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The THINSECT directory contains the unpublished thinsection descriptions of the alteration study completed earlier in the year, (saved in Excel 5.0).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.

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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

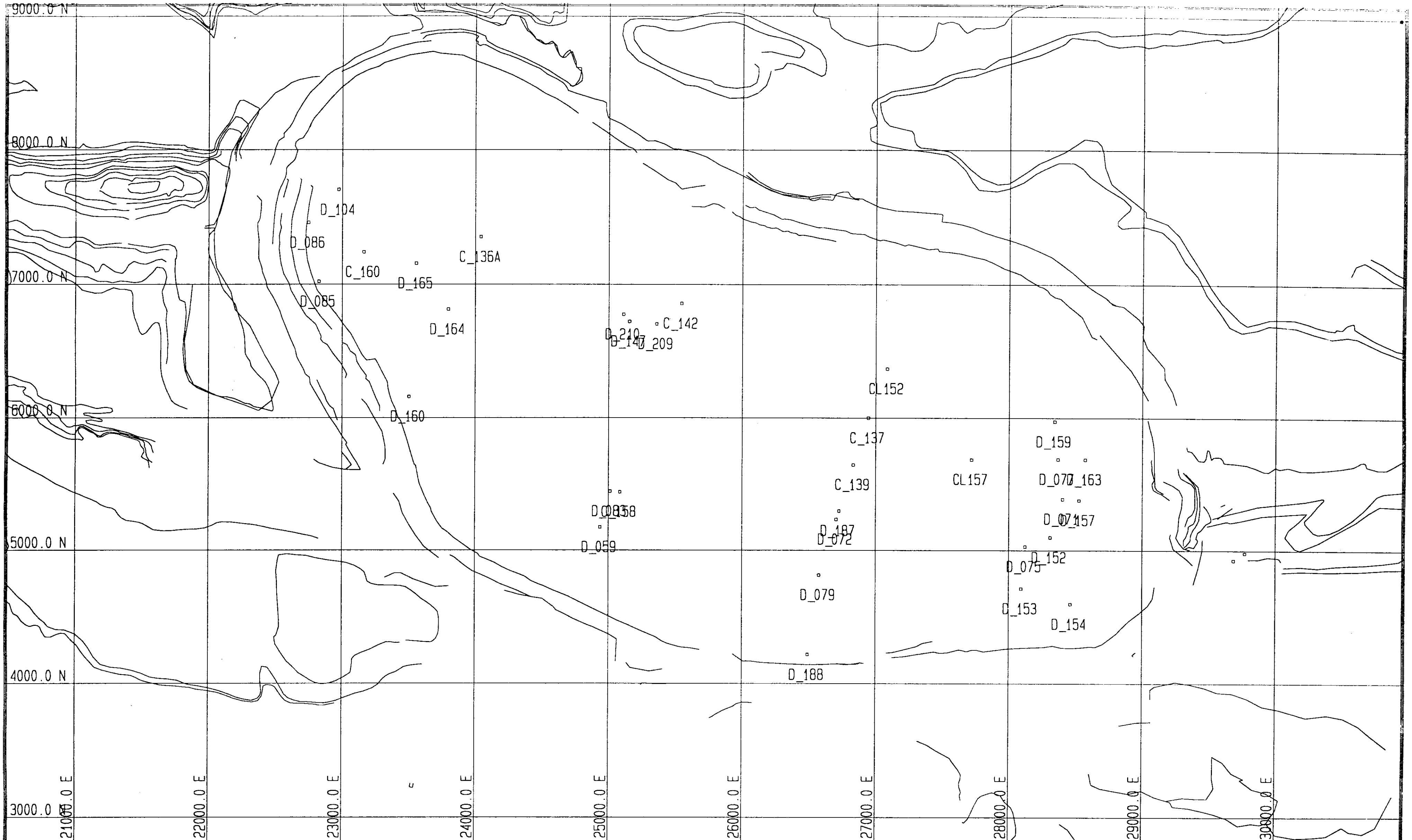
		114					fine grained volcanics, pervasive epidote , calcite-hematite veinlets, hematite is common in epidotized volcanics peripheral to the porphyry system
		122					a maroon, slightly porphyritic volcanic (flow?), 32 feet thick in core
		159					fine grained volcanics, pervasive epidote , euhedral pyrite
		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'

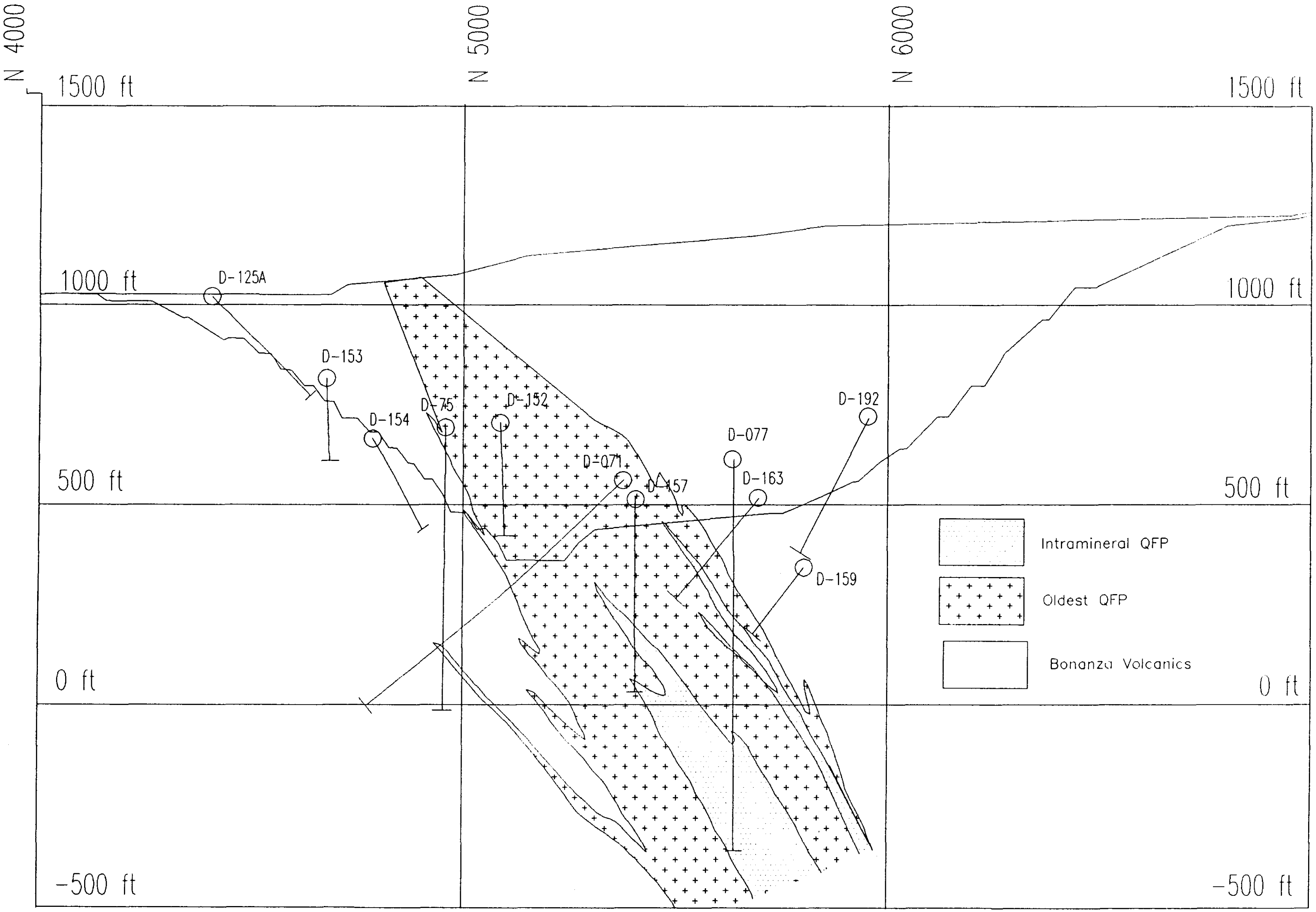
Software by GEMCOM Services Inc.

ICM PIT CORE SAMPLING PROGRAM
SAMPLED-HOLE LOCATIONS

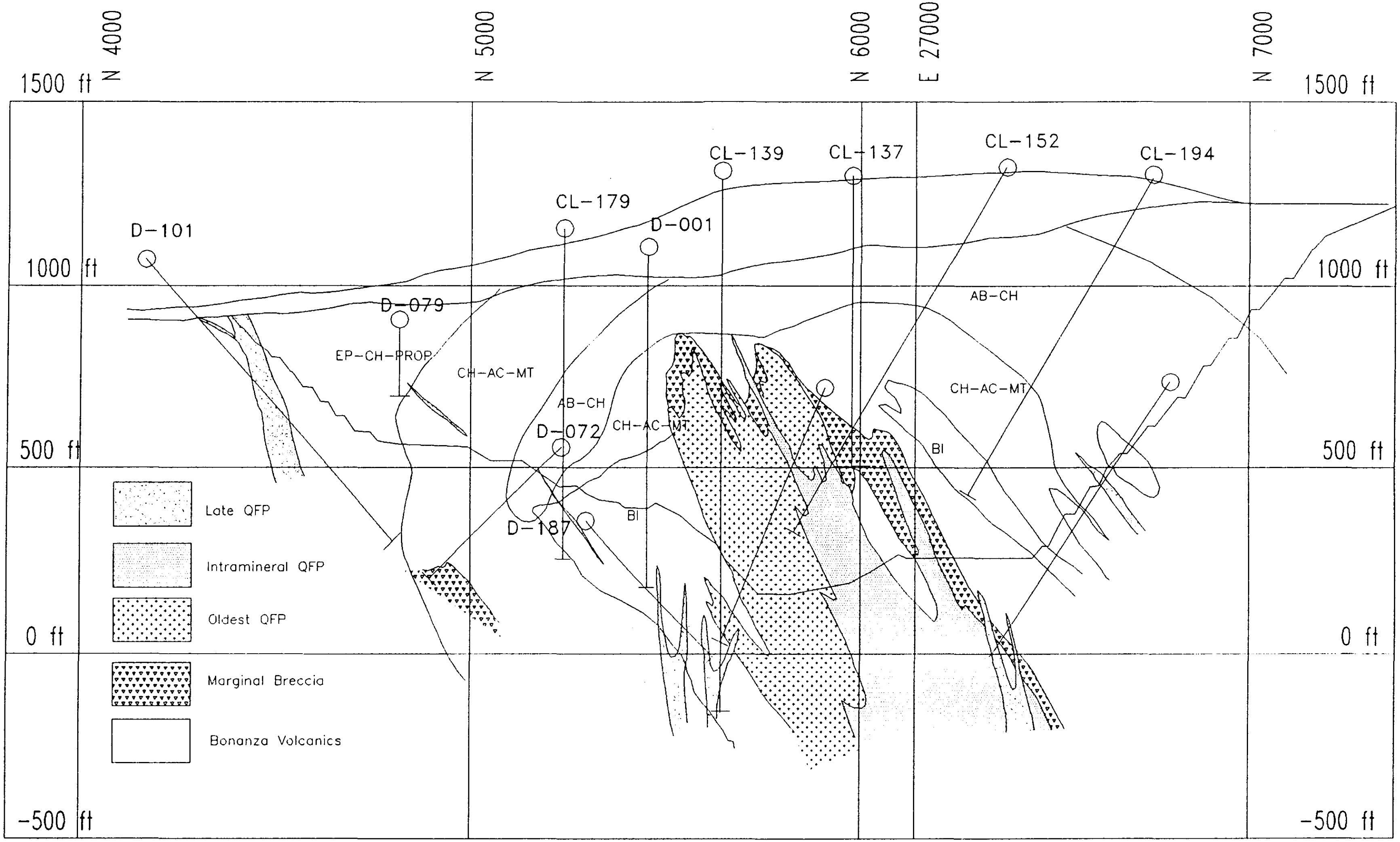
Holes Sampled November 17-22, 1995

To Accompany Report by Kika Ross

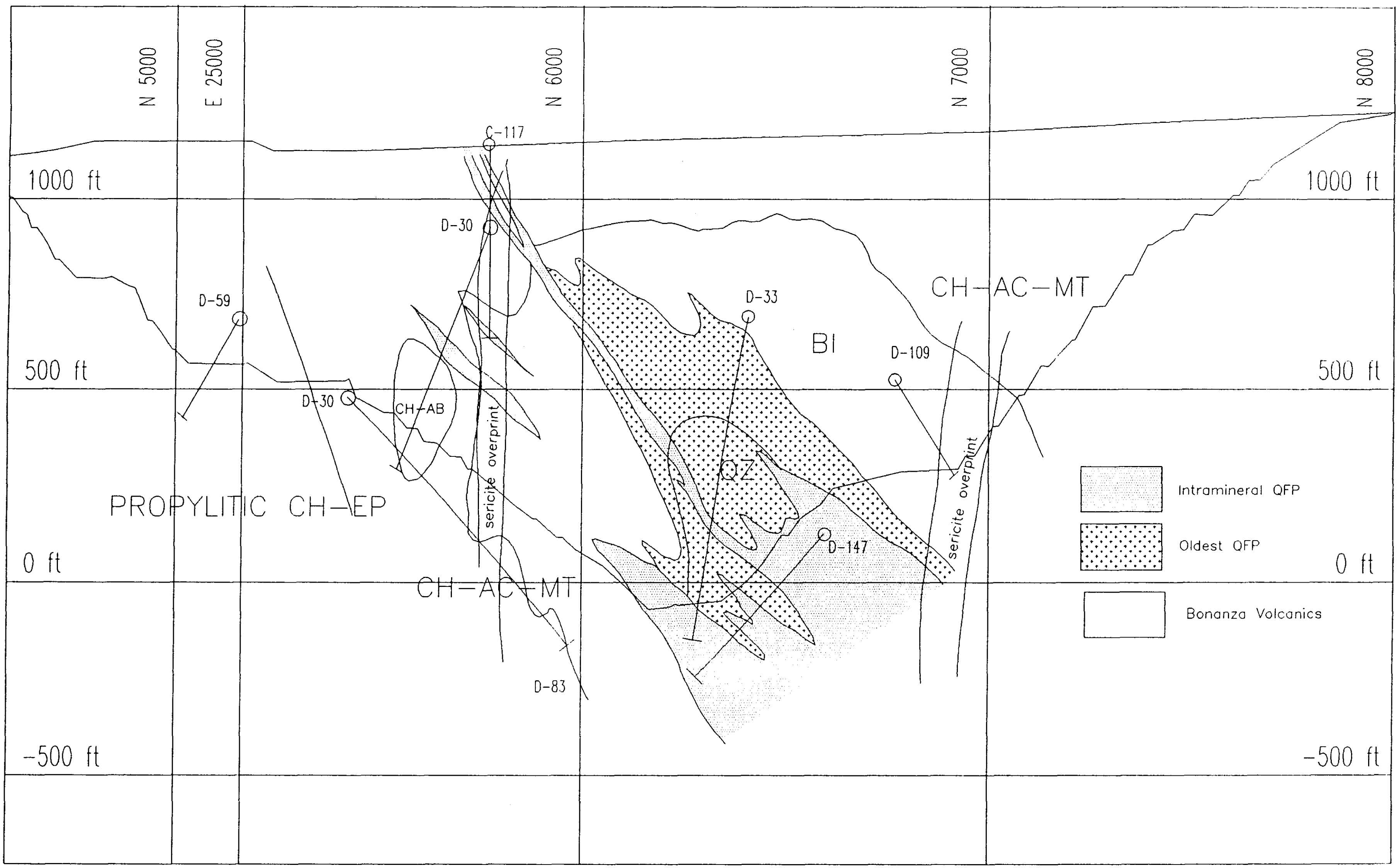
Cross Section 139



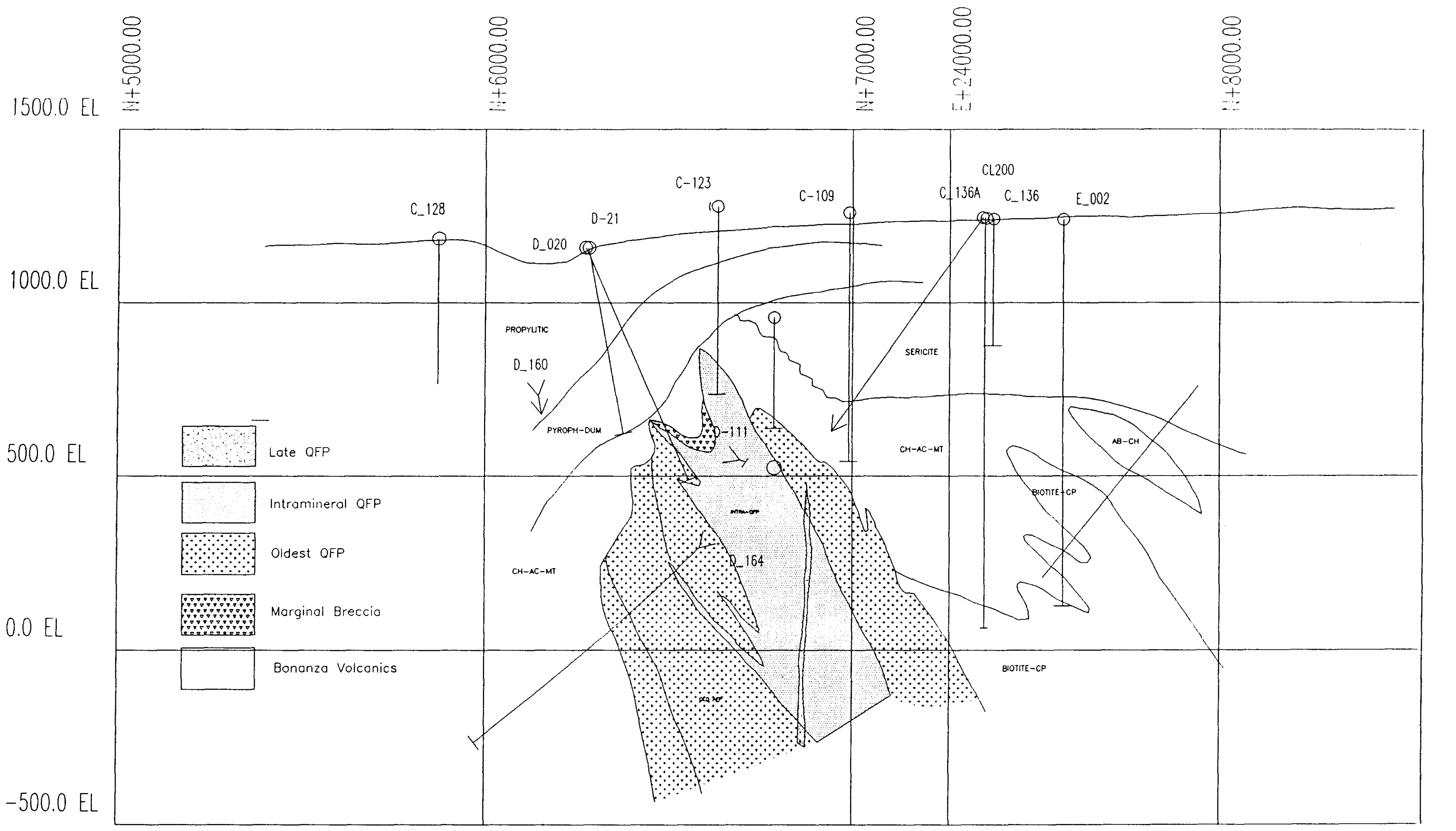
Cross Section 155



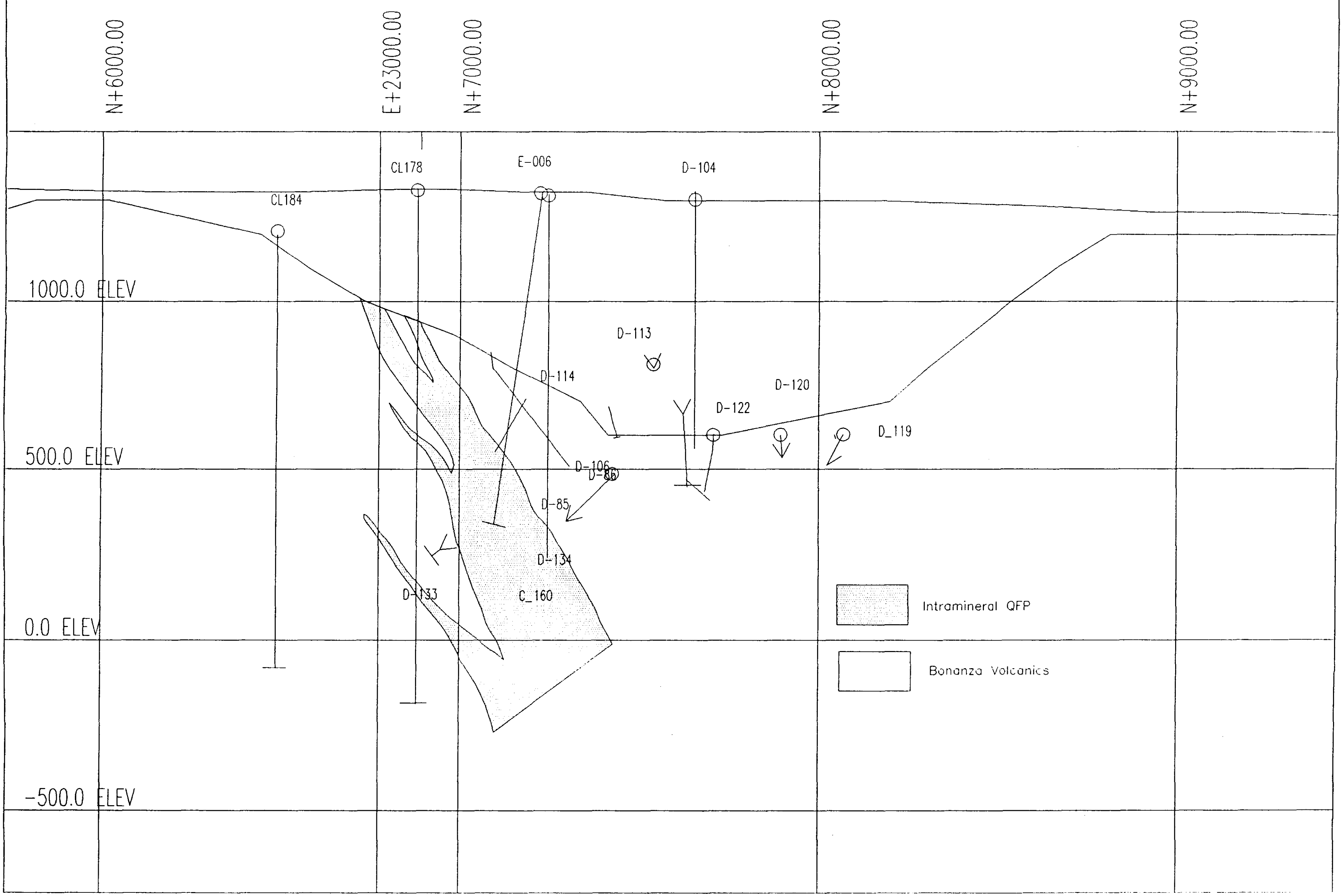
Cross Section 171



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

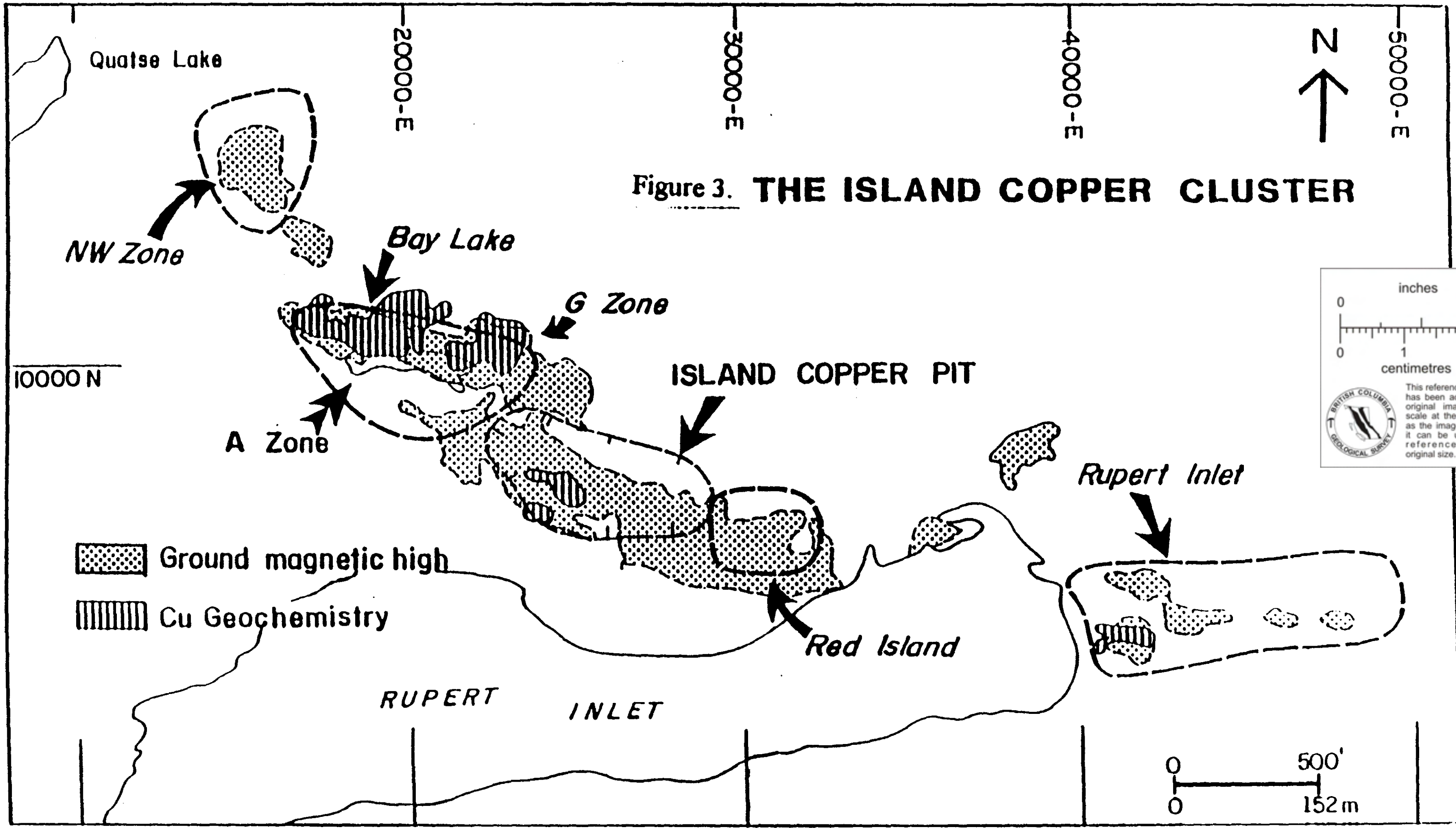


Figure 11. The Island Copper cluster (ICC), nothern Vancouver Island.

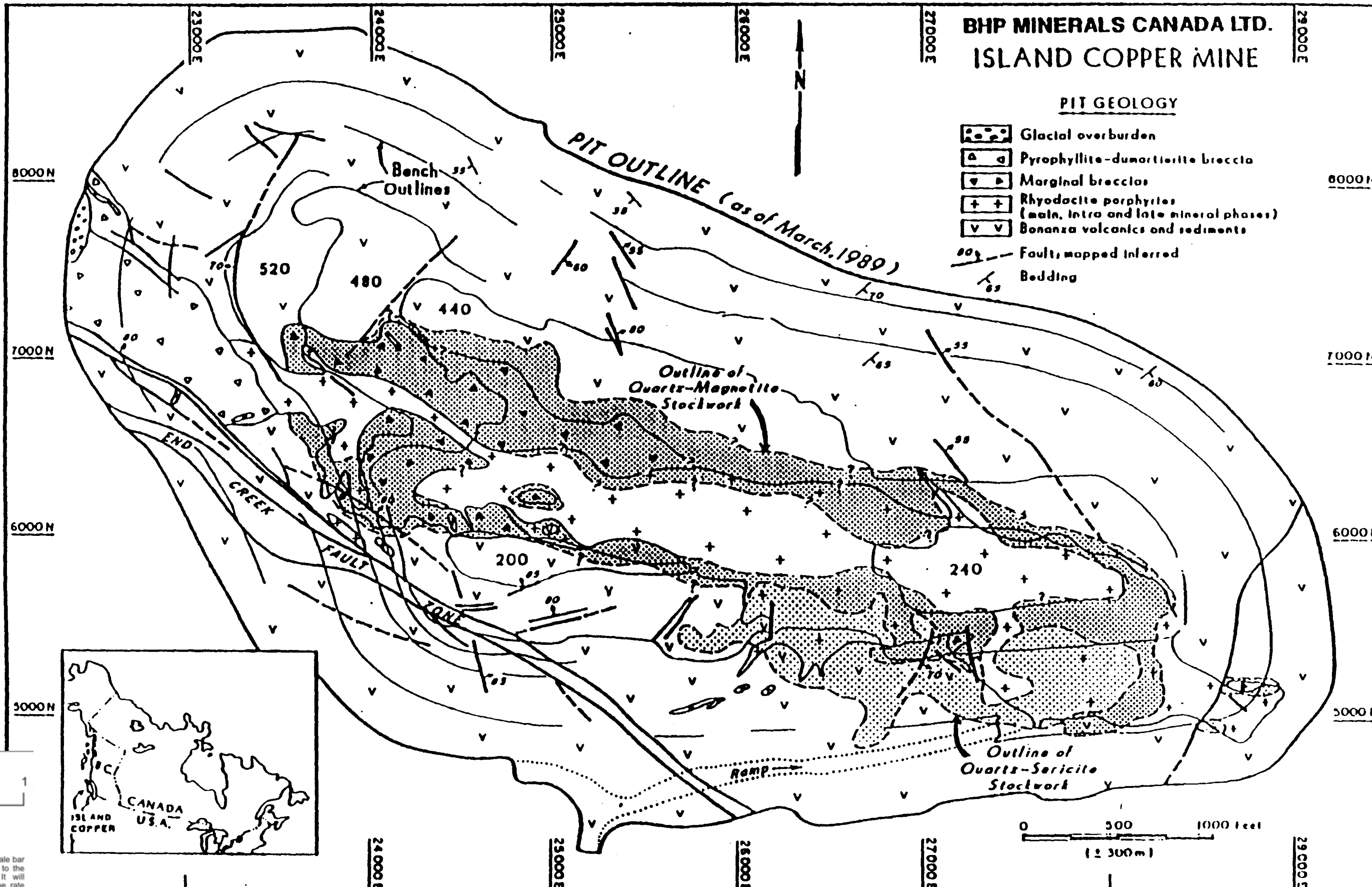
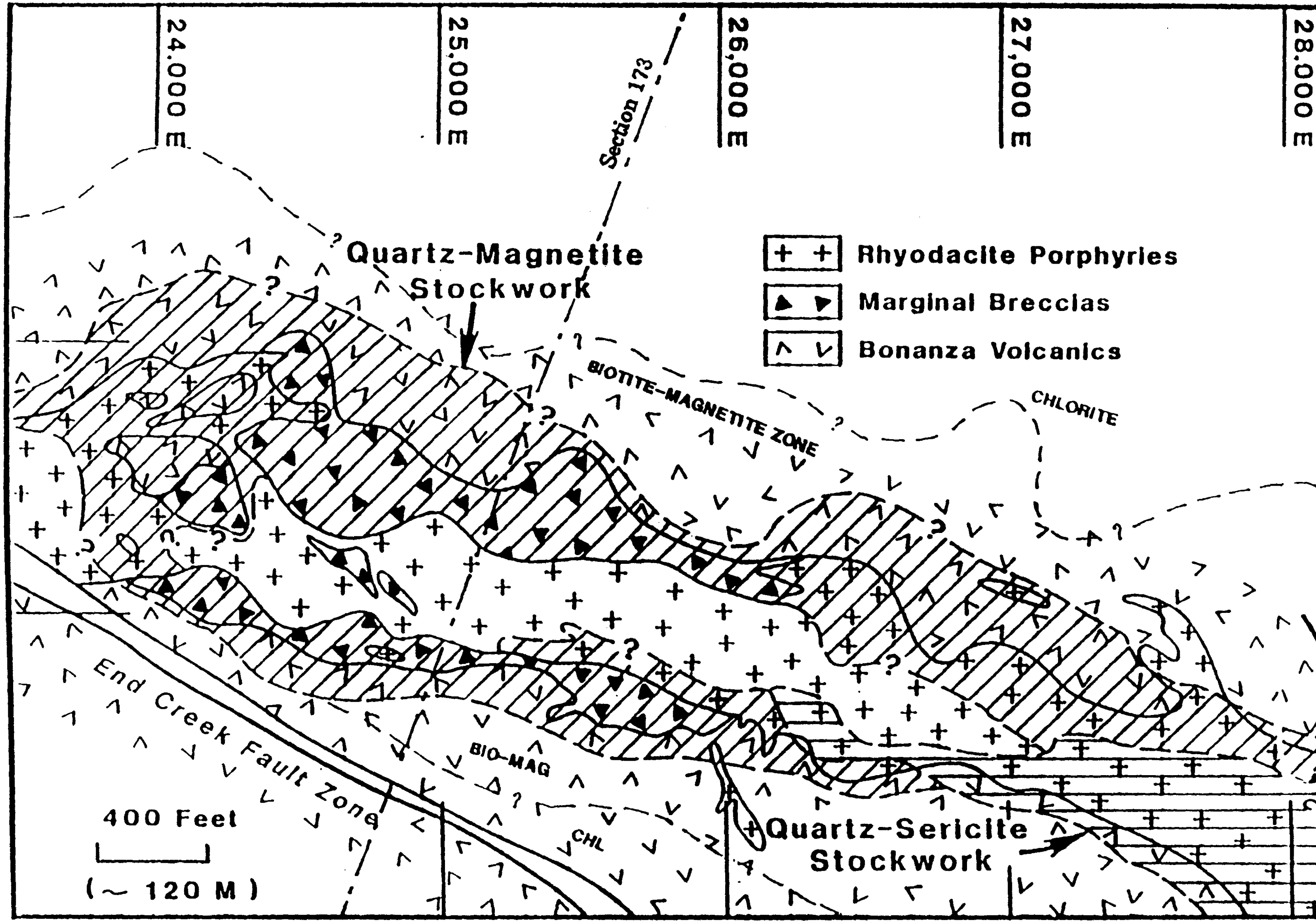


Figure 12. Pit plan geology (March 1989) of the Island Copper mine, nothern Vancouver Isl



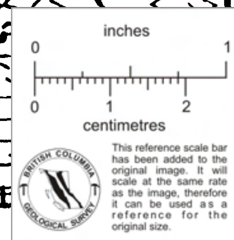


Figure 13. Detailed geology of the 560 bench, Island Copper mine, northern Vancouver Island.

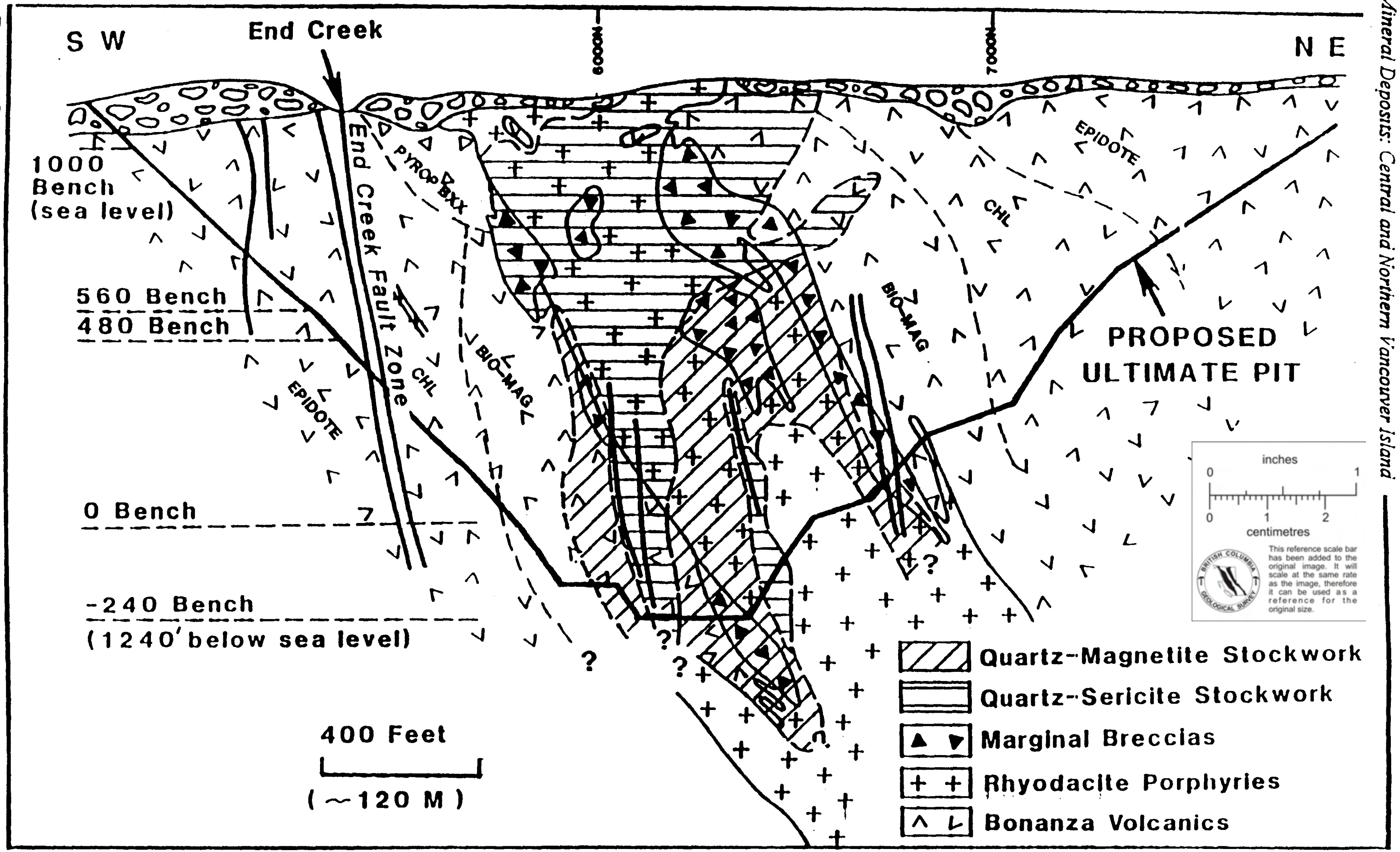


Figure 14. Detailed geology of section 173 west, Island Copper mine, northern Vancouver Island.

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.

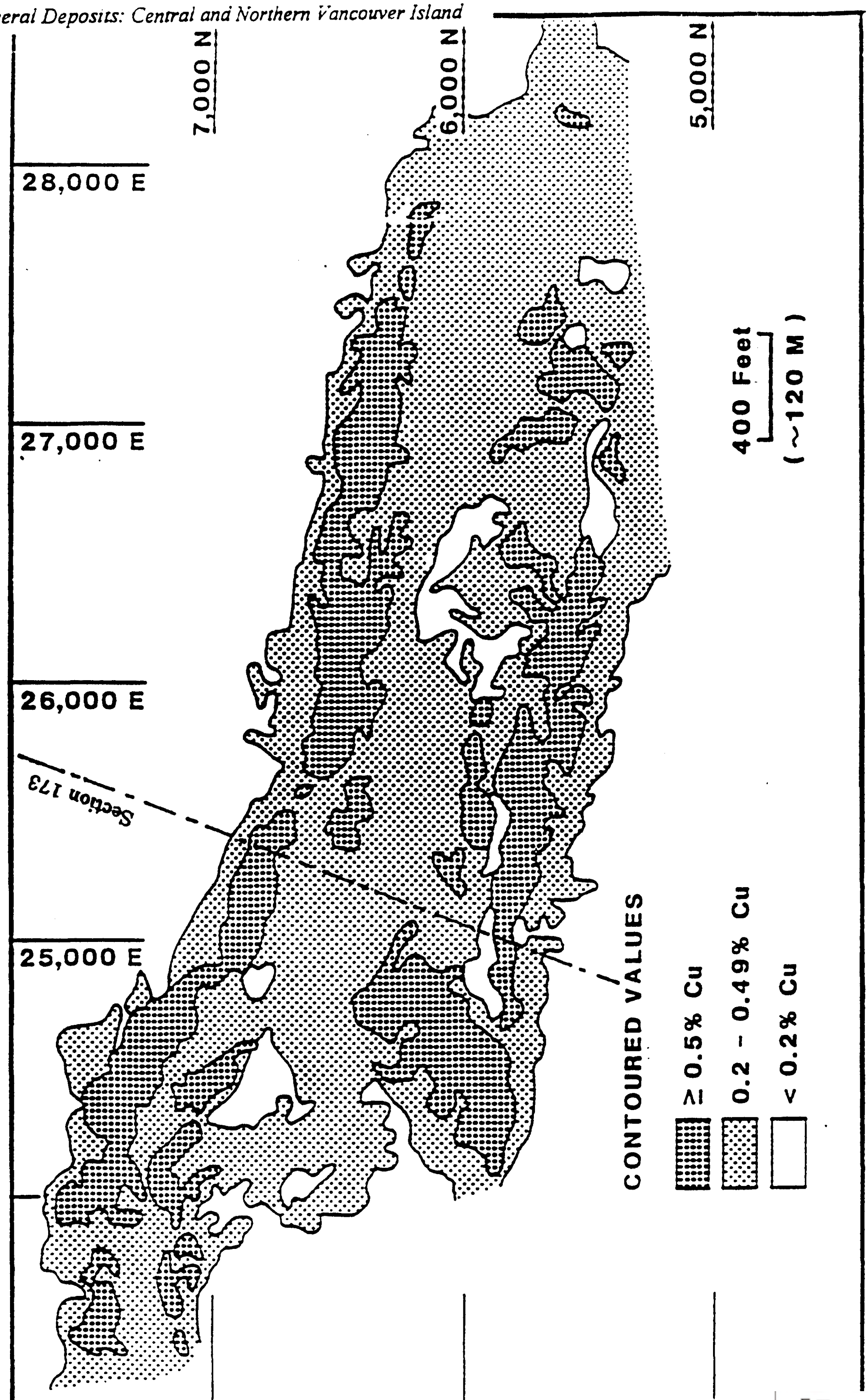


Figure 15. Contoured copper values, 560 bench, Island Copper mine, northern Vancouver Island.

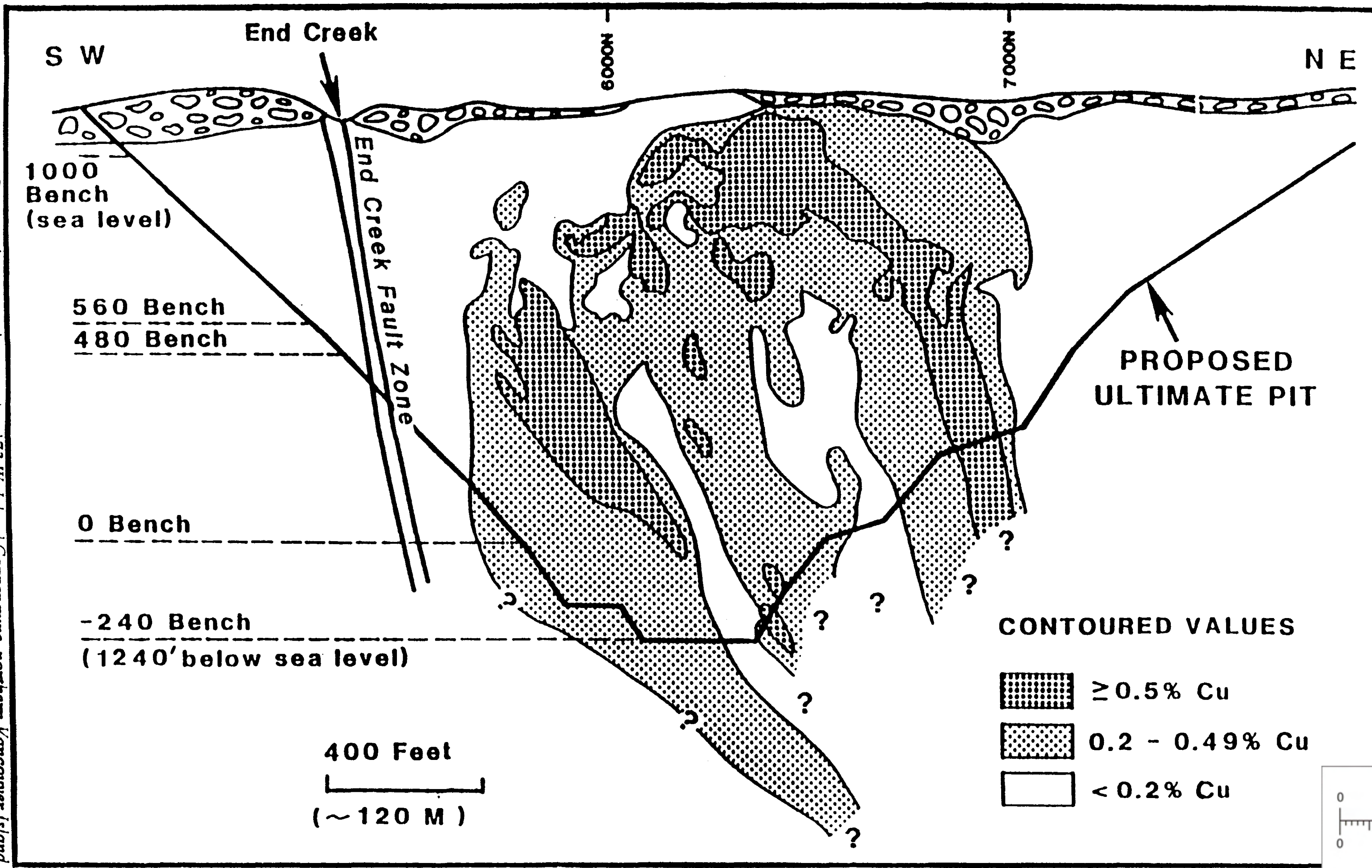


Figure 16. Contoured copper values, section 173 W, Island Copper mine, northern Vancouver Island.

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 ($An_{30\text{-}40}$) 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

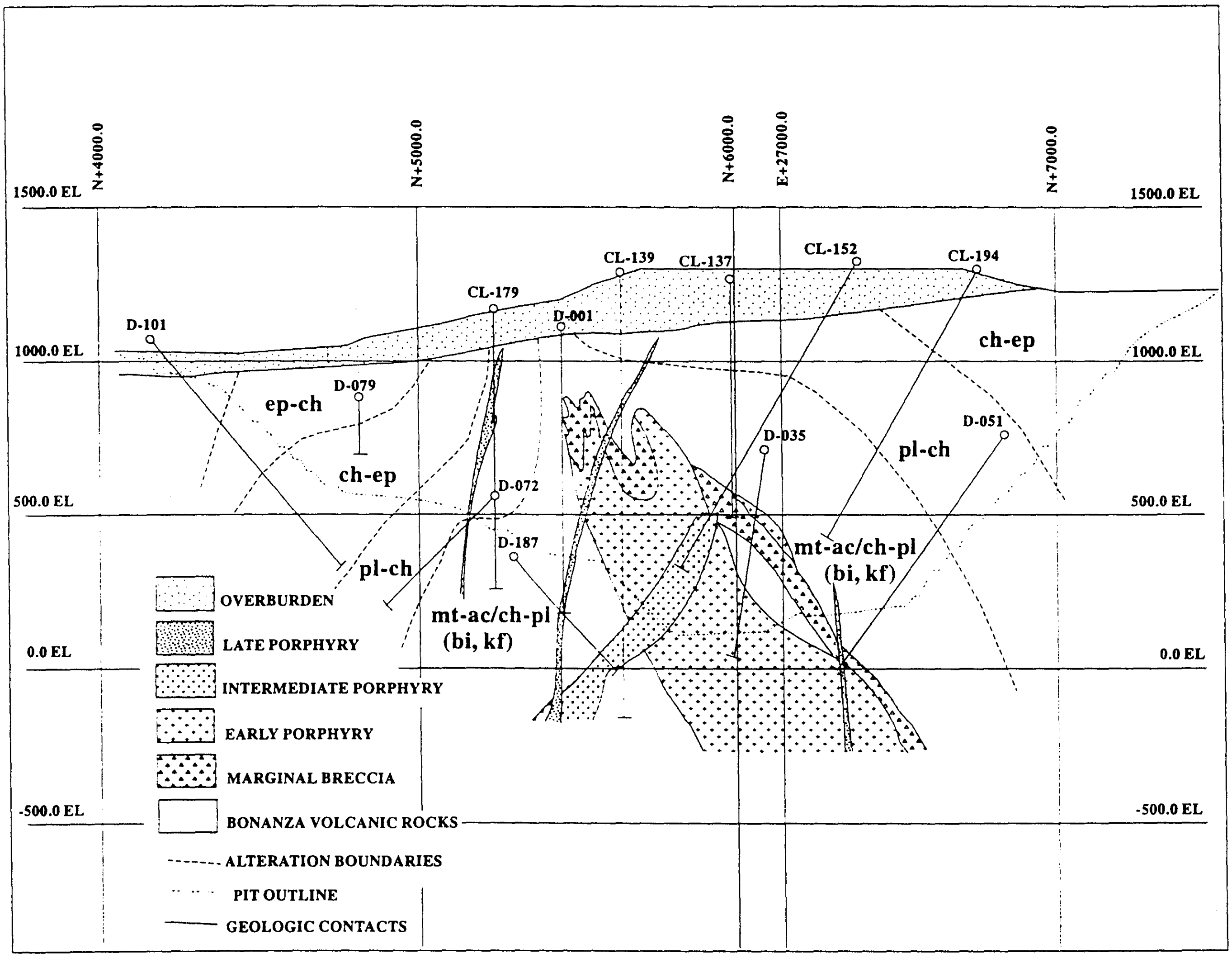


Figure 1. *Cross-section 155W at about 27000 E through the east-central part of the Island Copper deposit to illustrate interpreted geology and alteration zoning. All co-ordinates are in feet (vertical scale same as horizontal scale); mine elevations, used for pit bench designation, are relative to a 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.

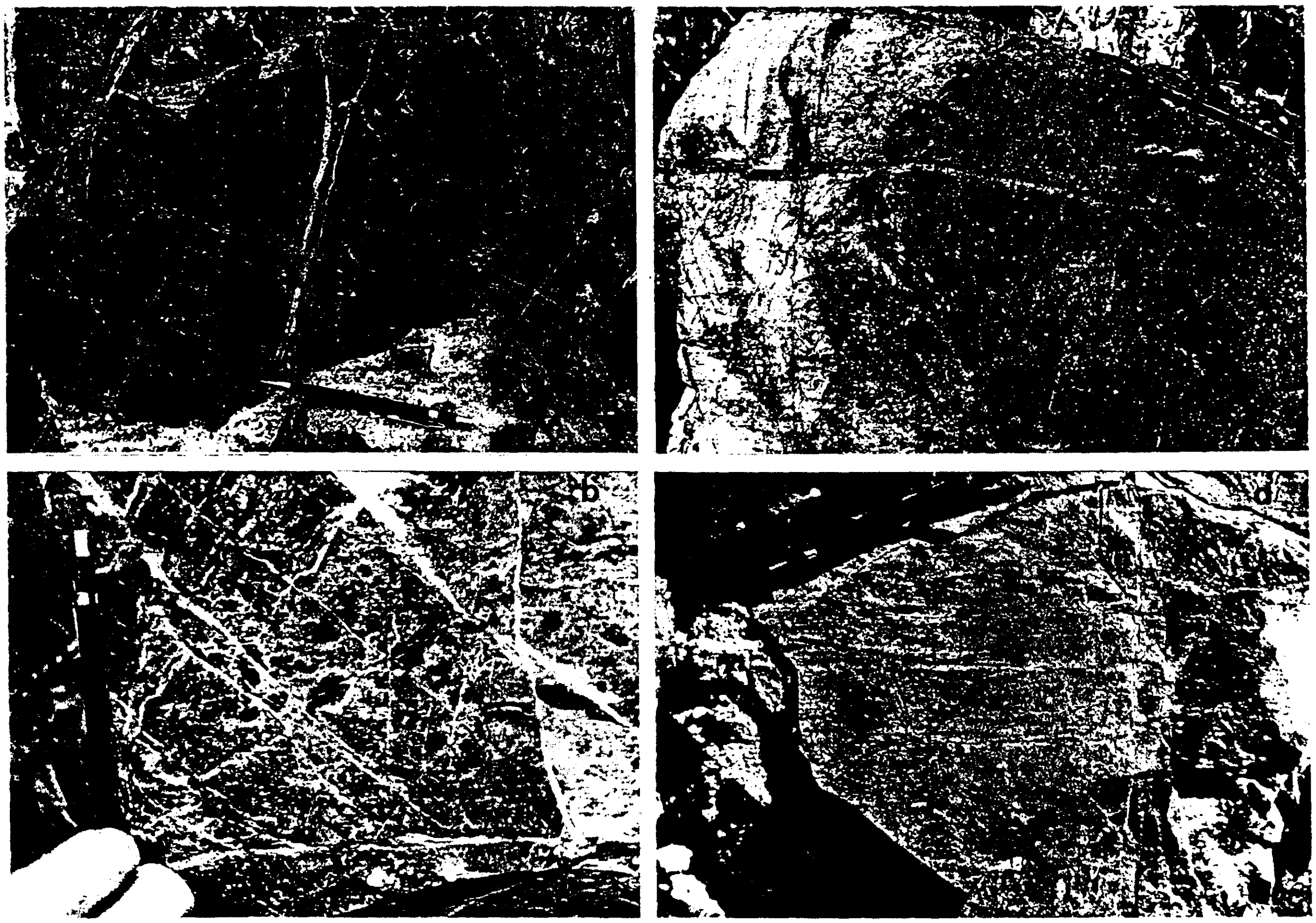
b) Contact of late porphyry (grey, rare white calcite-zeolite veins) with early porphyry (darker grey, intensely magnetite stockworked) at 469.8' and then of early porphyry with intensely magnetite-actinolite-chlorite altered Bonanza volcanics (black, cut by white calcite-zeolite fractures and grey quartz-sericite-pyrite-clay 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).*

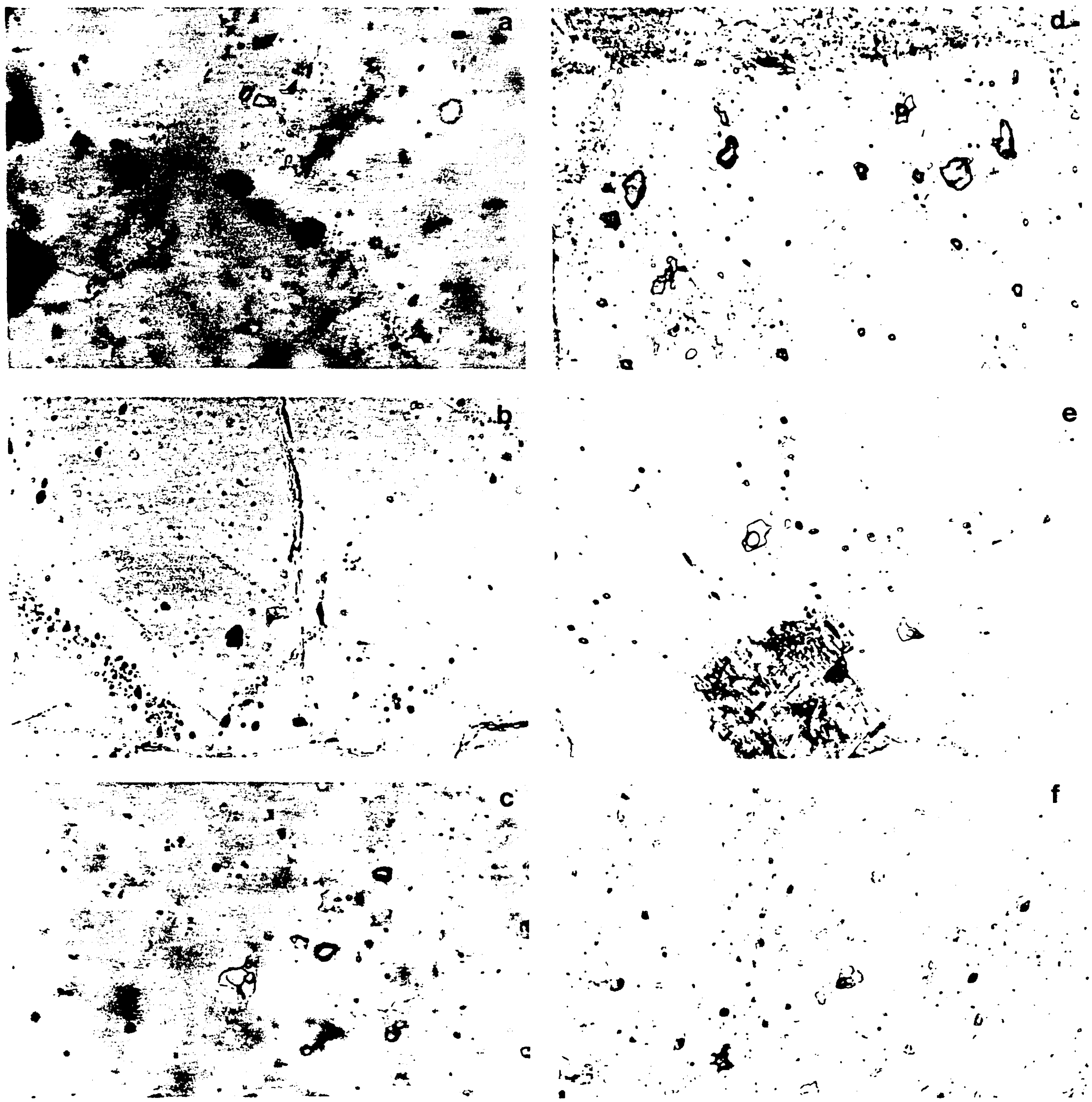
c) *Magnetite-quartz stockwork (dark) in porphyry (east end of pit, 160 level). Bleached area is due to later quartz-sericite-pyrite±clay alteration.*

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.

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