | | | | | fine grained volcanics , phenocrysts preserved, pervasive magnetite-biotite/actinolite? with ghosty quartz-magnetite veins, sulphides present |
| | | 890 | 930 | | | | coarse magnetite veinlet |
| | | 1020 | | | | | intense zeolite stockwork, rock is highly fractured |
| | | 1050 | | | | | fine grained volcanics with numerous planar magnetite veinlets |
| | | | | | | | |
| | D-77 | 16 | 24 | | | | intense pyrite-calcite overprint on volcanics |
| | | 16 | | | | | QFP or pebble dyke |
| | | | | | | | |
| | | 226 | 230 | 235 | | | QFP dykelet, intra to late mineral, has watery quartz veins with molybdenite, disseminated pyrite-chalcopyrite in groundmass |
| | | 250 | | | | | QFP with zeolite overprint |
| | | 260 | 265 | | | | disseminated magnetite in QFP with watery grey quartz veins |
| | | 285 | 320 | | | | QFP, sericite- pyrite-clay overprint the quartz-magnetite alteration, concentrated along fractures |
| | | 292 | | | | | relatively fresh QFP, primary K-feldspar in groundmass, intra mineral QFP |
| | | 333 | | | | | sericite- pyrite-quartz overprint of QFP, overprinted again by zeolite alteration |
| | | 575 | | | | | QFP with minor disseminated magnetite and pink primary K-feldspar in the groundmass, some salmon pink zeolite overprinting |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | 652 | | | | | same as above, note small fine grained clasts |
| | | 734 | | | | | textural change in the QFP, the quartz and plagioclase phenocrysts are smaller, higher proportion of pink K-feldspar matrix |
| | | 889 | 891 | | | | same QFP, some silicification |
| | | | | | | | |
| | D-152 | 20 | 25 | | | | QFP, intensely silicified matrix, chlorite alteration, disseminated sulphides, with surface weathering |
| | | 46 | | | | | intense quartz-chlorite, obliterates protolith-probably volcanic |
| | | 81 | 97 | 92 | | | volcanics grading into a pebble dyke texture with quartz vein clasts |
| | | 115 | | | | | QFP with sericite overprint |
| | | 152 | | | | | volcanic and quartz veins nearly a marginal breccia texture |
| | | 232 | | | | | quartz-se overprint on breccia |
| | | 240 | | | | | quartz-magnetite veins cross cutting another |
| | | 245 | | | | | pebble dyke/ marginal breccia |
| | | 252 | | | | | volcanic with quartz-magnetite-actinolite alteration |
| | | | | | | | |
| | D-153 | 25 | | | | | fine grained magnetite-actinolite altered volcanics |
| | | 31 | 32 | 33 | | | classic green pebble dyke, chlorite-pyrite matrix and quartz clasts |
| | | 71 | 83 | | | | propylitically altered volcanics, variable disseminated mt |
| | | 172 | | | | | volcanic, albite/quartz matrix, chlorite clots |
| | | 385 | | | | | volcanic, albite/quartz matrix, chlorite clots |
| | | | | | | | |
| | D-154 | 201 | 202 | | | | contact between quartz-magnetite altered volcanics and a green QFP with marginal breccia developed on sides, dyke is 5 metres wide |
| | | | | | | | |
| | D-157 | 14 | 16 | 17 | 21 | | actinolite-magnetite volcanic, watery quartz vein |
| | | 36 | | | | | watery quartz vein, some chalcopyrite on fractures |
| | | 42 | | | | | actinolite-magnetite volcanic, watery quartz vein |
| | | 69 | 70 | 72 | 81 | | old QFP, with quartz-magnetite-albite? vein and watery laminated quartz veins |
| | | 88 | 93 | | | | intense sericite overprint of QFP |
| | | 131 | | | | | QFP sericite-chlorite alteration, with an sericite-clay overprint, planar grey quartz with molybdenite down the center |
| | | 264 | | | | | contact between two phases of QFP, the older phase has coarse eyes and an intense silicification of the groundmass, the younger slightly finer grained phase has more intense sericite alteration of plagioclase phenocrysts |
| | | 340 | 391 | 400 | | | intense quartz-magnetite alteration of older QFP, sheeted quartz-magnetite veins cross cut by a watery quartz vein |
| | | 467 | 472 | | | | magnetite-actinolite altered volcanic |
| | | 472.5 | | | | | contact between volcanic and old QFP?? |
| | | 473 | | | | | QFP, oldest phase? |
| | | 522 | | | | | contact between volcanic and intra-mineral QFP |
| | | 529 | | | | | intense sericite alteration on QFP, cannot tell which phase |
| | | 555 | | | | | intra-mineral QFP, quartz-magnetite veins are still present but it lacks the intense quartz-magnetite alteration characteristic of the older phase |
| | | 640 | | | | | relatively fresh intra-mineral QFP, groundmass is still primary pinkish K-feldspar |
| | | | | | | | |
| | D-159 | 37 | 42 | 43 | | | fragmental volcanics with clotty chlorite alteration, possibly disseminated magnetite in groundmass |
| | | 102 | | | | | volcanics with abundant disseminated magnetite, chlorite clots and groundmass albite/quartz? alteration, pyrite on fractures |
| | | 220 | | | | | similar, with magnetite veinlets, cut by later calcite veins |
| | | 315 | | | | | similar volcanics with an overprint of zeolite-calcite, possibly overprinting pervasive chlorite-sericite alteration |
| | | 350 | 352 | 355 | | | first appearance of watery grey quartz veins in volcanics, followed by a sharp contact with an intra-late mineral QFP |
| | | 383 | 388 | 403 | | | sericite-pyrite alteration on QFP, possibly addition of quartz as well |
| | | 412 | | | | | pink primary K-feldspar and a zeolite overprint, weak quartz magnetite alteration |
| | | 442 | 445 | | | | sericite alteration, watery quartz veins |
| | | | | | | | |
| | D-163 | 92 | | | | | intensely zeolite altered volcanics? |
| | | 125 | | | | | volcanics, silicified matrix, chlorite clots, pyrite-chalcopyrite? present, zeolite overprint |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | 168 | 202 | | | | pink watery quartz veins, sericite alteration is common around them |
| | | 210 | | | | | intense quartz-zeolite alteration, quartz vein |
| | | 240 | | | | | may be oldest QFP, dark green, very large quartz eyes |
| | | 310 | | | | | sulphides in quartz veins, disseminated magnetite in eyes, sericitic alteration |
| | | | | | | | |
| | C-157 | 210 | 215 | | | | fragmental volcanics, ablite/quartz groundmass, chlorite clots |
| | | 315 | | | | | similar, with disseminated sulphides, variable fragmental component |
| | | 565 | 612 | | | | watery grey quartz veins in the same type of chlorite-albite altered volcanic |
| | | 620 | | | | | green QFP, old phase? |
| | | 824 | 845 | 840 | | | oldest QFP, intense sericite-chlorite alteration |
| | | 852 | 870 | | | | sheeted quartz-magnetite veins in old phase of QFP |
| | | 1008 | 990 | 985 | 1045 | 1050 | sheeted quartz-magnetite veins in old phase of QFP |
| | | 1060 | | | | | sericite overprint on quartz-magnetite altered QFP |
| | | 1270 | | | | | magnetite-quartz alteration in QFP?? |
| | | 1397 | | | | | magnetite-quartz alteration in QFP?? |
| | | | | | | | |
| SECTION 155 W | | | | | | | |
| | D-72 | 37 | 39 | 74 | | | clotty volcanics, matrix is either albitized or silicified, with chloritic clots |
| | | 88 | 84 | | | | similar with disseminated and veinlet magnetite |
| | | 97 | | | | | sericite- pyrite overprint on previous alteration |
| | | 140 | | | | | volcanics , possibly chlorite after pervasive biotite |
| | | 174 | | | | | magnetite-quartz veinlets in magnetite-actinolite/chlorite altered volcanics |
| | | 238 | | | | | clotty albite/quartz-chlorite with a weak pyrite overprint |
| | | 281 | | | | | porphyritic volcanics with disseminated magnetite and probably with pervasive actinolite/chlorite alteration |
| | | 372 | | | | | intense sericite- pyrite- clay overprint of porphyritic volcanics |
| | | 392 | 397 | | | | magnetite-chlorite/actinolite-albite alteration of volcanics |
| | | 452 | 457 | | | | green pebble dyke with definite QFP fragments, do not know which phase of QFP |
| | | | | | | | |
| | D-79 | 25 | 30 | 35 | | | intense pervasive and fracture controlled epidote pyrite-hematite alteration of volcanics with an overprinting calcite-zeolite stockwork |
| | | 71 | | | | | less intense propylitic alteration, confined to fractures, disseminated magnetite in groundmass |
| | | 116 | 127 | 137 | | | heterogenous fragmental volcanic, possibly a precusor to the clotty chlorite-albite /quartz altered volcanics |
| | | 140 | | | | | sericite- clay-pyrite alteration around a fracture, overprinting sericite- chlorite-epidote |
| | | 178 | | | | | propylitic alteration of volcanic |
| | | 182 | | | | | hole ends in a maroon volcanic unit with calcite veins |
| | | | | | | | |
| | D-187 | 25 | | | | | fine grained fragmental-tuffaceous volcanics with chlorite-pyrite alteration pervasive and in veinlets |
| | | 30 | | | | | intense albitic alteration, quartz veins appear to pre-date the albite, which is in turn overprinted by sericite-chlorite |
| | | 45 | | | | | quartz-magnetite veins, pervasive biotite alteration in volcanics |
| | | 66 | | | | | albite-chlorite overprinting the biotite |
| | | 163 | | | | | relict pervasive biotite alteration in volcanics |
| | | 230 | 231 | | | | chilled QFP in sharp contact with the volcanics, siliceous groundmass |
| | | 235 | 240 | 245 | | | usual coarse QFP, with large quartz eyes, albitized groundmass with a zeolite overprint, minor quartz veins present, lower contact with volcanics is also chilled |
| | | 263 | | | | | volcanic with chlorite-sericite alteration and a quartz stockwork |
| | | 343 | | | | | volcanics were probably pervasively biotite altered at one time, now with a sericite-chlorite overprint, watery quartz veins contain scattered blebs of chalcopyrite-pyrite |
| | | 357 | | | | | QFP dykelet with intense sericite alteration and watery quartz veins with pyrite-molybdenite ?-chalcopyrite |
| | | 415 | | | | | zone of pure pink-grey quartz ("quartzalite" in mine terminology), often occurs adjacent to contacts with intermediate QFP |
| | | 421 | 424 | | | | intra-mineral QFP, pink primary K-feldspar in groundmass, lower contact to volcanics is ambiguous, gradational over 30 cm |
| | | 475 | | | | | volcanic with a chlorite overprint, possibly on pervasive biotite, quartz veins |
| | D-188 | 47 | | | | | fine grained fragmental volcanics with intense pervasive epidote -sericite alteration |
| | | 66 | | | | | intense pervasive epidote alteration with calcite-sphalerite? veinlets and euhedral pyrite |

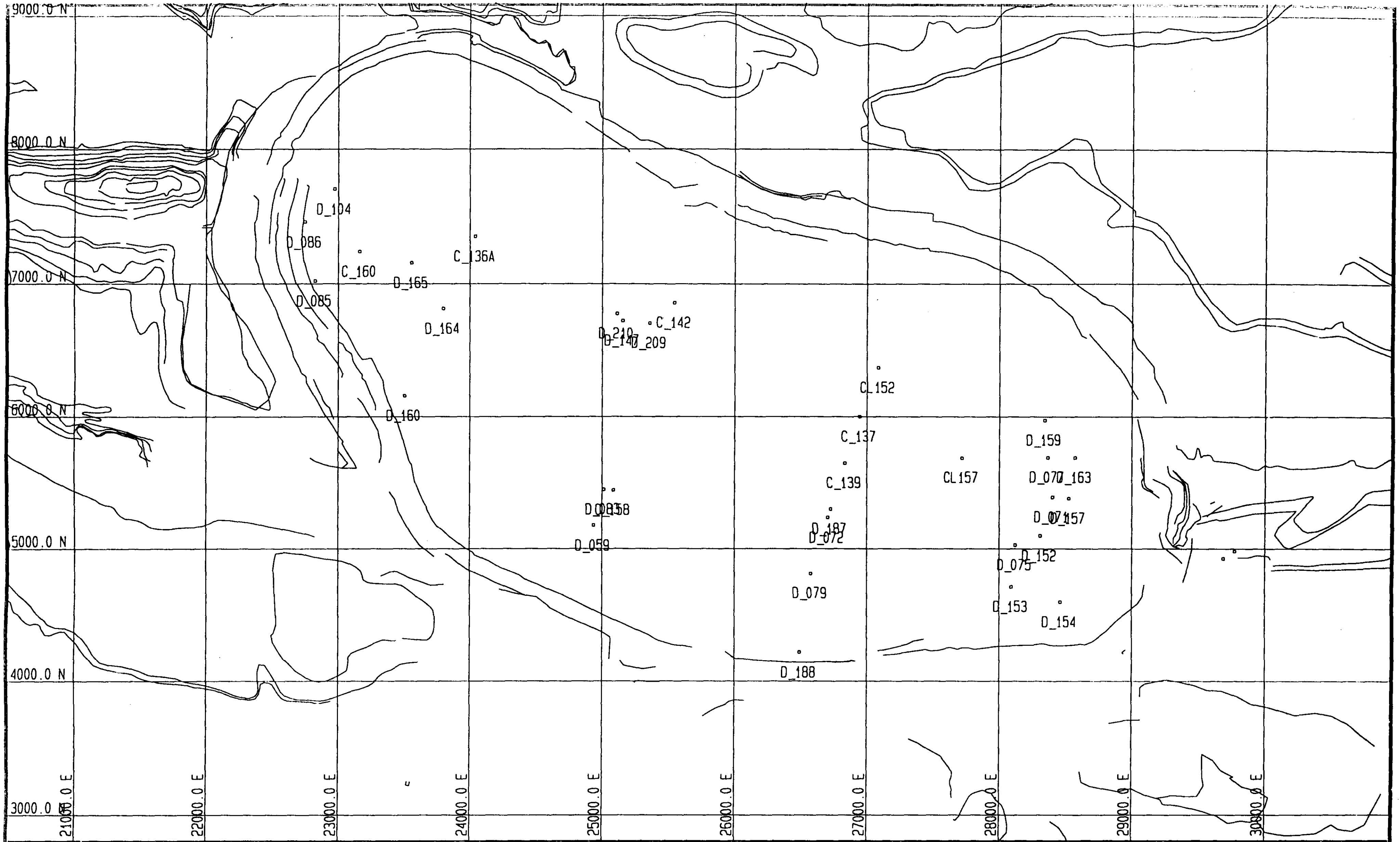
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | 114 | | | | | fine grained volcanics, pervasive epidote , calcite-hematite veinlets, hematite is common in epidotized volcanics peripheral to the porphyry system |
| | | 122 | | | | | a maroon, slightly porphyritic volcanic (flow?), 32 feet thick in core |
| | | 159 | | | | | fine grained volcanics, pervasive epidote , euhedral pyrite |
| | | 258 | | | | | End Creek Fault |
| | | 278 | 281 | | | | reddish coloured fine grained plagioclase-porphyritic rock, not a QFP, lacks the quartz eyes, abundant disseminated pyrite |
| | | 297 | 296 | 291 | | | same porphyritic rock, feldspars (plagioclase) are clay-sericite altered, groundmass is either silicified or sericite altered, highly variable over a short distance |
| | | 330 | 337 | | | | same porphyritic rock, either a dyke or a flow, not a QFP |
| | | 350 | | | | | fragmental volcanic with hematite and epidote alteration and abundant disseminated |
| | | 401 | | | | | maroon volcanic, 27 feet thick in core |
| | | 429 | | | | | green fragmental volcanic, epidote alteration |
| | | 532 | | | | | more homogenous volcanic, abundant disseminated pyrite |
| | | 661 | | | | | sericite-chlorite alteration of same volcanics |
| | | | | | | | |
| | C-137 | | | | | | old core, much missing |
| | | 230 | | | | | intense sericite-clay-pyrite alteration of QFP, quartz stockwork still visible, phase uncertain |
| | | 352 | 370 | 395 | 400 | 405 | chlorite-sericite-pyrite alteration on volcanics with quartz veins |
| | | 542 | 563 | 566 | | | chlorite-sericite-pyrite alteration on volcanics with quartz veins |
| | | | | | | | |
| | C-139 | | | | | | old core, much missing |
| | | 325 | 330 | | | | intensely sericite-clay altered QFP? with quartz veins, protolith unidentifiable |
| | | 370 | 374 | | | | fine grained volcanics with siliceous or albitized groundmass, clots of chlorite and disseminated magnetite?? |
| | | 432 | 440 | | | | sericite-clay alteration of volcanics, overprinting albite-chlorite |
| | | 855 | 860 | 865 | | | old QFP, large quartz eyes, sheeted quartz-magnetite veins |
| | | 1189 | 1200 | 1205 | | | intra-late? mineral QFP, weak alteration |
| | | 1430 | | | | | chloritized volcanics with calcite-zeolite stockwork |
| | | | | | | | |
| | C-152 | | | | | | old core, much missing |
| | | 469 | 470 | | | | fine grained volcanics with pervasive magnetite-ac/chlorite alteration, late pyrite fractures |
| | | 645 | 650 | 662 | | | possibly quartz-magnetite-actinolite alteration of volcanics, quartz veins |
| | | 684 | 690 | | | | quartz-actinolte-magnetite alteration of fine grained volcanics |
| | | 824 | 826 | | | | grey massive quartz, "quartzalite" |
| | | 1130 | 1140 | | | | old QFP sericite-chlorite alteration |
| | | | | | | | |
| SECTION 171 W | | | | | | | |
| | D-59 | 26 | | | | | volcanics, peripheral propyllitic alteration, chlorite-epidote -calcite with cross cutting zeolite-calcite veins |
| | | 52 | | | | | pervasive chlorite-epidote alteration with disseminated pyrite and calcite veins |
| | | 104 | | | | | intense pervasive epidote sericite-pyrite alteration of volcanics |
| | | 245 | | | | | "Yellow Dog" Fe-carbonate-dolomite-hematite alteration overprinting propyllitic alteration, dolomite in groundmass, calcite and Fe-carbonate in veinlets-stockworks |
| | | 280 | | | | | fine grained volcanics with chlorite-epidote alteration |
| | | 290 | 295 | | | | fine grained volcanics with chlorite-epidote calcite alteration |
| | | | | | | | |
| | D-83 | 25 | 30 | | | | fine grained dark grey volcanic, overprinted with sericite- pyrite and abundant calcite |
| | | 60 | 70 | | | | volcanic, dark grey chlorite-sericte-quartz altered matrix, chlorite-pyrite clots and calcite veins |
| | | 98 | | | | | sericite- pyrite overprint on same clotty volcanic |
| | | 150 | | | | | volcanic, fine grained, epidote chlorite-se-calcite alteration |
| | | 182 | | | | | matrix quartz-sericite- albite?? with chlorite-pyrite clots |
| | | 235 | | | | | "Yellow Dog" dolomite-calcite-Fe-carbonate overprint on fine grained volcanic, |
| | | 278 | | | | | intense sericite-pyrite overprint on volcanics |
| | | 281 | | | | | "Yellow Dog" dolomite-calcite-Fe-carbonate overprinting intense sericite altered fine grained volcanics |
| | | 357 | | | | | "Yellow Dog" dolomite-calcite-Fe-carbonate alteration of volcanics, crackle veinlets of calcite and Fe-carbonate |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | 407 | | | | | "Yellow Dog" dolomite-calcite-Fe-carbonate alteration of possibly previously magnetite-quartz altered volcanics, quartz vein may be relicts of this stage |
| | | 484 | | | | | sericite- chlorite-pyrite altered volcanics with calcite veins |
| | | 592 | | | | | sericite- chlorite alteration with dolomite overprint |
| | | 759 | | | | | fine grained volcanic, pervasive biotite alteration with a chlorite overprint, magnetite-albite quartz-chalcopyrite-pyrite veinlets and disseminated pyrite-chalcopyrite |
| | | 783 | | | | | biotite alteration spreading from a vein overprinting actinolite alteration, pervasive sericite overprint and late calcite veinlets |
| | | 812 | | | | | strong dolomite-carbonate-sericite overprint of volcanics |
| | | 846 | | | | | pervasive actinolite-magnetite overprinted by chlorite-pyrite, relict magnetite-albite veins |
| | | 865 | | | | | biotite-sulphide overprint in actinolite-magnetite alteration, weak sericite- pyrite overprint as well |
| | | | | | | | |
| | D-147 | 40 | | | | | intra-mineral QFP, pink K-feldspar matrix, some magnetite veinlets and inclusions of older QFP with sheeted quartz-magnetite veins, variable zeolite overprint |
| | | 84 | 92 | | | | older QFP with quartz-magnetite veins, rare inclusion in younger QFP |
| | | 181 | | | | | intra-mineral QFP, minor magnetite-quartz veins present, magnetite disseminated in groundmass locally, molybdenite on slip surfaces |
| | | 232 | | | | | fresh intra-mineral QFP, molybdenite on slip surfaces |
| | | 258 | 276 | | | | older quartz-magnetite altered QFP, contact between the two in faulted, crushed |
| | | 383 | | | | | QFP, possibly a slightly younger phase, it appears to be cutting a quartz-magnetite clast |
| | | 402 | | | | | pure quartz-magnetite with pyrite on fractures |
| | | 431 | 436 | | | | younger QFP in sharp contact with older phase, intense clay sericite alteration |
| | | 571 | | | | | intra-late? mineral QFP with a "Yellow Dog breccia" overprint, Fe-carbonate-dolomite alteration, veinlets form a crackle breccia texture, dolomite is also present in the |
| | | 623 | | | | | contact between volcanics and QFP is quartz veined and brecciated, and overprinted by the Yellow Dog alteration as well, textures are destroyed, this sample is volcanics only |
| | | | | | | | |
| | D-209 | 25 | 30 | | | | marginal breccia, chlorite (after actinolite?) altered volcanics and pervasive quartz-magnetite alteration, in sharp contact with a chilled QFP, quartz-magnetite alteration in the QFP in the first few cm, then QFP is totally non-magnetic |
| | | 52 | | | | | magnetite altered QFP, the magnetite may be due to partial assimilation of the volcanics |
| | | 62 | | | | | non-magnetic QFP with a quartz stockwork, this is an intermediate phase, not the one responsible for the earlier intense magnetite alteration, siliceous, chloritized mafics, disseminated sulphide, possibly some relict K-feldspar |
| | | 85 | | | | | QFP with some magnetite +/- quartz sheeted veins, some sulphide replacement of the magnetite |
| | | 176 | | | | | this is large body continuous body of porphyry, magnetite hairline veinlets are increasing in abundance, sericite alteration of the plagioclase phenocrysts , K-feldspar in groundmass is still fresh looking, groundmass is intensely silicified locally |
| | | 236 | | | | | intense quartz-sericite- clay overprint nearly obliterating the QFP texture, quartz-magnetite veinlets were not abundant here |
| | | 252 | | | | | alteration front or contact? intense sericite alteration in sharp contact with very fresh QFP, the texture of this QFP is slightly different then that previously occuring in this hole, it may be a younger phase, |
| | | 270 | | | | | examples of the QFP, there is more K-feldspar groundmass, fewer plagioclase phenocrysts than before, some biotite may still be unchloritized, there is a zeolite |
| | | 288 | | | | | inclusion? of older sericite- quartz altered QFP in fresh younger phase, x-cutting quartz-molybdenite vein |
| | | 305 | | | | | quartz-molybdenite vein |
| | | 345 | | | | | intense zeolite overprint, destroys the plagioclase, changes the texture of the QFP, quartz+-pyrite-chalcopyrite-molybdenite stockwork |
| | | 438 | | | | | intense silicification of QFP, quartz-molybdenite-pyrite+- chalcopyrite veins |
| | | 549 | | | | | localized intense sericite of matrix, quartz-molybdenite veins |
| | | 605 | | | | | sericite alteration possibly albite alteration of groundmass, some zeolite overprint , sulphides in quartz veins and disseminated |
| | | 642 | | | | | relatively fresh QFP |
| | | 662 | 670 | | | | faulted, brecciated contact between volcanics and QFP, interfingering |
| | | 689 | | | | | volcanic, intense actinolite-magnetite alteration, overprint by chlorite, sheeted quartz-magnetite veins, abundant later calcite veins, clast of QFP in one sample |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | C-142 | 250 | | | | | volcanics, clotty chlorite in a sericite- chlorite-quartz groundmass, disseminated pyrite |
| | | 470 | 500 | | | | Yellow Dog overprint in sericite- chlorite altered volcanics |
| | | 640 | | | | | sericite- chlorite alteration, quartz veins, sulphide on fractures, late calcite veinlets |
| | | | | | | | |
| | C158 | 200 | 201 | 206 | | | intense quartz-sericite-clay overprint of chlorite-sericite, quartz veins in volcanics |
| | | 266 | | | | | chlorite-pyrite clots in a sericite- chlorite-quartz groundmass, volcanics |
| | | 270 | | | | | intense silicification of the same volcanics |
| | | 400 | 403 | | | | textural variation of the volcanic, plagioclase-phyric, actinolite-magnetite? altered groundmass appears to be transitional back to the clotty chlorite altered volcanics |
| | | 470 | | | | | heterogenous, possisbly a fragmental volcanic, quartz-chlorite-sulphide clots with albite-K-feldspar? rims in a quartz-albite? altered matix |
| | | 780 | | | | | pervasive biotite alteration with quartz veins and disseminated sulphides |
| | | 782 | 907 | | | | an example of the uncommon quartz veins with a K-feldspar envelope, sericitic alteration and coarser sulphides |
| | | 1421 | | | | | Yellow Dog overprint on volcanics |
| | | 1480 | | | | | volcanic, actinolite-magnetite alteration, calcite-zeolite veins |
| | | 1530 | | | | | volcanic, actinolite-magnetite alteration, calcite-zeolite veins |
| | | | | | | | |
| SECTION 187 W | | | | | | | |
| | C-136A | 142 | | | | | silicified volcanic with chlorite clots |
| | | 495 | 515 | 563 | | | quartz-magnetite ? altered volcanic |
| | | 586 | | | | | old green QFP |
| | | 635 | | | | | volcanic |
| | | 829 | | | | | volcanic |
| | | | | | | | |
| | D-160 | 325 | | | | | volcanics, chloritized and intensely zeolite-calcite altered, some quartz vein fragments |
| | | 365 | | | | | contact with QFP, some quartz-magnetite alteration of QFP at the contact |
| | | 370 | 375 | | | | non-magnetic QFP dyke, sharp lower contact at 419 with intense sericite- clay alteration |
| | | 420 | | | | | chlorite-magnetite-quartz altered volcanics, cut by quartz-molybdenite veins |
| | | 467 | | | | | obliterating sericite- clay-pyrite overprint on quartz-magnetite altered volcanic |
| | | 469 | | | | | protolith to above alteration, intense quartz-magnetite , very little volcanic component, this is the beginning of a large body of marginal breccia |
| | | 566 | | | | | marginal breccia, dominantlysheeted and massive quartz-magnetite |
| | | 715 | | | | | marginal breccia with a higher proportion of volcanic rock than previous section |
| | | 768 | | | | | small QFP dykelet in sharp contact with pervasively biotite? altered volcanics |
| | | 827 | | | | | pervasive biotite-magnetite ? altered volcanics with disseminated chalcopyrite -pyrite |
| | | 892 | | | | | pervasive biotite-magnetite ? altered volcanics with disseminated chalcopyrite -pyrite |
| | | 980 | | | | | pervasive biotite-magnetite altered volcanics with disseminated chalcopyrite -pyrite and calcite-chalcopyrite veinlets, some quartz veins with irregular pervasive K-feldspar |
| | | 982 | | | | | pervasive biotite-magnetite altered volcanics with disseminated chalcopyrite -pyrite and calcite-chalcopyrite veinlets |
| | | | | | | | |
| | D-164 | 30 | | | | | intra or late mineral QFP, silicified or albitized?? groundmass, epidote pyrite alteration and intense pervasive zeolite alteration |
| | | 129 | 132 | 137 | | | intra or late mineral QFP, albitized groundmass with an intense pervasive zeolite overprint |
| | | 185 | 188 | | | | magnetite is disseminated in the groundmass locally, but is generally lacking in this QFP |
| | | 200 | | | | | molybdenite and chalcopyrite on a fracture surface |
| | | 224 | 227 | | | | intense clay alteration of a coarse QFP - possibly the older phase |
| | | 250 | 252 | | | | quartz-magnetite stockwork/breccia |
| | | 334 | 337 | | | | quartz-magnetite stockwork/breccia |
| | | 397 | | | | | QFP with quartz-magnetite stockwork |
| | | 476 | 481 | 479 | | | QFP with sheeted quartz-magnetite veins and partially digested inclusions of volcanic, pink colour due to primary K-feldspar |
| | | 530 | 536 | 542 | | | QFP with intense quartz-magnetite stockwork |
| | | 691 | 694 | 695 | | | pure quartz-magnetite , pyrite along fractures |
| | | 707 | | | | | End Creek Fault/ cuts off the orebody |
| | | 730 | | | | | volcanic with intense calcite-zeolite stockwork |
| | | 807 | | | | | volcanic with intense calcite-zeolite stockwork |
| | | 895 | 897 | | | | fragmental volcanic with chloritic alteration and pyrite veinlets |
| | | 915 | | | | | intense calcite-zeolite stockwork forming a crackle breccia in the volcanic |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | 966 | | | | | regional? propylitic alteration of volcanics, chloritic clots in an albitized matrix, disseminated magnetite?? |
| | | 1161 | | | | | volcanic with an aphanitic groundmass and rounded lapilli? of epidote chlorite-pyrite-calcite |
| | | | | | | | |
| SECTION 195 W | | | | | | | |
| | D-85 | 84 | 85 | 81 | | | pyrophyllite-dumortierite altered volcanics |
| | | 110 | 120 | | | | possible precusor to the pyrophyllite-dumortierite rock - a clotty chlorite-albite /quartz altered volcanic |
| | | 143 | 165 | | | | pyrophyllite-dumortierite altered volcanics |
| | | 265 | | | | | pyrophyllite-dumortierite altered breccia |
| | | 316 | | | | | possible precusor a clotty chlorite-albite /quartz altered volcanic |
| | | 396 | | | | | sericite overprint of pyrophyllite or chlorite stage |
| | | | | | | | |
| | D-86 | 35 | 40 | | | | pyrophyllite-dumortierite altered volcanics, some remnant chlorite |
| | | 96 | | | | | pyrophyllite-dumortierite alteration developed on a breccia, QFP and quartz vein clasts are visible |
| | | 184 | 189 | | | | precusor breccia, predates the pyrophyllite-dumortierite |
| | | 199 | | | | | intense sericite overprint, abundant quartz veining |
| | | 290 | 284 | 315 | | | quartz-sericite alteration on volcanics |
| | | 335 | | | | | sericite overprint on chlorite |
| | | 453 | | | | | intense sericite- pyrite-quartz alteration and gilsonite? - black mineral |
| | | 476 | 481 | | | | clotty volcanic, ab/quartz groundmass with chloritic clots |
| | | 535 | 545 | 548 | | | clotty volcanic, albitic rims on chlorite clots and along fractures |
| | | | | | | | |
| | D-104 | 88 | | | | | fine grained volcanics with clotty chlorite in a quartz-sericite- chlorite altered groundmass, minor epidote |
| | | 112 | | | | | similar, coarser chlorite clots with pale albitic? or sericitic rims |
| | | 117 | 135 | | | | sericite- pyrite overprint on the chlorite alteration |
| | | 185 | | | | | weaker sericite overprint, chlorite clots are still visible, groundmass is more siliceous, pyrite in fractures and clots |
| | | 355 | | | | | alternating quartz-sericite alteration and chlorite-sericite alteration in volcanics |
| | | 418 | | | | | sericite- chlorite alteration, chlorite veinlets, later zeolite-calcite-pyrite-chalcopyrite veinlets |
| | | 527 | | | | | fine grained volcanics, silicified, pervasive actinolite-magnetite? |
| | | 666 | | | | | pervasive biotite with a sericite overprint, quartz vein with a chlorite envelope and a quartz+magnetite? vein with no envelope |
| | | 727 | | | | | chlorite overprint on pervasive biotite, some vague groundmass replacement by quartz and possibly K-feldspar, disseminated and blebby sulphides |
| | | 767 | | | | | chlorite overprint on pervasive biotite, relict quartz-magnetite veins with albite envelope , disseminated sulphides |
| | | | | | | | |
| | C-160 | | | | | | old core, much missing |
| | | 127 | | | | | fine grained featureless volcanics with intense pyrophyllite-sericite alteration |
| | | 137 | | | | | intense pyrophyllite with some dumortierite |
| | | 430 | | | | | intense sericite- clay altered QFP, texture bearly recognizable, 10 m dyke |
| | | 450 | | | | | intensely silicified, chlorite altered volcanic, sulphide veinlets |
| | | 775 | 860 | | | | fine grained volcanic, chlorite-sericite alteration, possibly overprinting pervasive biotite, disseminated sulphides? |
| | | | | | | | |
| Miscellaneous | | | | | | | |
| | D-165 | 141 | | | | | late mineral? QFP, intense albite alteration of groundmass, coarse euhedral pyrite |
| | | 143 | 148 | 150 | | | igneous? breccia with propylitic alteration, volcanic clasts in a possilby igneous matrix, both with pyrite-epidote alteration |
| | | 167 | | | | | magnetite-rich, volcanic clast dominated marginal breccia |
| | | 287 | | | | | quartz-magnetite-actinolite stockwork in volcanic, possibly pervasive biotite alteration in the larger clasts |
| | | 331 | 335 | 360 | 349 | | intense zeolite-epidote overprint of the breccia, volcanic clasts dominant, rare QFP |
| | | 523 | 537 | | | | marginal breccia with more QFP clasts than further up the hole |
| | | 637 | | | | | sharp contact, intra-mineral QFP and breccia |
| | | 640 | | | | | the QFP is chilled the first 2m from the contact, minor quartz-magnetite veinlets are |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | 645 | | | | | the QFP grades into a coarse grained variety with large (1cm) quartz eyes, salmon pink colour is due to pervasive zeolite alteration |
| | | 660 | | | | | fresher QFP, pink colour is due to primary K-feldspar |
| | | 668 | 681 | 704 | | | sharp contact between intra-mineral QFP and older quartz-magnetite altered volcanics |
| | | 803 | 815 | | | | typical sheeted quartz-magnetite veins, comprise 90% or more of the rock |
| | | 830 | | | | | End Creek Fault cuts off the quartz-magnetite alteration |
| | | 857 | 862 | | | | volcanics with a stockwork of calcite-zeolite, generally highly fractured |
| | | 1020 | | | | | fine grained volcanics, less zeolite alteration, disseminated mag in matrix? |
| | | 1052 | | | | | propylitically altered volcanics, pyrite-epidote calcite-hematite, typical of propylitic alteration peripheral to the deposit |
| | | | | | | | |
| | D-210 | | | | | | very briefly logged to observe QFP/volcanic contacts and nature of QFP |
| | | 168 | | | | | fine grained volcanic, non-magnetic?? in sharp contact with fresh QFP, minor |
| | | 171 | 164 | 175 | | | examples of contact between rocks |
| | | 175 | | | | | QFP, fresh K-feldspar groundmass, chloritized biotite, large body of intra or late-mineral porphyry |
| | | 356 | 366 | | | | QFP, locally silicified, locally overprinted by zeolite, quartz-molybdenite -pyrite veins, same to end of drill hole |
| Bay Lake Zone | | | | | | | |
| | E-92 | | | | | | hole goes through over 600 feet of intensely calcite-zeolite altered volcanics |
| | | 660 | | | | | quartz stockwork increasing in intensely altered volcanics, clhorite/actinolite-magnetite with calcite-zeolite overprint |
| | | 701 | | | | | sheeted quartz-magnetite veins, K-feldspar? or zeolite in volcanics |
| | | 755 | | | | | sheeted quartz-magnetite veins, in chlorite/actinolite altered volcanics |
| | | 781 | 782 | 783 | | | sharp, but intensely zeolite altered and crumbly contact with QFP |
| | | 798 | | | | | very fresh QFP, primary K-feldspar matrix, weak zeolite overprint |
| | | 840 | | | | | same QFP with zeolites replacing plagioclase phenocrysts |
| | | 909 | | | | | QFP without the zeolites |
| | | 939 | 964 | | | | partially assimilated inclusion? this fine grained rock shows up sporadically in this QFP for less than 1 m intervals, in some cases quartz and plagioclase phenocrysts occur in it |
| | | 999 | | | | | QFP/volcanic contact |
| | | 1029 | | | | | actinolite-quartz-magnetite altered QFP, quartz-magnetite veins with intense zeolite |
| | | 1067 | | | | | actinolite-quartz-magnetite altered QFP, quartz-magnetite veins with intense zeolite |
| | | | | | | | |
| ** | Four matching suites of rocks were collected, two for BHP, one for MDRU at UBC and one for the BC Geological Survey, | | | | | | |
| | therefore multiple footages are listed for samples that were collected further than one foot apart. Each suite will only have | | | | | | |
| | one sample. | | | | | | |




BHP Minerals Canada Ltd.
P.O. Box 370
Port Hardy, BC
VON 3P0

DATE: 11/29/95 TIME: 11:21:40

SCALE (HOR) 1": 1000' SCALE (VERT) 1": 1000'

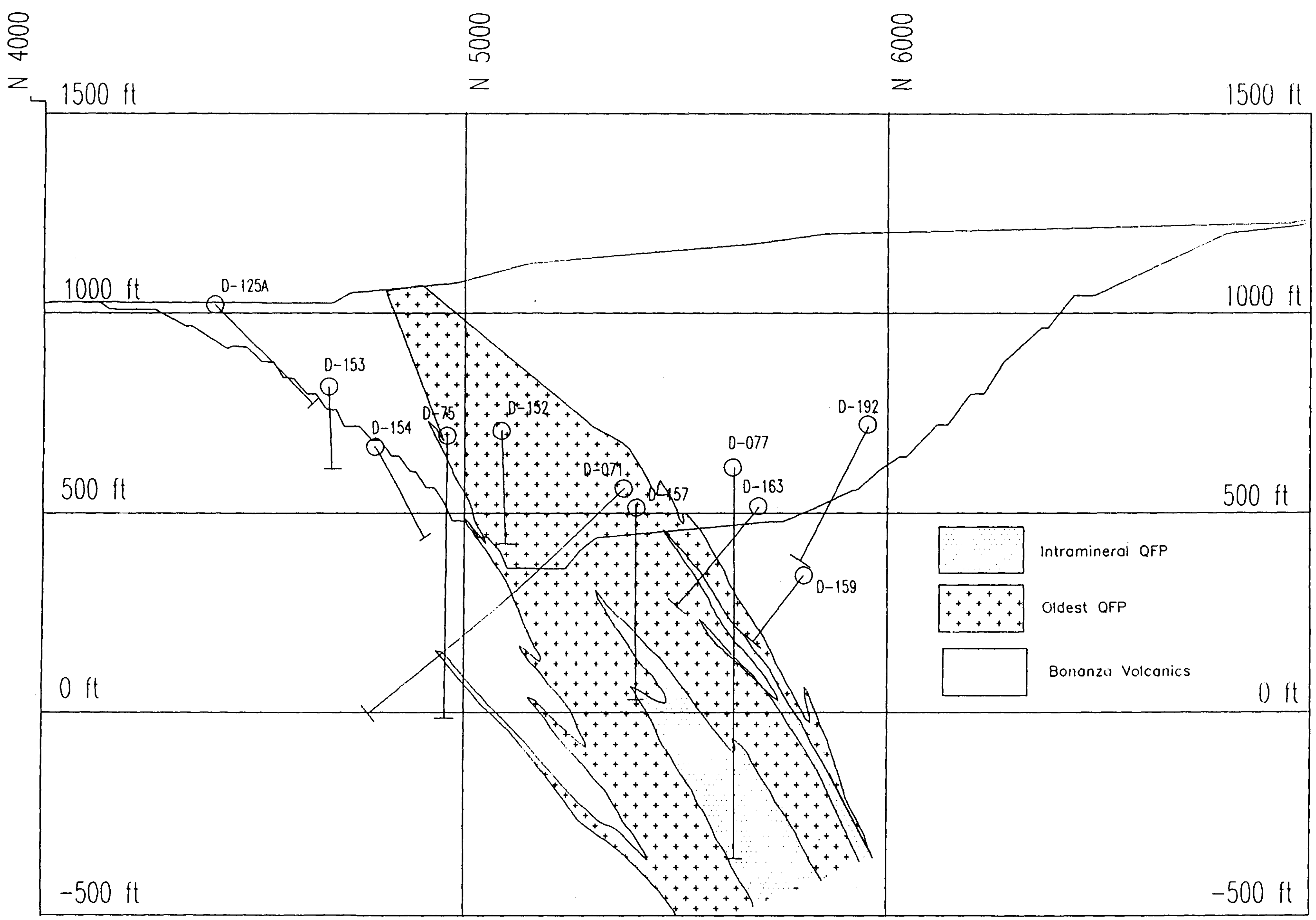
# ICM PIT CORE SAMPLING PROGRAM
## SAMPLED-HOLE LOCATIONS

Holes Sampled November 17-22, 1995

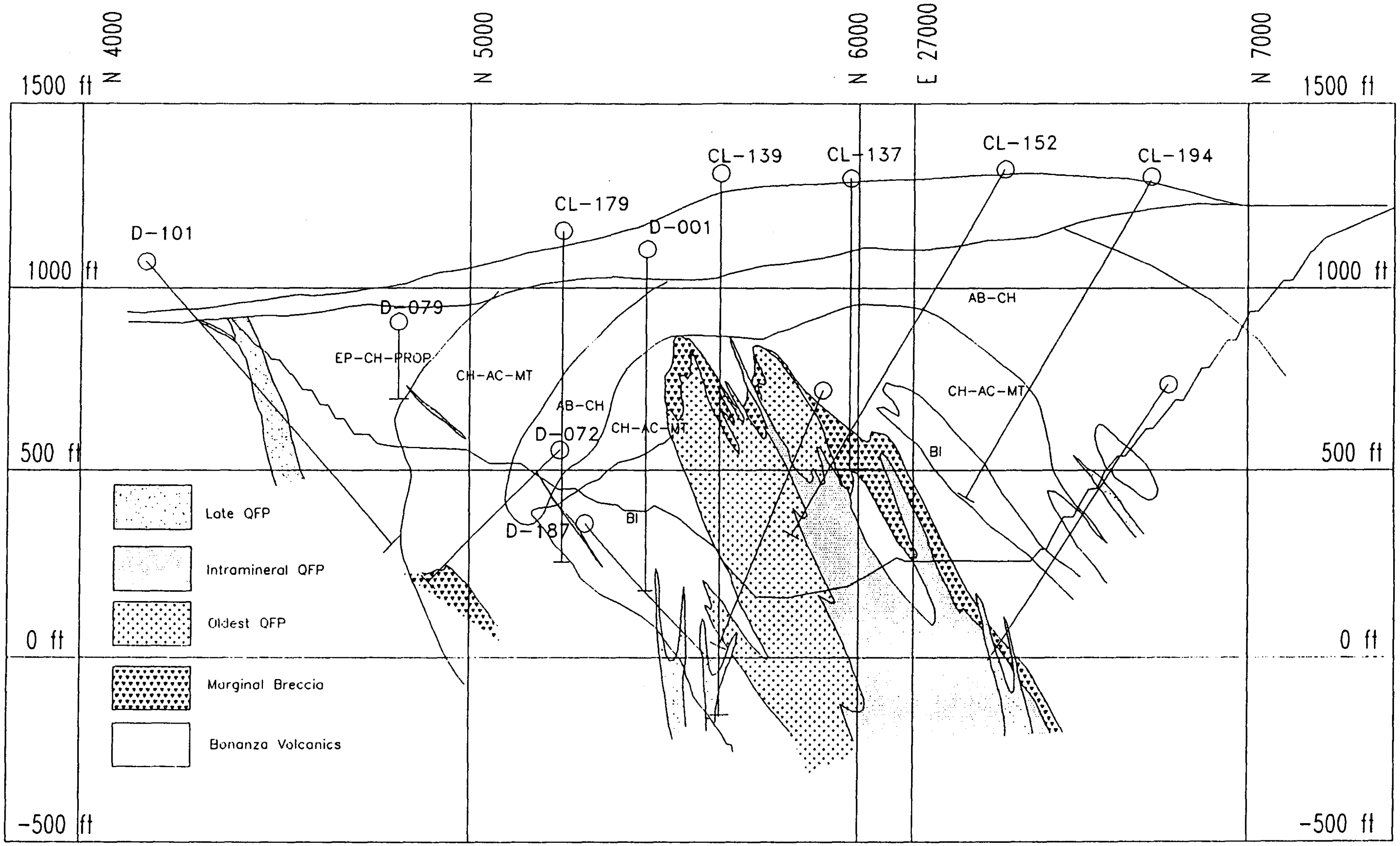
To Accompany Report by Kika Ross

Software by GEMCOM Services Inc.

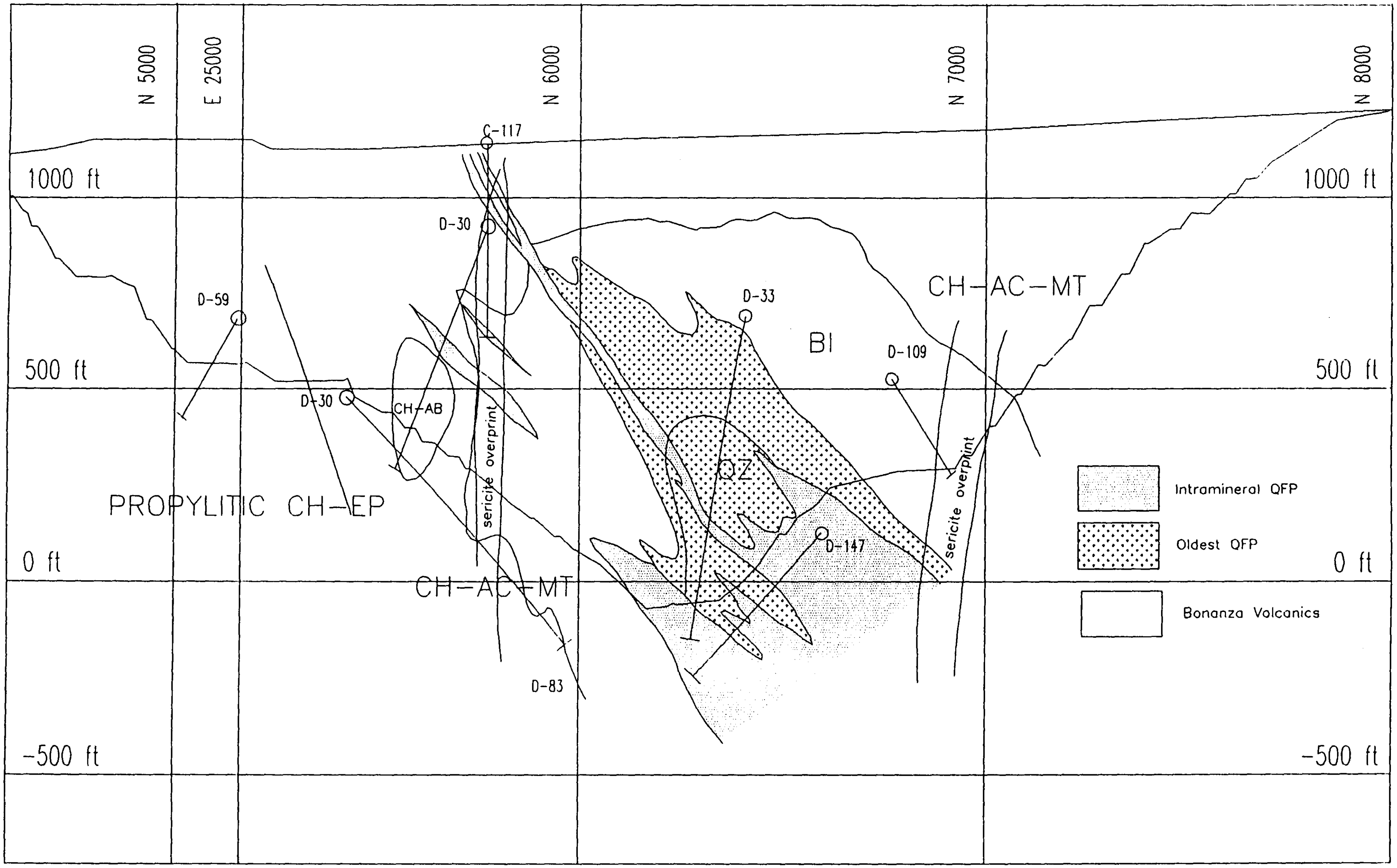
# Cross Section 139



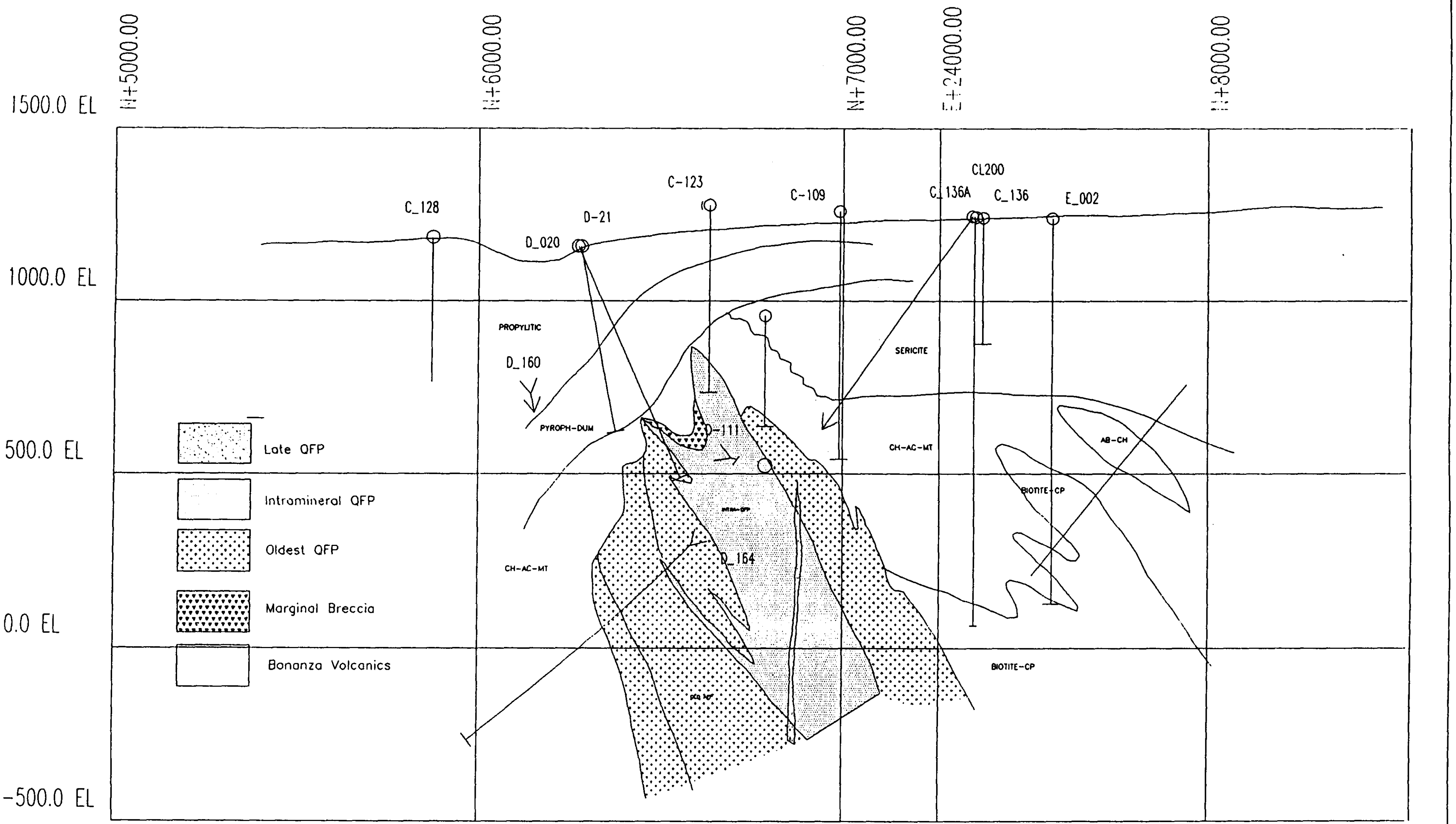
# Cross Section 155



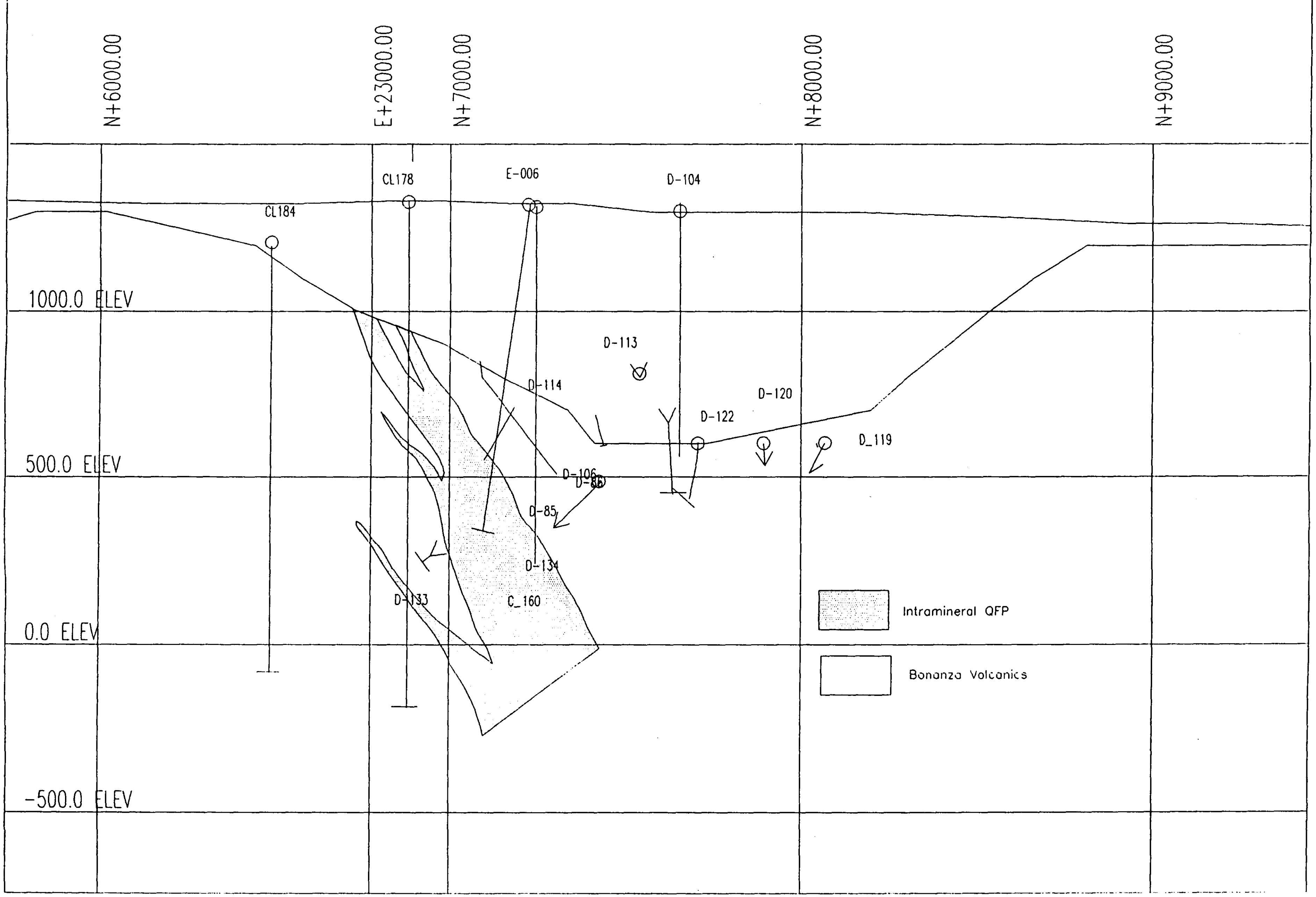
# Cross Section 171



# Cross Section 187



# Cross Section 195



# PORPHYRY COPPER-GOLD-MOLYBDENUM MINERALIZATION IN THE ISLAND COPPER CLUSTER, VANCOUVER ISLAND

**Perelló, J.A., and O'Kane, K.P., Minera BHP de Chile Inc., Av. Apoquindo 4499, 12th Floor, Las Condes, Santiago, Chile;**
**Fleming, J.A., Clarke, G.A., and Reeves, A.T., BHP Minerals Canada Ltd., Island Copper Mine, Box 370, Port Hardy, B.C., Canada V0N 2P0;**
**Burt, P.D., BHP Minerals Canada Ltd., Suite 610, 33 Young Street, Toronto, Ontario, Canada M5E 1G4;**
**Himes, M.D., Ok Tedi Mining Ltd., Dakon Road, P.O. Box 1, Tabubil, Western Province, Papua New Guinea**

## Introduction

The Island Copper Cluster (ICC; Figure 11), situated at the northern end of Vancouver Island, consists of five porphyry copper-gold-molybdenum systems genetically associated with stock and dike-like rhyodacitic porphyries of Jurassic age (approximately 180 ma) that intruded the island arc, calc-alkaline basalts, andesites and pyroclastic rocks of the comagmatic Bonanza Group. The systems (Island Copper; Bay Lake; G Zone; Red Island; and Rupert Inlet) are coincident with a series of northwest-trending magnetic highs and regional faults aligned for more than 10 km. They all share many similarities in the alteration-mineralization geometries but vary largely in size and grades. Copper-bearing skarn and vein-type mineralization also constitutes an integral part of the porphyry systems.

## Reserves and deposit geology

The only economic deposit of the cluster is the Island Copper mine controlled and operated by BHP Minerals Canada Ltd. The mine had initial estimated reserves of 257 million tonnes at 0.52% copper and 0.017% molybdenum at a 0.3% copper cutoff grade.

Mineralization at Island Copper is associated with multiphase rhyodacitic intrusions and hydrothermal breccia bodies (Figures 11 to 13). Available data suggest that the porphyry system evolved dynamically from an early, probably juvenile-dominated stage, to one strongly influenced by meteoric waters, as the main heat source cooled and further intrusion and brecciation took place. Three main stages of alteration and mineralization have been differentiated:

1. An Early Stage, related to the intrusion of a main rhyodacite porphyry, involved the development of four outwardly progressing zones: (a) a copper-barren stockworked core of quartz-amphibole-albite-magnetite-(apatite, scapolite); (b) a biotite-magnetite zone containing chalcopyrite, pyrite and molybdenite; (c) a chlorite zone containing pyrite and minor chalcopyrite and magnetite; and (d) an outermost epidote zone. All are found in Bonanza volcanic rocks except the quartz-amphibole-magnetite stockwork core which, in addition, formed along the margins of the rhyodacite porphyry. The biotite alteration, together with the main copper mineralization, partly overprinted the stockworked core. Preliminary fluid inclusion data indicate that the fluids associated with the iron-rich core of the system were hot (> 500°C) and saline (>50 equiv. weight per cent NaCl) consistent with a magmatic derivation. Mass balance calculations for these assemblages indicate gains of up to 450 per cent Fe and 42 per cent Na.

2. A structurally-controlled Intermediate Stage, superimposed upon the earlier assemblages, was related to the emplacement of quartz stockworks and hydrothermal breccias associated with the intrusion of intermineral rhyodacitic porphyry during the

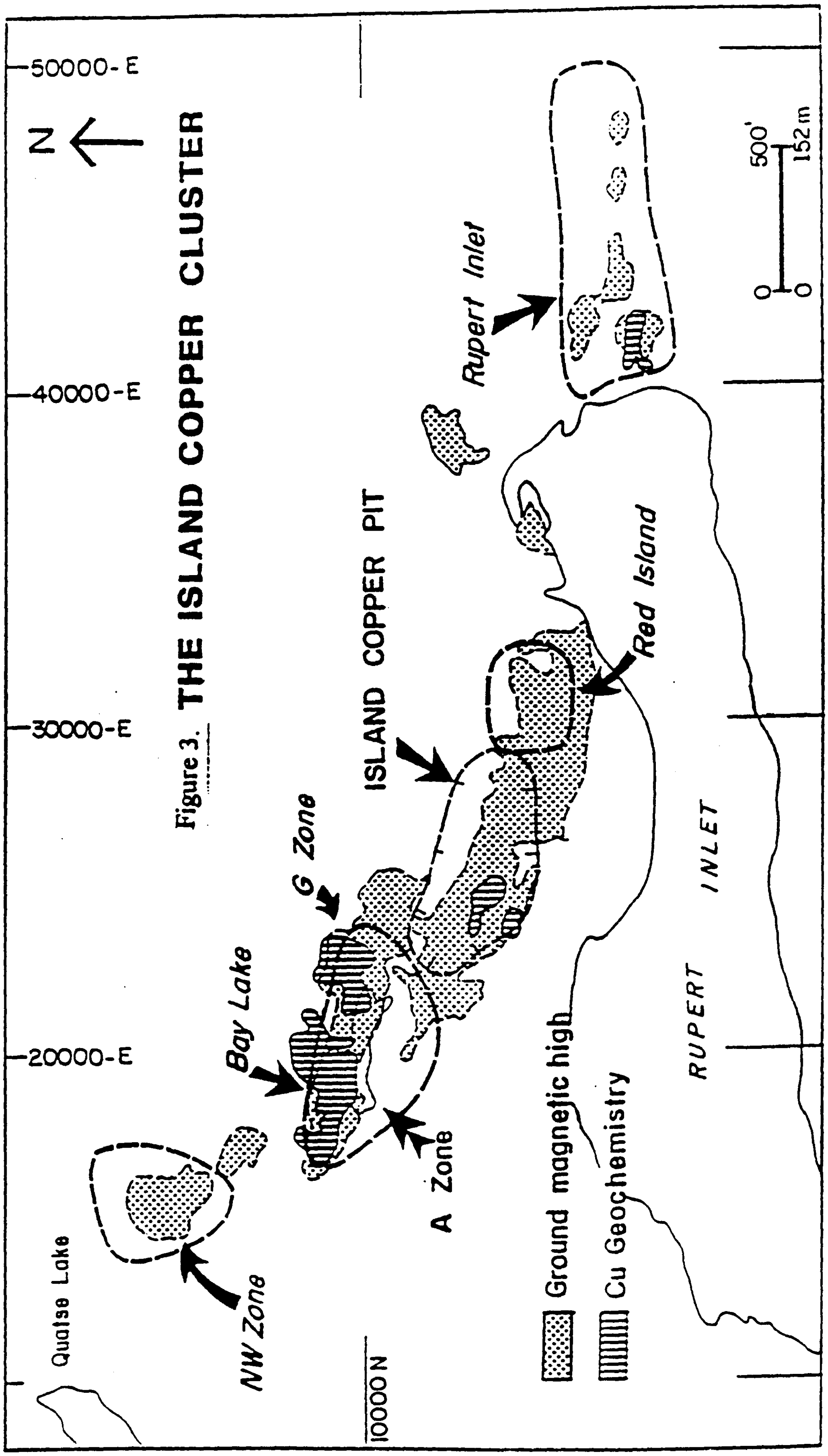



Figure 11. Tthe Island Copper cluster (ICC), nothern Vancouver Island.

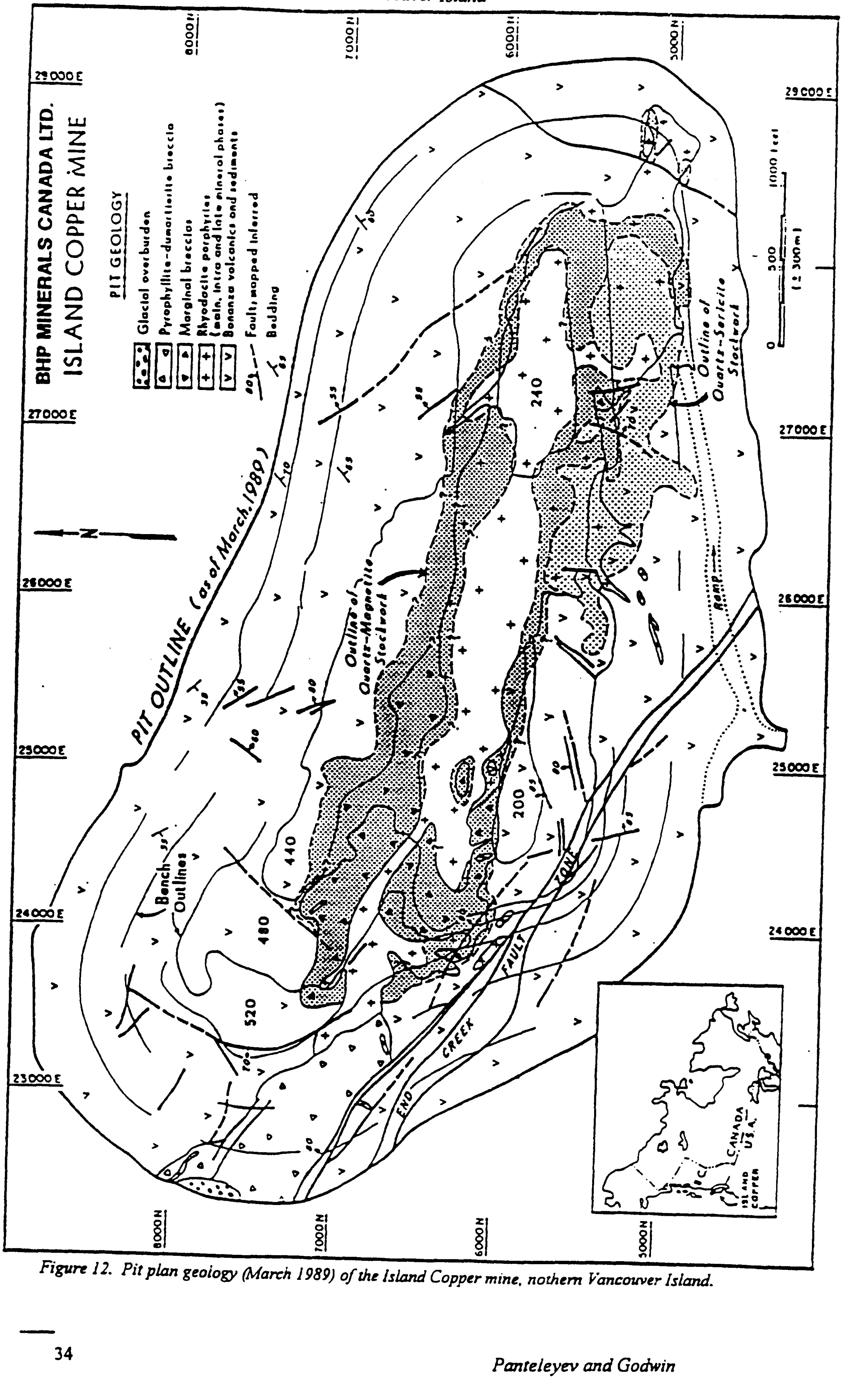



*Figure 12. Pit plan geology (March 1989) of the Island Copper mine, nothern Vancouver Island.*

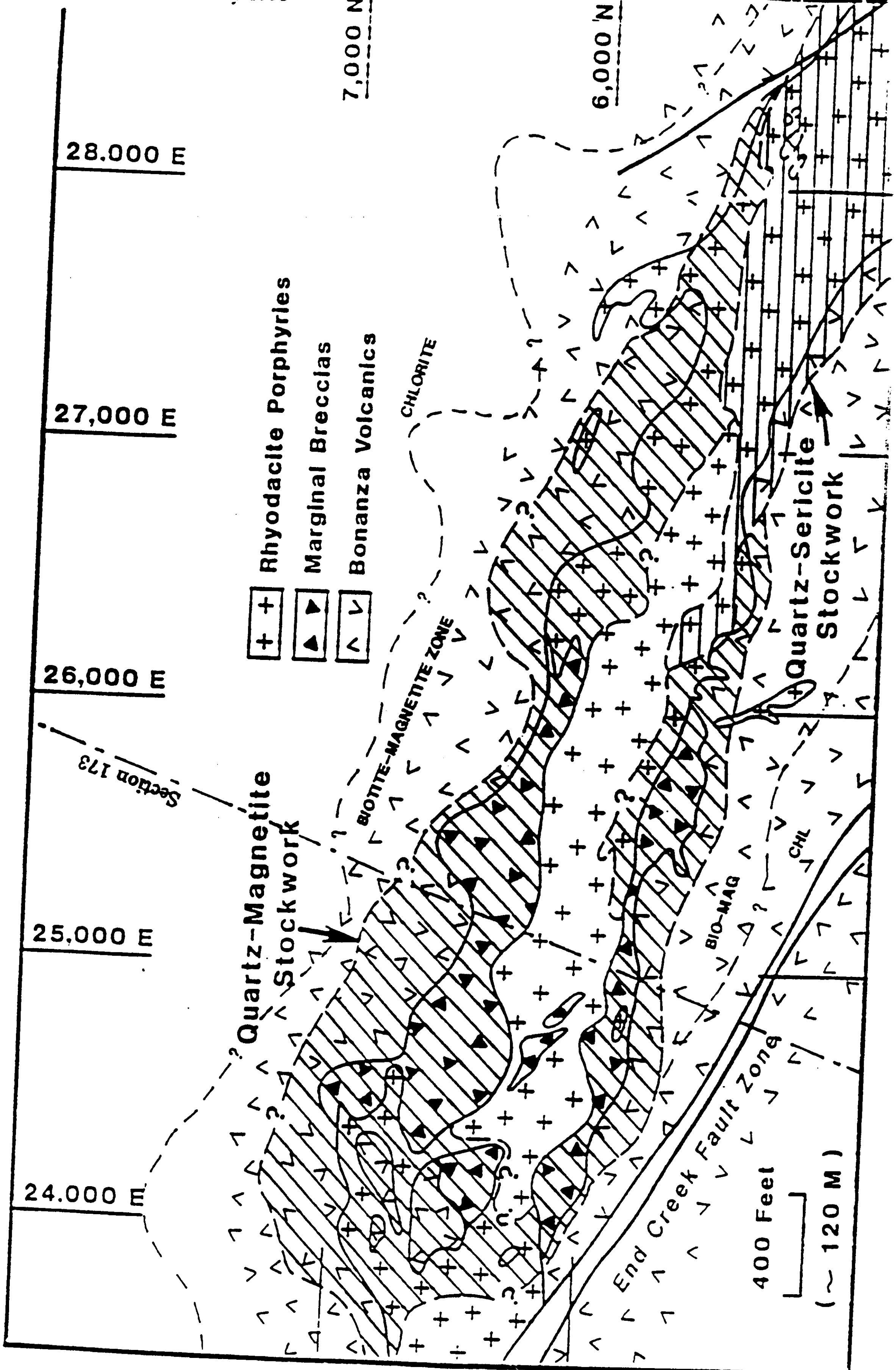



*Figure 13. Detailed geology of the 560 bench, Island Copper mine, northern Vancouver Island.*

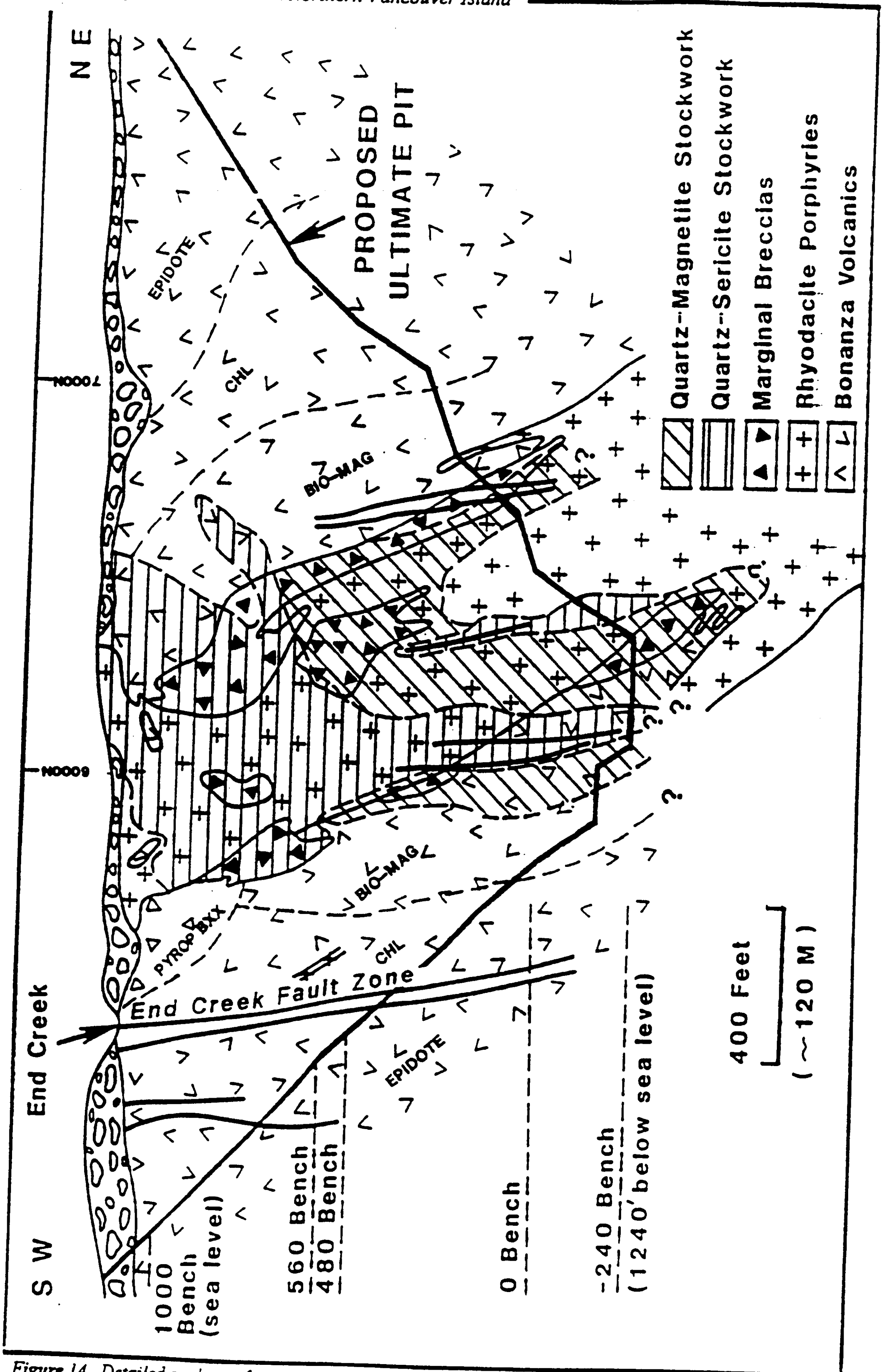



*Figure 14. Detailed geology of section 173 west, Island Copper mine, northern Vancouver Island.*

collapse of the hydrothermal system. Alteration was dominated by quartz-sericite and sericite-clay-chlorite (SCC) assemblages together with pyrite, chalcopyrite and molybdenite.

3. A Late Stage, related to the emplacement of the Pyrophyllite Breccia assisted by further late-mineral rhyodacitic intrusions, is characterized by a pyrite-bearing, copper-barren advanced argillic alteration assemblage of pyrophyllite, kaolinite, sericite and dumortierite. Further low temperature alteration episodes included ankerite-calcite veining, widespread zeolite development and the precipitation of remobilized carbon-bearing organic compounds.

## Mineralization

The bulk of the copper mineralization at Island Copper was introduced during the Early Stage in feldspar-stable, K-silicate conditions (see bench and section copper values in Figures 15 and 16). Copper mineralization was followed by a main episode of molybdenum in a feldspar-destructive, sericitic environment. All of the recovered copper occurs as chalcopyrite, predominantly hosted by biotite-altered Bonanza volcanic rocks. Similar alteration-mineralization geometries characterize the other members of the ICC although hydrothermal pyroxene is conspicuous in the quartz-amphibole-magnetite stockworked core at Bay Lake.

Gold production from Island Copper since production started in 1971 through to the end of 1993 is over 32 000 kilograms, and annually amounts to 1200 to 1500 kilograms. This renders Island Copper one of the largest current gold producers, and historically the seventh largest lode gold producer, in British Columbia. Historical average head-grade of the deposit is about 0.19 ppm gold but includes large volumes having assayed more than 0.40 ppm gold. Only about 50% of the gold is recovered in the copper concentrate, which has averaged about 24% copper, 7 ppm gold and 60 ppm silver.

The bulk of the gold was associated with Early Stage copper mineralization. Some gold seen to be associated with Intermediate Stage assemblages could have originally been introduced by this event or remobilized from earlier mineralization. Gold has been observed in the native form, as micron-sized inclusions in chalcopyrite, pyrite, molybdenite and silicates.

Certain features such as the positive correlation between gold and copper, the association of gold with the potassic, biotite-rich alteration, and the high content of magnetite in the system (> 8 vol. per cent) are characteristic of gold-rich porphyry copper deposits from elsewhere. The spatial arrangement of the ore zones (biotite-chalcopyrite around a copper-barren, quartz-magnetite core) is, however, considered to be unique among porphyry deposits, because copper-gold ore normally accompanies the quartz-magnetite stockwork veinlets (eg. Philippine porphyry deposits).

The copper-gold-molybdenum assemblage at Island Copper confirms that porphyry deposits cannot be exclusively divided into copper-gold and copper-molybdenum categories, but are rather part of a larger spectrum containing intermediate copper-gold-molybdenum examples that has copper, gold and molybdenum-only deposits as end members. Comparisons are also valid between the iron-rich, quartz-amphibole-magnetite-albite-(apatite, scapolite) stockworked core of the systems of the ICC, which at Bay Lake contains additional pyroxene, and the iron ore mineralization of the Kiruna-type.

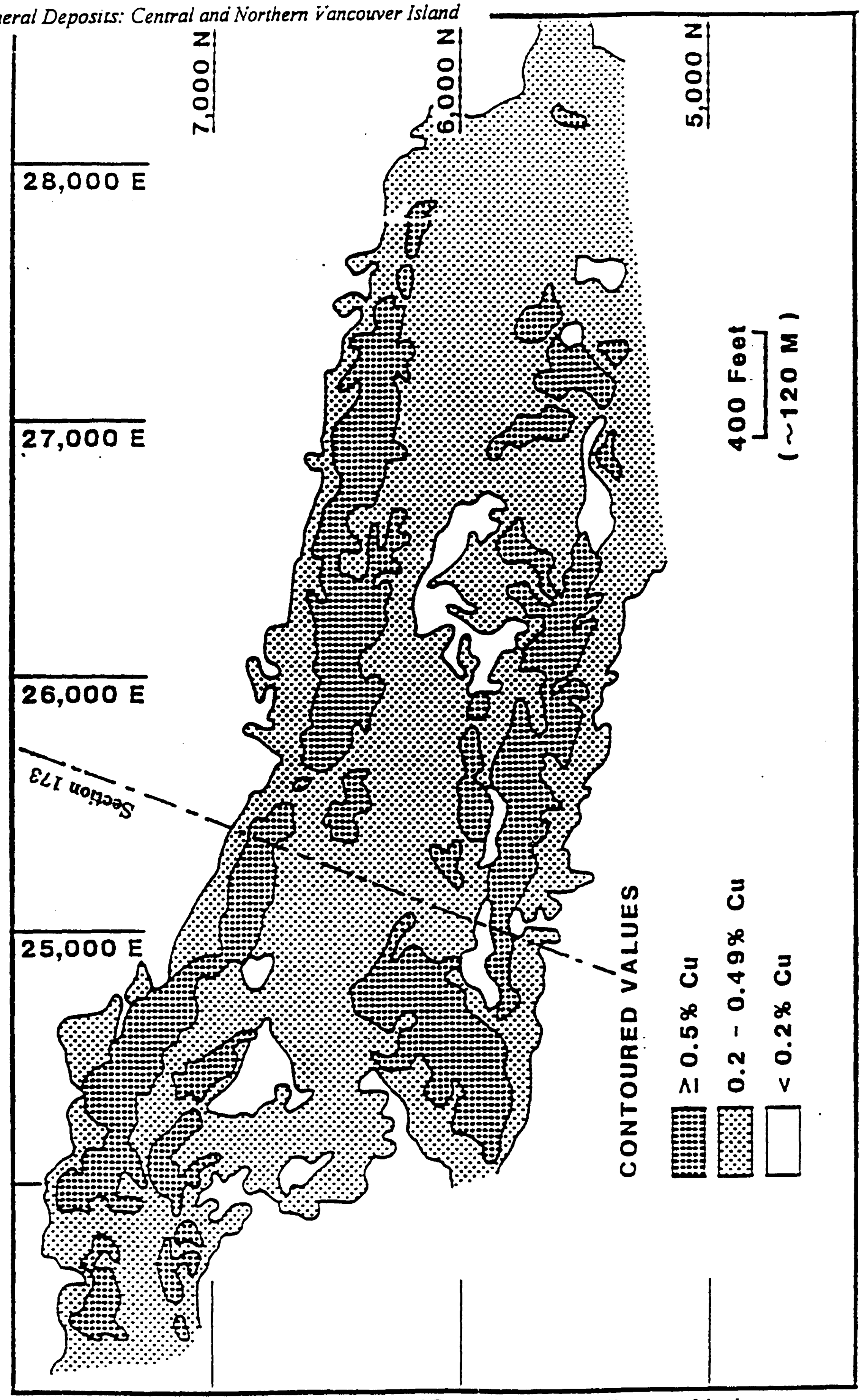



*Figure 15. Contoured copper values, 560 bench, Island Copper mine, northern Vancouver Island.*

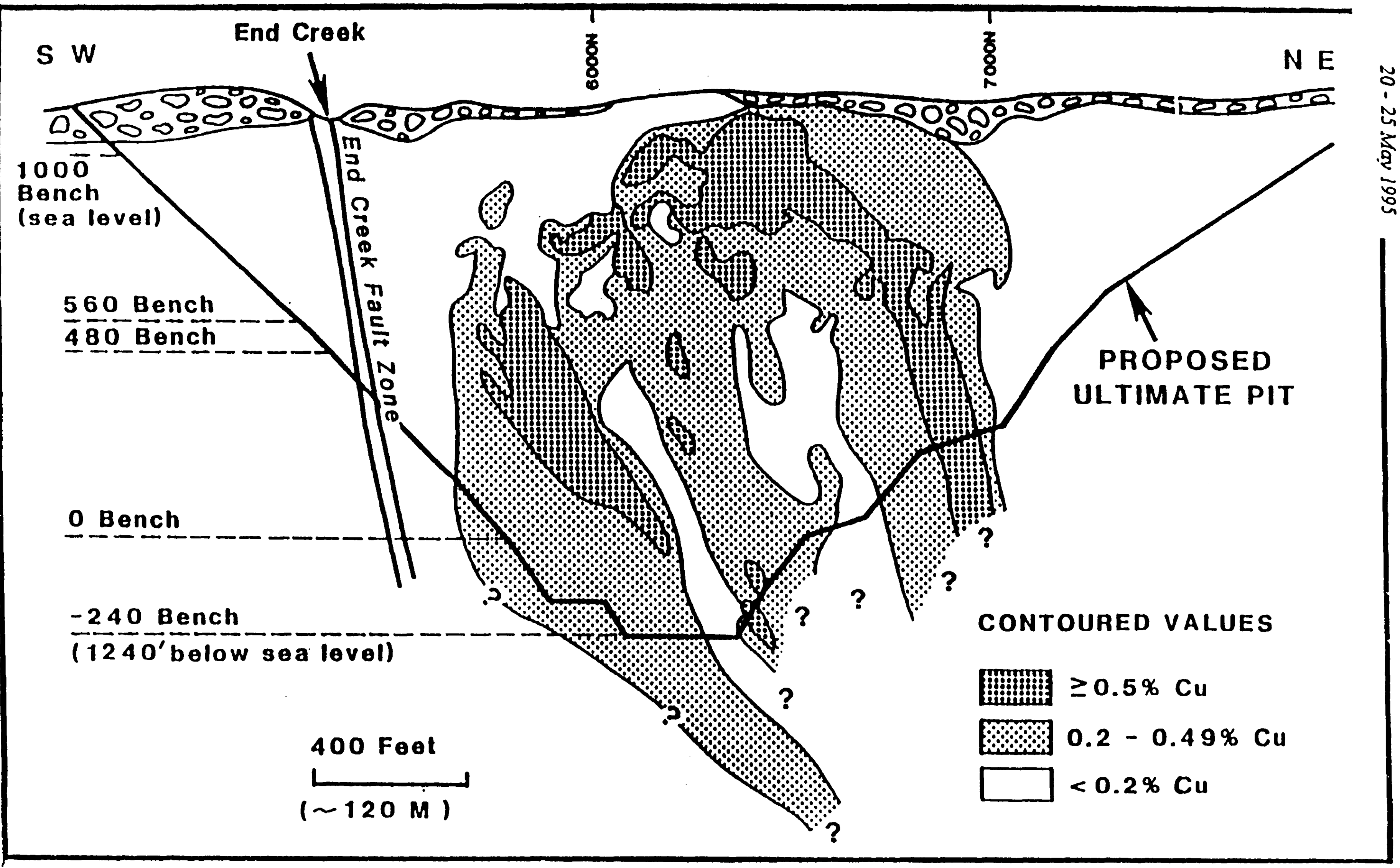



Figure 16. Contoured copper values, section 173 W, Island Copper mine, northern Vancouver Island.

# Preliminary studies of hydrothermal alteration events at the Island Copper deposit, northern Vancouver Island, British Columbia

Craig H.B. Leitch, Katherina V. Ross, John A. Fleming[1], and K.M. Dawson

Mineral Resources Division, Vancouver

*Leitch, C.H.B., Ross, K.V., Fleming, J.A., and Dawson, K.M., 1995: Preliminary studies of hydrothermal alteration events at the Island Copper deposit, northern Vancouver Island, British Columbia; in Current Research 1995-A; Geological Survey of Canada, p. 51-59.*

**Abstract:** Core logging/pit mapping suggest three main stages of intrusion (early, intermediate, late), defined by differences in alteration intensity. Hydrothermal events comprise early biotite-magnetite "hornfels", followed by magnetite-actinolite-plagioclase veining, and then quartz-chalcopyrite veins and fractures with or without "hydrothermal" biotite envelopes. Chlorite-sericite ± clay are likely retrograde overprints as the system cooled and collapsed inwards; epidote may be prograde peripheral, retrograde, or both. Chalcopyrite was introduced in several stages: minor with magnetite-biotite, followed by main-stage disseminations/fracture fills accompanying quartz veins, some with biotite envelopes, and finally with epidote-chlorite and pyrite-chalcopyrite filled fractures. Fluid inclusions in quartz-magnetite veins are highly saline (multiple daughter products); in quartz-chalcopyrite veins saline (halite only); in late veins or reopenings associated with epidote less saline (liquid/vapour only).

**Résumé :** De nombreux indices géologiques ont été découverts d'un ou de plusieurs séismes d'importance qui ont secoué la zone de subduction de Cascadie il y a environ 300 ans. Les séismes ont provoqué de fortes secousses, une subsidence crustale et de gigantesques tsunamis le long de la côte du Pacifique, depuis l'île de Vancouver jusqu'au nord de la Californie. Ils ont dû affecter grandement les habitants de ces régions. Les traditions orales des Amérindiens de la côte du Nord-Ouest font état, quoiqu'avec des exagérations, de tsunamis provoqués par ces événements rares, se produisant à la frontière de plaques. Le plus ancien séisme connu de la période historique en Colombie-Britannique a eu lieu en février 1793 et a été consigné par des explorateurs espagnols passant l'hiver dans le détroit de Nootka, dans l'île de Vancouver. Il est possible que ce séisme se soit produit à une faible profondeur dans la croûte ou encore plus profondément, au sein de la plaque Juan de Fuca en subduction.

[1] BHP Minerals Canada Ltd., Island Copper Mine, P.O. Box 370, Port Hardy, British Columbia V0N 2P0

## INTRODUCTION

Island Copper is an island-arc type porphyry Cu-Mo-Au deposit (Perelló et al., 1989; Arancibia and Clark, 1990) operated by BHP Minerals Ltd. on northern Vancouver Island near Port Hardy, British Columbia. It resulted from the intrusion of a series of dyke-like bodies of rhyodacitic quartz-feldspar porphyry of about 180 Ma age into possibly comagmatic high-alumina basalts, basaltic andesites, minor rhyolites and pyroclastic rocks of the Middle Jurassic Bonanza Group (Northcote and Robinson, 1973; Muller, 1977; Nixon et al., 1994). The size of the deposit was initially estimated at 257 million tons of ore at 0.52% Cu and 0.017% Mo (Cargill et al., 1976); the final mined plan envisages a total of 377 million tons at 0.41% Cu and 0.017% Mo at a 0.2% Cu cutoff (Perelló et al., in press). Gold has been produced at an annual rate of 1200-1500 kg (40-50 000 oz) from a head grade of 0.19 g/t. Only about 50% of the gold is recovered in the copper concentrate, which averages 24% Cu, 7 g/t Au and also contains 60 g/t Ag. The molybdenum concentrate contains up to 1400 ppm rhenium, making Island Copper Canada's only producer of this element (Perelló et al., in press).

A joint project with the Mineral Resources Division of the Geological Survey of Canada (GSC-MRD), the British Columbia Geological Survey Branch (BCGSB), BHP Minerals Ltd., and Auckland University (New Zealand) has been initiated to study the deeper levels of the deposit before mine closure and pit flooding, anticipated in 1995 or 1996. Project members involved include: Craig Leitch, Katherina Ross, Ken Dawson, Rod Kirkham, Colin Dunn, and Mel Best of the GSC; Graham Nixon, Jan Hammack, Andre Panteleyev, Victor Koyanagi, Steve Sibbick and Peter Bobrowsky of the BCGSB; John Fleming of BHP Minerals; and Stuart Simmons and Geraint Mathias of Auckland University. The objectives of the GSC-MRD team are to study the geology and alteration of the deep exposures and drill core, to better understand the sequence of intrusive, alteration, and mineralizing events at all levels in the deposit. Methods include U-Pb zircon geochronology, fluid inclusion and stable isotope studies, and lithogeochemistry. Other related studies include biogeochemistry over and around the deposit by Colin Dunn of GSC-MRD and depth of overburden using geophysical methods by Mel Best of GSC-Geophysics and Marine Geoscience Branch. The BCGSB team is updating knowledge of the regional geology, mineral deposits, geochronology, and geochemistry of the surrounding part of northern Vancouver Island. A detailed study of the high-level advanced argillic alteration is the focus of the Auckland University members.

## PREVIOUS WORK

Since the beginning of production in 1971, the Island Copper deposit has been the subject of numerous geological studies. Brief summaries of the geology were published by Young and Rugg (1971) and Northcote and Robinson (1973). A more detailed description was published by Cargill et al. (1976), and an updated review of the geology was presented by Fleming (1983). Several theses, including those of Cargill (1975), Fahey (1979), and Perelló (1987), have been completed on the deposit; a PhD study by Arancibia, begun in 1977, remains unfinished. The most recent publications include a comprehensive review by Perelló et al. (in press) and partial results of the Arancibia thesis work (Arancibia and Clark, 1990 and in press).

## TIMING OF EVENTS

### *Porphyry intrusions*

All phases of the porphyry are texturally and mineralogically similar, and probably of rhyodacite composition (dacite to rhyolite: O.N. Arancibia, in Perelló, 1987). Unaltered porphyry (O.N. Arancibia, unpublished data; Leitch, unpublished data) consists of approximately 20-30% coarse (0.5-1 cm) bipyramidal quartz phenocrysts, 15-30% 2-5 mm plagioclase laths and <5% chloritized biotite books to 2 mm set in a fine (10 to 30 μm) matrix of quartz and K-feldspar or albite. The plagioclase phenocrysts are oscillatory zoned oligoclase-andesine ($An_{30-40}$) from rim to core (Leitch, unpublished data).

Distribution of the porphyry phases is shown for section 155 through the mine in Figure 1. Three main intrusive events of quartz-feldspar porphyry are recognized in the present study (cf. Perelló, 1987; Perelló et al., in press; Arancibia and Clark, in press), based on differences in alteration/veining intensity, crosscutting relations and included fragments:

Early phase, characterized by intense magnetite-quartz to quartz-magnetite stockwork and/or flooding by disseminated magnetite, frequently leading to total destruction of texture. Quartz-magnetite veins appear to form a continuum with quartz-pyrite±chalcopyrite-molybdenite-magnetite veins. Increasingly quartz-rich veins crosscut magnetite-quartz veins.

Intermediate phase, cut only by rare quartz-magnetite veins and magnetite fractures, and characterized by a general abundance of planar grey quartz-pyrite±chalcopyrite±molybdenite veins. This phase rarely contains clasts of intensely magnetite-quartz stockworked porphyry. It is generally less intensely altered by clay-sericite-chlorite than the early phase, but the contacts are not always clear, as the porphyries are texturally almost identical. Distinction between the phases is based on the abrupt disappearance of intense quartz-magnetite alteration (including the truncation of veins).

Late phase, completely lacking quartz-magnetite stockwork. This phase contains only minor amounts of disseminated magnetite, and clearly truncates quartz-magnetite veining in the early phase (Fig. 2a, b). It is also observed to cut marginal breccia (see below) developed around the early porphyry. Chalcopyrite is restricted to altered mafic mineral sites. Rare quartz±pyrite veins and crosscutting molybdenite on slips occur. Contacts are fresh, sharp and slightly chilled. Inclusions of earlier intrusive phases are common, but crosscutting relations with intermediate porphyry have not been observed.

### *Breccias*

A "marginal breccia" unit mapped around the margins of the early intrusive at Island Copper by previous authors (e.g. Perelló, 1987) appears to be an inclusive term for several breccia types. These range from crackled and hydrothermally veined or stockworked porphyry (unrotated blocks) to heterolithic breccias including volcanic and porphyry clasts (transported blocks) to hydrothermal breccias composed of rounded, intensely altered clasts (highly milled blocks). Matrix to the breccia is difficult to resolve pending petrographic study, but may include some igneous material in addition to the dominant rock flour (cf. Sillitoe, 1989; Perelló et al., 1989). The milled breccia contains clasts of white quartz, dark magnetite-quartz±hematite, and clay-sericite-pyrite altered rock in a matrix of siderite-quartz-hematite-pyrite±chalcopyrite and rare bornite-chalcocite-covellite.

In exposures of marginal breccia, quartz-magnetite veins are cut off in some clasts but cut through other clasts (cf. Padilla-Garza, 1993), indicating several stages of brecciation that possibly overlap the transition from intrusive breccia to hydrothermal breccia associated with the early porphyry. The marginal breccia was not observed to be associated with the intermediate and late porphyries, although Perelló (1987) stated that some breccias post-date the main mineralizing stage.

An extensive area at the west end of the pit is underlain by what has been termed "pyrophyllite-dumortierite breccia"; it has been reported to include fragments of intermediate porphyry and to be cut by late porphyry (Perelló, 1987). Examination of available drill core and pit exposures of this unit, however, suggest an origin by pyrophyllite-dumortierite alteration of a fragmental volcanic rock or intrusion breccia (or both). The location of this breccia adjacent to and transitional

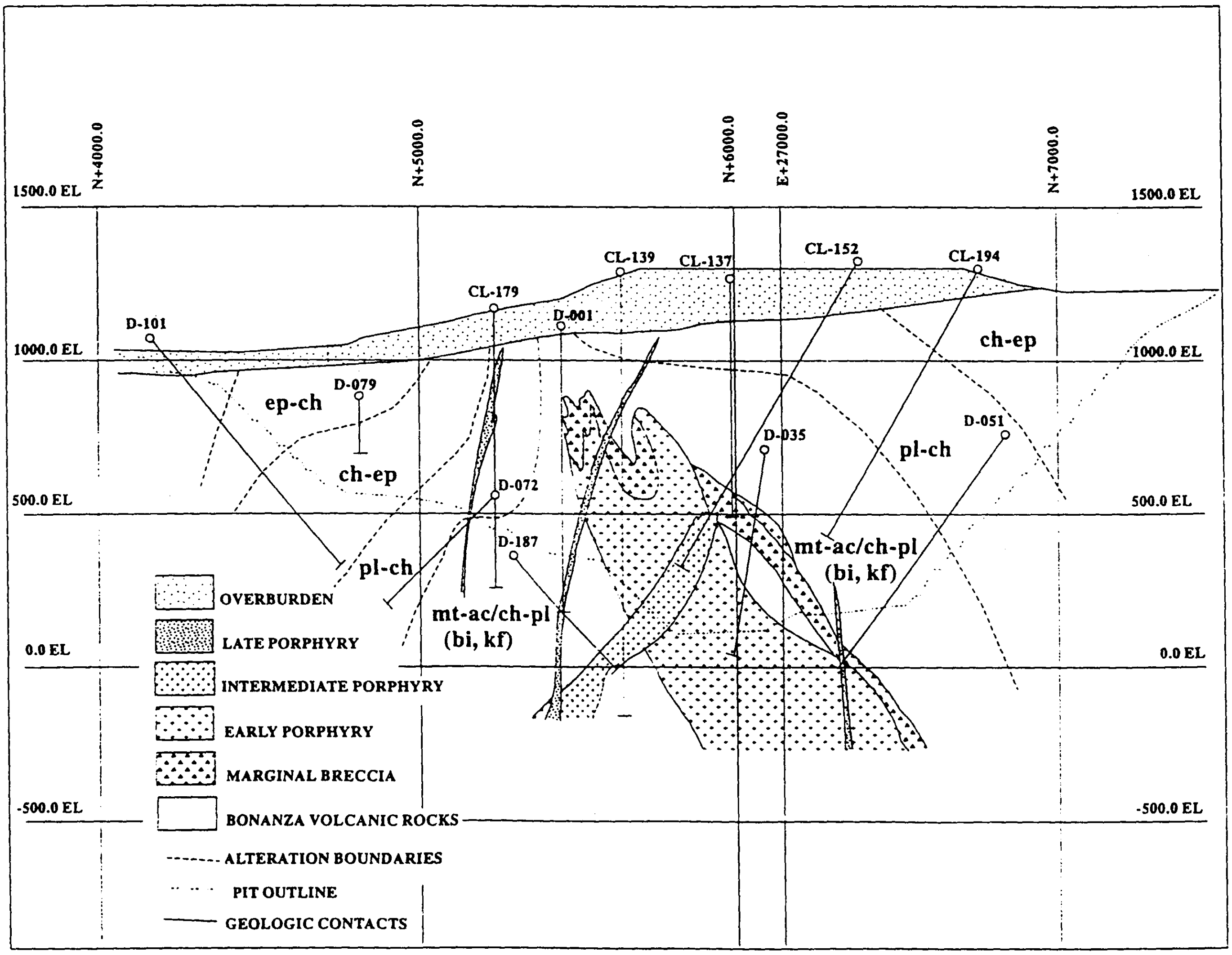



*Figure 1. Cross-section 155W at about 27000 E through the east-central part of the Island Copper deposit to illustrate interpreted geology and alteration zoning. All co-ordinates are in feet (vertical scale same as horizontal scale); mine elevations, used for pit bench designation, are relative to a zero at 1000' below sea level. Abbreviations: ac = actinolite, bi = biotite, ch = chlorite, ep = epidote, kf = K-feldspar, pl = plagioclase, mt = magnetite. Drill hole collars are shown by open circles and identified by number.*

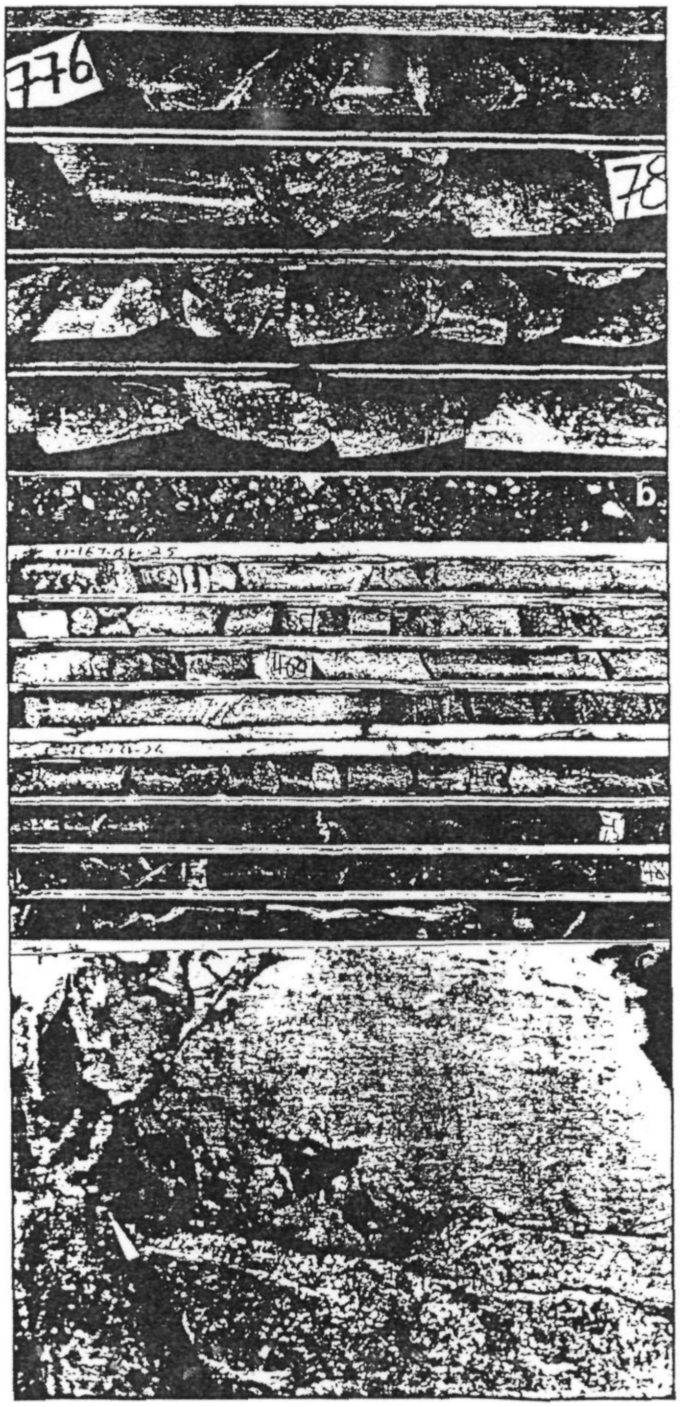
to marginal breccia indicates the possibility that it is an early breccia that has later undergone intense advanced argillic alteration.

### *Pebble dykes*

Late pebble dykes, rarely observed in the pit, generally trend about 325° across the middle of the deposit. These dykes are up to 0.5 m thick and subvertical, and roughly parallel a minor porphyry dyke trend seen in the pit. They have sharp, commonly faulted or sheared contacts. Other examples are observed in drill core, with apparent widths (probably exaggerated in these steep holes) up to several metres. Pebble dykes are divisible into two types: a possibly slightly earlier type that is green, sericitic and strongly pyritic (up to 10% pyrite in the matrix), and a later pink, crumbly and unpyritic type that grades into calcite-zeolite rich fractured or crushed zones. The dykes contain clasts of highly altered and mineralized early porphyry, quartz-magnetite±chalcopyrite veins, and rare clasts of later porphyry in an aplitic-looking matrix (Fig. 2c). The age distinction between the two types is based on the greater degree of alteration, pyritization and lithification of the green type, plus the relation of the pink type to fractured zones. The green type is similar in appearance to some exposures of marginal breccia, implying it may not be much later. Variably pyritic, clay-rich gouge zones are abundant and may in places superficially resemble the pebble dykes, but generally are distinguished by the presence of a less "igneous-looking" matrix (petrography is required to resolve the pebble dyke matrix).

### *Alteration*

A concentric pattern of alteration assemblages developed within the Bonanza volcanic rocks and centred on the porphyritic intrusions, has been recognized by previous authors (Cargill et al., 1976; Fleming, 1983; Perelló et al, in press; Arancibia and Clark, in press). However, the temporal relationships between porphyry intrusion, alteration and mineralization are not yet completely understood. The main alteration assemblages within the Bonanza volcanic rocks recognized in this study are, from innermost to outermost (Fig. 1): magnetite-actinolite/chlorite-plagioclase±biotite ±K-feldspar (Fig. 3a); plagioclase-chlorite (Fig. 3b); and chlorite-epidote. The distinction between actinolite and chlorite is almost impossible to make in hand specimen; in many places both may be present. Biotite appears to be partly relict in the inner two assemblages and partly late (see below). The alteration feldspar is generally albite but ranges from -




a) *Contact (sheared) of intensely magnetite stockworked and flooded early porphyry (dark grey, texture destroyed) with late, pink porphyry (grey, unveined except by calcite-zeolite). Hole E92 at 781 feet, from Bay Lake zone west of the pit.*

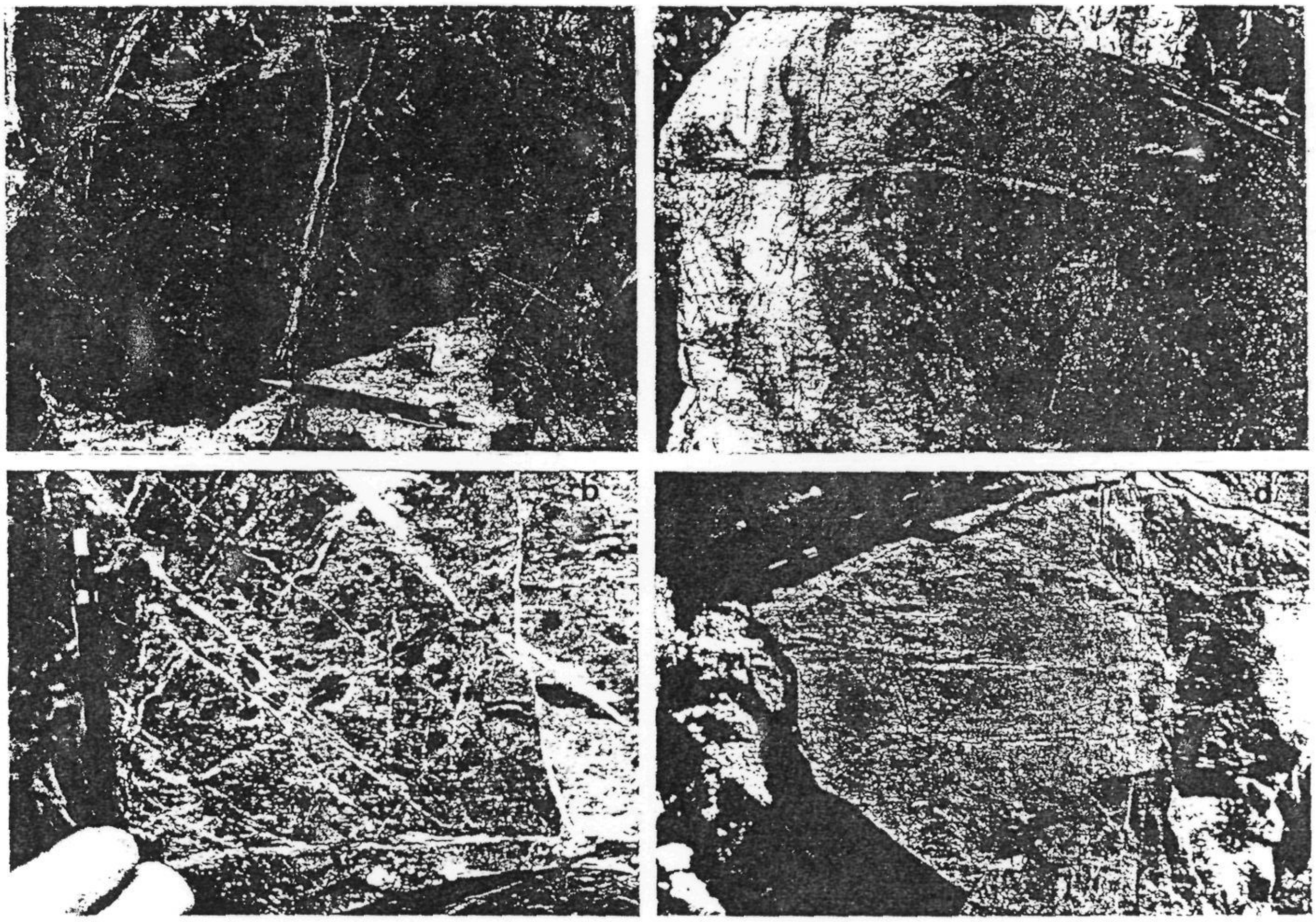
b) *Contact of late porphyry (grey, rare white calcite-zeolite veins) with early porphyry (darker grey, intensely magnetite stockworked) at 469.8' and then of early porphyry with intensely magnetite-actinolite-chlorite altered Bonanza volcanics (black, cut by white calcite-zeolite fractures and grey quartz-sericite-pyrite-clay envelopes). Hole D187, section 155W, centre of pit at 0 level (Fig. 1)*

c) *Pebble dyke (pink type) containing fragments of quartz vein, magnetite flooded early porphyry, and less altered intermediate or late porphyry in an aplitic matrix (southeast wall of pit, 120 level).*

***Figure 2.*** *Contact relations of intrusive phases at Island Copper.*

oligoclase to locally andesine; K-feldspar, likely orthoclase, is also found with increasing alteration intensity closer to the centre of the system or inward in a single fracture envelope (Arancibia and Clark, 1990; Leitch, unpub. data; cf. Leitch, 1981). Pyrite is found throughout all zones. All these alteration types are cut by later, generally structurally controlled, quartz-sericite-clay- pyrite and pyrophyllite-dumortierite alteration assemblages. Plagioclase±chlorite and quartz-sericite-pyrite±clay alteration assemblages are intensely developed locally in both porphyritic intrusions and volcanic rocks. Silicification and magnetite alteration are also moderately to locally intensely developed in the porphyritic intrusive rocks and breccias (Fig. 3c). The distribution of altered intrusive rocks is too variable to show in Figure 1.

The timing of biotite alteration is both significant and contentious. Biotite altered volcanic rock is the most abundant host to copper-gold mineralization. Our observations from pit mapping and drill core logging indicate that a




*a)* *Biotite alteration as remnant "cores" (dark) in Bonanza volcanics cut by dark magnetite-actinolite ±pyrite veinlets with narrow white plagioclase envelopes, encroached on by albitic alteration (pale grey, on left) and chloritic alteration (grey, on right). Late white calcite-zeolite fractures cut all alteration types (east end of pit, 280 level).*

*b)* *"Mottled" albite (light grey)-chlorite (dark grey) alteration replacing biotite±magnetite altered Bonanza volcanics, cut by late white calcite-zeolite fractures (east end of pit, 320 level).*

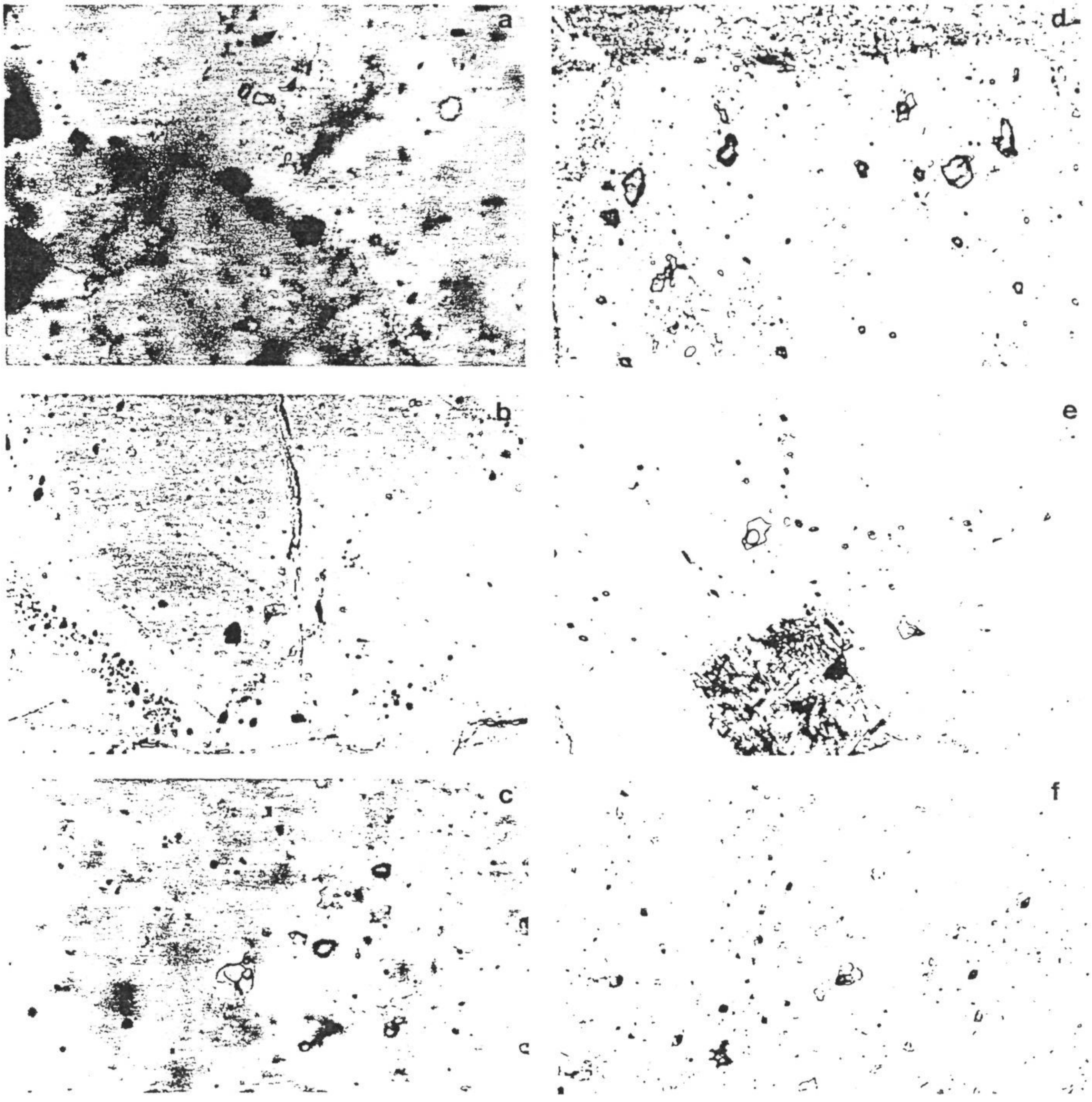
*c)* *Magnetite-quartz stockwork (dark) in porphyry (east end of pit, 160 level). Bleached area is due to later quartz-sericite-pyrite±clay alteration.*

*d)* *Late pyrite-chalcopyrite fractures with sericitic envelopes cutting variably biotite-albite altered Bonanza volcanics (north wall of pit, 280 level).*

***Figure 3.*** *Photographs illustrating mesoscopic features bearing on the timing of alteration and mineralization in the Island Copper deposit.*

pervasive biotite alteration is everywhere cut by magnetite-actinolite/chlorite-plagioclase-pyrite-chalcopyrite veinlets. However, in places (rare in the pit; not uncommon in drill core) the magnetite-bearing veinlets are themselves cut by brown biotite-filled fractures and biotite envelopes to quartz-chalcopyrite veins. The biotitic envelopes appear in many places to be retrograded to later sericite. The principal occurrence of the earlier biotite is as widespread remnant "cores" in relatively less fractured areas of the veinlet controlled magnetite-actinolite-plagioclase alteration assemblage (Fig. 3a). Therefore we interpret two biotite episodes: an earlier hornfelsic biotite that predated the magnetite-actinolite/chlorite-plagioclase±chalcopyrite± pyrite alteration, and a later hydrothermal biotite localized along fractures that cut magnetite-bearing alteration assemblages. Biotite-magnetite along with the copper mineralization partly overprints the quartz-amphibole-magnetite "core" assemblage according to Perelló et al. (1989); and biotite-chalcopyrite assemblages that crosscut magnetite have been described by Arancibia and Clark (in press).

Epidote-chlorite hydrothermal alteration assemblages form a peripheral shell that grades outwards to a regional metamorphic assemblage of the same minerals. Quartz-sericite-pyrite±clay alteration assemblages are best developed in the quartz-feldspar porphyry intrusions. It overprints quartz-magnetite stockwork, resulting in a quartz-pyrite stockwork. Locally porphyritic intrusions are reduced to a



mass of clay with rounded quartz crystals and pyrite. The pyrophyllite-dumortierite alteration assemblages that occur in the upper levels of the western end of the pit, apparently overprinting fragmental volcanic rocks and/or breccias (see below), will be the focus of a MSc. thesis by Geraint Mathias at Auckland University.

### *Mineralization and veining*

At the Island Copper deposit, multiple episodes of copper introduction are interpreted from crosscutting relations observed in drill core and pit exposures, but require refining by detailed petrography.

1. The first introduction was near the end of the period of quartz-magnetite veining (e.g. minor chalcopyrite is found with pyrite in magnetite veins in the Bonanza volcanic rocks, particularly in the east end of the pit, north side.
2. The "main-stage" copper introduction involved abundant fine hairline fracture fills and disseminations either accompanying or cutting pervasively biotitized rock – it is not clear which. In places this style of mineralization is accompanied by quartz-pyrite-chalcopyrite veins (±biotite envelopes where they cut volcanics, but not porphyritic intrusive rocks; many of these veins now have sericitic envelopes). This is comparable to the main Cu introduction of Arancibia and Clark (in press).
3. Minor epidote-chlorite±pyrite±chalcopyrite veining may represent either minor introduction or possibly remobilization of copper.
4. Pyrite-chalcopyrite fractures that cut all other veins (Fig. 3d) also possibly represent minor introduction or remobilization of copper.
5. Finally, the minor chalcopyrite present in late calcite-zeolite-gilsonite veins in the north wall of the pit, probably is remobilized copper.

There may have also been several episodes of molybdenum mineralization:

1. The earliest introduction occurs as disseminations, ribbons and parallel fractures in planar, frequently laminated grey-pink quartz veins. These veins are up to 0.3 m in width and occur in sets trending northwest with steep to vertical dips; they can be traced over 30 m.
2. The coarsest molybdenite occurs locally in high grade copper-molybdenum breccias developed in the intermediate porphyry.
3. The most economically significant molybdenite occurs on widespread slips that cut the late pyrite-chalcopyrite fractures.

Sphalerite was observed in rare quartz-?calcite veins peripheral to the main mineralization. It has also been noted in thin sphalerite-rich veins cutting intermediate and late porphyries, giving rise to local zones of over 1% Zn (Perelló, 1987).

### *Fluid inclusion petrography*

A preliminary investigation of fluid inclusions was conducted on 40 thin and polished sections from previous petrographic work done on the Island Copper property. There are at least four types of inclusions present:

- Type 1: One phase or vapour-dominant (no liquid phase visible).
- Type 2: Two-phase aqueous inclusions containing liquid and vapour.
- Type 3: Moderately saline three-phase inclusions containing liquid, vapour and a salt crystal, likely halite.
- Type 4: Highly saline inclusions with multiple daughter products.

Type 1-4 inclusions occur dominantly in vein quartz and in quartz phenocrysts in the porphyries, either isolated or along fracture planes indicating pseudosecondary and secondary origin. No inclusions were observed in recognizable growth zones. Two phase inclusions occur in vein quartz, calcite, K-feldspar and ?zeolite. No temperature or salinity data are available yet for any inclusions.

*a) Type 2 (2-phase) in quartz vein, showing highly variable vapour/liquid ratios from 10 to 70 per cent in a single cluster (hole E96-711').*

*b) Type 3 (3-phase) in quartz-pyrite-chalcopyrite vein, showing vapour bubble, halite crystal, and saline brine (hole E95-387').*

*c) Type 4 (multi-phase) in quartz-magnetite vein, showing vapour bubble, transparent and opaque daughter products, and saline brine (sample 88PPit 010, intensely potassic (biotite-K-feldspar-magnetite-chalcopyrite ±pyrite-molybdenite) altered Bonanza volcanic, from unknown location in pit; note several adjacent vapour-rich inclusions).*

*d) Type 2 (2-phase) in quartz phenocryst from strongly albite-quartz-chlorite-magnetite±pyrite-chalcopyrite altered early porphyry (hole E111-367.5'). Note abundant Type 1 (dark, vapour-rich) examples in the field of view.*

*e) Type 3 (3-phase with halite cube, to right of altered feldspar crystal) and larger Type 2, in quartz phenocryst from clay-sericite-pyrite altered intermediate porphyry cut by calcite-zeolite veins (hole E138-507').*

*f. Abundant Type 4 (multi-phase) inclusions in quartz phenocryst from intensely magnetite-chlorite altered early porphyry cut by calcite-zeolite veins (hole E140-168').*

***Figure 4.*** *Photomicrographs of typical fluid inclusions in quartz from the Island Copper deposit (all in plane polarized light; width of field of view 130 μm except 50 μm in c).*

The vapour-rich inclusions (Fig. 4) are difficult to interpret because of their superficial similarity to decrepitated inclusions that are filled with air. They are variable in size, but tend to be large (over 15 µm) and have rounded, smooth outlines with vapour to liquid ratios 90% or over. There are no visible daughter minerals. These inclusions could contain variable amounts of carbonic ($CO_2$+$CH_4$) vapour. Crushing and freezing tests will be necessary to further identify the materials present in these inclusions.

The two phase liquid-vapor inclusions are mainly associated with late quartz, quartz-epidote or chlorite reopenings of main stage quartz veins (Fig. 4a). They are also found in late quartz±calcite±zeolite±K-feldspar veins, or in fractures in quartz phenocrysts in porphyritic intrusive rocks (Fig. 4d). Vapour to liquid ratios are highly variable, from 10 to 90 per cent. These inclusions tend to be small, less than 10 µm in maximum dimension, and are rounded to irregular in shape. No consistent variation in degree of filling with location in the deposit has so far been observed.

The three phase inclusions are associated with the intermediate stage quartz±pyrite±chalcopyrite±magnetite veins, locally with potassic (biotite and/or K-feldspar) alteration envelopes. They contain a liquid phase, a vapour bubble, and a halite cube. These inclusions are the most important from the point of view of the mineralization, but are the least abundant in the veins (Fig. 4b). They also occur in quartz phenocrysts in altered quartz-feldspar porphyry (Fig. 4e). They range in size from 3-12 µm, and are rounded to irregular in shape; liquid to vapour ratios range from 10-40 per cent.

The highly saline, multiphase inclusions are associated with the early stage quartz-magnetite±actinolite/chlorite ±pyrite±chalcopyrite veins. The inclusions are generally in the 5-15 µm size range, with a few up to 30 µm. They have smooth to rounded or irregular shapes (Fig. 4c). The inclusions consist of a liquid phase, a vapor phase, a halite cube, and a variable number of other daughter products. Two colourless, platelet-shaped (one hexagonal), highly birefringent minerals are most common. A red, translucent, hexagonal phase (hematite?) and an opaque phase (magnetite or chalcopyrite?) are less frequently seen. Liquid to vapour ratios range from 10 to 30 per cent. Inclusions of this type were also commonly observed in quartz phenocrysts in intensely quartz-magnetite±actinolite altered quartz-feldspar porphyry (Fig. 4f).

The inclusion populations thus far outlined fit well with the commonly observed progression in porphyry deposits from early high-salinity fluids trapped in veins and phenocrysts to late low-salinity fluids trapped in veins with phyllic alteration envelopes (e.g. Reynolds and Beane, 1985). So-called "blue" quartz veins at Island Copper that contain scattered low-salinity fluid inclusions have been attributed to early quartz that has been recrystallized by later fluids but without affecting the vein envelope mineralogy (J.T. Reynolds, pers. comm., 1994).

### *Outline of work plan*

Geochronology: Three samples of the quartz-feldspar porphyry, representing the early, intermediate and late phases, have been collected for zircon U-Pb dating. These data will complement the zircon U-Pb dating of rhyolitic and andesitic phases of the Bonanza volcanic rocks currently underway on rocks collected by the BCGSB.

Geochemistry: Approximately 50 samples of the main alteration types in volcanic and porphyry and representative, least-altered samples of the three porphyry phases have been submitted for whole-rock and trace element analysis.

Isotope geochemistry: Samples of vein and phenocryst quartz and feldspar, plus vein calcite, magnetite, and hydrous minerals (chlorite, actinolite, biotite) will be analyzed for oxygen, deuterium, and carbon isotopes. Analyses of feldspar lead and sulphide sulphur are also planned.

Petrography: A comprehensive suite of samples from the lower levels of the pit and from drill core was collected this year to examine alteration changes in detail. Data will be presented as five cross sections and two long sections.

Fluid inclusion studies: At the time of the preliminary investigation, the hand sample equivalents of the thin sections were not available, therefore the overall relationships of veins and alteration were somewhat ambiguous. However, a well constrained set of samples was collected during this year's fieldwork to continue the fluid inclusion study. Following detailed petrography of these samples, microthermometry will be completed.

## ACKNOWLEDGMENTS

We are grateful to Island Copper Mines for access to the pit and core library, assistance in the field, and permission to publish this report. Constructive review by Suzanne Paradis is much appreciated.

## REFERENCES

**Arancibia, O.N. and Clark, A.H.**
1990: Early magnetite-rich alteration/mineralization in the Island Copper porphyry copper-molybdenum-gold deposit, British Columbia; Geological Association of Canada - Mineralogical Association of Canada, Program with Abstracts, v. 15, p. A4.
in press: Magnetite-amphibole-plagioclase alteration-mineralization at Island Copper, British Columbia: early hydrothermal processes in a porphyry copper-molybdenum-gold deposit; Economic Geology.

**Cargill, D.G.**
1975: Geology of the "Island Copper" Mine, Port Hardy, British Columbia; PhD. thesis, University of British Columbia, Vancouver, British Columbia, 133 p.

**Cargill, D.G., Lamb, J., Young, M.J., and Rugg, E.S.**
1976: Island Copper; Canadian Institute of Mining and Metallurgy, Special Volume 15, p. 206-218.

**Fahey, P.L.**
1979: The geology of Island Copper Mine, Vancouver Island, British Columbia; MSc. thesis, University of Washington, Seattle, Washington, 52 p.

**Fleming, J.A.**
1983: Island Copper; Geological Association of Canada, Field Trip Guidebook, p. 21-35.

**Leitch, C.H.B.**
1981: Secondary alkali feldspars in porphyry systems; Canadian Institute of Mining and Metallurgy Bulletin, v. 74, No. 831, p. 83-88.

**Muller, J.E.**
1977: Evolution of the Pacific margin, Vancouver Island and adjacent regions; Canadian Journal of Earth Sciences, v. 14, p. 2062-2085.

**Nixon, G.T., Hammack, J.L., Koyanagi, V.M, Payie, G.J., Panteleyev, A., Massey, N.W.D., Hamilton, J.V., and Haggart, J.W.**
1994: Preliminary geology of the Quatsino – Port McNeill map areas, northern Vancouver Island (92L/12,11); in Geological Fieldwork 1993; British Columbia Ministry of Energy, Mines, and Petroleum Resources, Paper 1994-1, p. 63-85.

**Northcote, K.E. and Robinson, W.C.**
1973: Island Copper Mine; in Geology, Exploration and Mining in British Columbia – 1972; British Columbia Department of Mines and Petroleum Resources, p. 293-303.

**Padilla-Garza, R.A.**
1993: Breccias in Island Copper deposit, Vancouver Island, Canada; unpublished report, BHP Minerals Ltd, 6 p.

**Perelló, J.A.**
1987: The occurrence of gold at Island copper Mine, Vancouver Island, British Columbia; MSc. thesis (Mineral Exploration), Queen's University, Kingston, Ontario, 85 p.

**Perelló, J.A., Arancibia, O.N., Burt, P.D., Clark, A.H., Clarke, G.A., Fleming, J.A., Himes, M.D., Leitch, C.H.B., and Reeves, A.T.**
1989: Porphyry Cu-Mo-Au mineralization at Island Copper, Vancouver Island, B.C.: Paper presented at Geological Association of Canada - Mineral Deposits Division Workshop on Porphyry Cu-Au Deposits, Vancouver, B.C. April 1989, 22 p.

**Perelló, J.A., Fleming, J.A., O'Kane, K.P., Burt, P.D., Clarke, G.A., Himes, M.D., and Reeves, A.T.**
in press: Porphyry copper-gold-molybdenum mineralization in the Island Copper cluster, Vancouver Island; Canadian Institute of Mining and Metallurgy, Special Volume 44.

**Reynolds, J.T. and Beane, R.E.**
1985: Evolution of hydrothermal fluid characteristics at the Santa Rita, New Mexico, porphyry copper deposit; Economic Geology, v. 80, p. 1328-1347.

**Sillitoe, R.H.**
1989: Comments on the Island Copper and associated porphyry copper-gold systems, Vancouver Island, British Columbia, Canada; unpublished report, BHP-Utah International Ltd., 7 p.

**Young, M.J. and Rugg, E.S.**
1971: Geology and mineralization of the Island Copper deposit; Western Miner, v. 44, No. 2, p. 31-40.

Geological Survey of Canada Project 740098

TOS → Reg. Mg
Nanaimo

# I N T E R O F F I C E   M E M O R A N D U M

Created: 21-Oct-1997 11:15am PST
Sent: 24-Oct-1997 12:24pm PST
From: Ted Hall of EI
TJHALL
Title. Regional Manager, Nanaimo
Dept: Employment & Investment
Tel No: 751-7375

TO: See Below

Subject: Southwest Region Update - October 24, 1997

ISSUES:

IM

* Northwest Landscape are considering applying for lease on their Spumoni claim on Brohm Ridge, following successful marketing of facing stone in Whistler; if expanded, this quarry operation will be a major concern to the proposed Garibaldi Alpen ski resort.

Island Copper

* Completion of sale of Island Copper plant site for value-added wood processing plant requires government sign-off on contaminated soils clean-up before year-end; consultant's report is being filed with Contaminated Sites Unit of MELP, but a lengthy review period may jeopardize this government-supported economic development opportunity; Gregg Stewart will provide briefing material for ADM's office.

Gaffers

* The Pacheedaht First Nation have asked regional staff to delay processing a permit application for a bulk sampling and test milling program on the Gaffers mineral property near Port Renfrew; they claim the area is part of proposed Settlement Lands in their treaty negotiations; MAA have been asked to provide a Provincial response confirming that the Pacheedaht interest in this land will be protected under the treaty process.

* Gravel pit concerns raised by the District of Mission at UBCM are again forcing regional permitting staff to rationalize their mandated authority against public and local government interests; resolution of concerns over Allard/Keystone Pit will be very difficult.

* J. Alvarez found illegal gravel pit operation on routine inspection trip to Campbell River area; Island Redi-Mix has been operating without tenure, cutting authority or mine permit; operator has been put on notice and is seeking necessary approvals.

FYI:

* VIMDRC meeting and inspection held at Island Copper Mine; progress made on outstanding issues should lead to closure plan

TGS → ~~DG~~ ~~Vancouver~~ Island Copper

INTEROFFICE MEMORANDUM

Date: 27-Mar-1995 04:02pm PDT
From: Robert Pinsent
RPINSENT
Dept: Energy, Mines & Petroleum Res.
Tel No: 660-0223

TO: (see below)

Subject: SOUTHWESTERN REGION WEEKLY REPORT: MARCH 20TH - 31ST

EXPLORATION:

ISLAND COPPER - The **Island Copper** "porphyry copper" operation will close at the **end of December**. BHP Minerals (Canada) Ltd. will extract **2.0 million of the 16.0 million tonnes of destabilized "ore" in the south wall of the pit.** It expects to **cease mining** the **floor** of the pit by the **end of July** and **exhaust** the **low-grade stock-pile** by the **end of the year**. It will **start laying-off staff at the end of August.** Most will be gone by the end of December.

MORE - Cominco Ltd. plans to explore its 100% owned **More** 1-5 (bulk tonnage gold) property, on Moresby Island, in the Queen Charlotte Islands. It will construct 20 line Km of grid, conduct geological and geophysical programmes and drill **7 short (100 metre) holes.**

- Romulus Resources intends to reopen the adit at Cinola and slash out sites for a detailed underground drill programme. It will drill approximately 50 holes, for an aggregate length of 6,000 metres, to test the continuity and grade of several silicious "high-grade" gold zones.

- La Rock Mining Corp. announced some impressive intersections from the Brandywine property (0.69 o/t gold over 27 feet and 0.75 o/t over 40 feet in hole 95-6). The intercepts confirm the presence of erratic "high-grade" mineralization. There is still no indication of size potential. The results have lead to renewed staking in the Callaghan Valley, immediately adjacent to the PAS Study Area!!

LAND-USE:

- Vancouver Sun indicates that Government will announce 20 (small) new "protected areas" (total 4,000 hectares) in the Lower Mainland on 10th April! Most were negotiated with GVRD and City Surrey outside of the Lower Mainland Regional Process. They will be acquired through contributions from all three and the financial support of the Lower Mainland Nature Legacy Fund. The new "protected areas" will include Sumas Mountain, Surrey Bend, Colony Farm, Douglas Island etc. Burns Bog was deemed too expensive.

TOS -> Reg. Mgr — Nanaimo

I N T E R O F F I C E   M E M O R A N D U M

Created: 13-Jun-1997 10:10am PDT
Sent: 13-Jun-1997 12:22pm PDT
From: Ted Hall of EI
TJHALL
Title. Regional Manager, Nanaimo
Dept: Employment & Investment
Tel No: 751-7375

TO: See Below

Subject: Southwest Region Update - June 13, 1997

ISSUES:

Sumas Mtn

* The Concerned Citizen's of Sumas Mountain have indicated that the City of Abbotsford will not issue a soil removal permit for the proposed Western Rock Quarry, which is presently under review by MEI. If confirmed, this will again put the ministry toe to toe with local government (and the public) in a conflict over permitting of quarry operations.

Tsable R.

* A public meeting in Union Bay to review the proposed Tsable River Coal bulk sample program drew a large crowd of local residents opposed to the project. Further public meetings will likely be required to resolve issues related to truck traffic, noise, etc.

* Regional staff are reviewing an incident at Garibaldi Granite where an employee drank from an unlabelled bottle of methyl hydrate. The worker was hospitalized but apparently suffered no long term effects.

FYI:

* A two-day technical forum on the Vancouver Island Land Use Plan was held in Nanaimo. Extensive revisions to the interim technical report are planned by mid-summer, in response to pressure from environmental and community resource groups as well as to proposed changes in the Forest Practices Code. MEI will have ongoing input to the final report through the IAMC.

Island Cppr

* BHP have announced the sale of most of the remaining infrastructure at the Island Copper Mine to Royal Hoyalas Specialty Wood Products, a joint venture of the Quatsino Band and two Vancouver Island wood manufacturers. Royal Hoyalas will establish a sawmill and lumber kiln on the 30-hectare plant site, utilizing existing mine buildings and facilities, including the deep sea dock. Phase I will see construction of the sawmill, which will employ 40 persons, within a year, with further expansion to follow.