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Project: Equity Silver Mines - 1987 Core Samples

Samples: 87-P-1 -179, -193.5, -197.3, -223, -287, -288, -301.5, -399, -462, -492.3
87-P-2 -58.5, -65, -94.5, -120.1, -138, -160, -223, -245, -247, -272.5, -363
87-B-3 -266, -301, -481, -487

Summary:

The rocks are divided into the following types:

1. Porphyritic Latite/Dacite Dike

Phenocrysts of plagioclase and much fewer of biotite, quartz, and hornblende are set in a groundmass dominated by plagioclase with lesser sericite, quartz, dolomite, and in part, K-feldspar. Mafic phenocrysts are altered completely to muscovite/sericite-dolomite-(Ti-oxide). Plagioclase is altered slightly to sericite and dolomite.

87-P-1 179

87-P-1 193.5 flow banded, coarser grained bands with K-feldspar, finer grained band without

2. Altered Ultramafic Rocks

ranging from serpentinized peridotite and dunite to talc-carbonate altered rocks to dolomite-quartz-sericite altered rocks; altered rocks mostly contain relic chromite. Serpentinite contains magnetite (partly altered to hematite); some samples show relic magmatic textures. Strongly altered rocks commonly strongly sheared and tightly folded. Veins of serpentine, carbonate, talc and quartz are common. A few samples contain quartz-barite veins. Arsenopyrite, pyrite and much less chalcopyrite form minor dissemination grains in many of the altered ultramafic rocks.

(continued)

2A. Serpentinite

In a few samples relic magmatic textures are preserved. With increasing degree of deformation, these are destroyed as serpentine is recrystallized.

87-P-2 160	dunite/peridotite; patchy alteration to magnesite-talc
87-P-2 223	dunite; patches and veins of magnesite-talc
87-P-2 245	dunite; more strongly altered to magnesite-talc
87-B-3 266	peridotite; olivine-orthopyroxene; veins of carbonate-talc

2B. Carbonate-Talc Alteration

Carbonate probably is magnesite; however, optical properties cannot distinguish it from dolomite. Carbonate is indicated as magnesite in talc-carbonate alteration, and as dolomite or carbonate in carbonate-quartz-(sericite) alteration. Ankerite is tentatively distinguished on the basis of higher relief. Likewise, talc and sericite are similar optically; talc is indicated in talc-magnesite alteration, and sericite (and locally mariposite) is indicated in rocks with quartz.

87-P-2 245	with relics of serpentine

2C. Dolomite-Chert Alteration (sericite noted where abundant)

87-P-1 197.3	abundant dolomite-quartz veins, no chromite
87-P-1 223	brecciated dolomite; mariposite seams; two unidentified sulfides, no chromite
87-P-2 94.5	veins of dolomite-quartz, quartz-barite
87-P-2 120.1	quartz-barite veins
87-P-2 138	ankerite-quartz-sericite; quartz-barite veins
87-P-2 247	minor quartz-barite veinlet, minor pyrite
87-P-2 272.5	breccia; carbonate-quartz altered ultramafic rock fragments in quartz-carbonate-chalcedony groundmass
87-B-3 481	quartz-dolomite veins
87-B-3 487	dolomite-quartz-sericite; dolomite-(kaolinite quartz) veins

3. Chert with Dolomite-Quartz Replacement

These samples are dominated by chert, cut by veins and replacement patches of dolomite-quartz. They probably have a different origin from the samples in Group 2, but similarities to the dolomitic-quartz-sericite alteration assemblage suggest that they may be related.

87-P-1 287	seams of carbonaceous opaque and of pyrite
87-P-1 288	seams of sericite-opaque-quartz with lenses of andesite; veins of dolomite-(kaolinite)

4. Dacite to Andesite Crystal Tuff, Tuffaceous Sediments

Rocks contain angular fragments of plagioclase, lesser quartz, and much less other minerals in an extremely fine grained tuffaceous groundmass.

87-P-1 399	abundant fragments of andesite flow; dolomitic groundmass; dolomite and calcite veins
87-P-1 462	andesitic tuffaceous sediment; veinlets of chlorite-calcite
87-P-1 492.3	bedded andesite tuff, one graded bed; veins of calcite-(chlorite-quartz-pyrite)
87-P-2 65	sheared cherty dacite tuff; ankerite alteration, quartz-ankerite veins
87-P-2 363	metamorphosed dacite tuff, brecciated, with veins of ankerite
87-B-3 301	metamorphosed dacite crystal tuff, quartz-dolomite veins

5. Volcanic Flow Rocks

87-P-1 301.5	andesite flow, wispy seams of pyrite; replacement patches of dolomite, and lenses of quartz-dolomite
87-P-2 58.5	metamorphosed dacite (?) : quartz-albite-sericite-ankerite-pyrite alteration; quartz-(dolomite) veins

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87-P-1 179 Porphyritic Latite/Dacite

The rock contains phenocrysts of plagioclase and lesser biotite, quartz and hornblende in a groundmass of very fine grained plagioclase with lesser sericite and much less dolomite and quartz. Alteration of plagioclase phenocrysts is slight to moderate to sericite and lesser dolomite. Mafic phenocrysts are altered to muscovite-dolomite.

phenocrysts	
plagioclase	17-20%
biotite	3- 4
hornblende	1
quartz	1
Ti-oxide	0.2
groundmass	
plagioclase	50-55
sericite	17-20
dolomite	4- 5
quartz	2- 3

Plagioclase forms subhedral to euhedral phenocrysts up to 2 mm in size and clusters of similar phenocrysts. Composition probably is oligoclase. Alteration is variable from slight to moderate to extremely fine grained sericite and lesser patches of dolomite.

Biotite forms ragged to subhedral flakes up to 1.5 mm in size. It is altered completely to pseudomorphic muscovite with lenses and patches of dolomite and minor lenses of Ti-oxide parallel to cleavage.

Quartz forms a few anhedral phenocrysts, commonly with subrounded and slightly embayed borders. Most are from 0.1-0.3 mm in size, and one large one is 2 mm long.

Hornblende forms subhedral to euhedral phenocrysts from 0.5-0.8 mm in size. It is replaced completely by dolomite with lesser sericite and minor Ti-oxide.

Ti-oxide forms scattered, equant patches averaging 0.1-0.2 mm in size, with a few up to 0.4 mm across.

In the groundmass, plagioclase forms anhedral, slightly interlocking grains averaging 0.03-0.1 mm in size. Sericite forms ragged flakes and clusters of flakes averaging 0.05-0.1 mm in length. Dolomite forms irregular patches averaging 0.2-0.3 mm in size, and a few up to 0.9 mm across. Quartz forms disseminated grains averaging 0.02-0.05 mm in size. Apatite forms subhedral prismatic grains up to 0.12 mm long. Pyrite forms an extremely fine grained lens in one biotite flake. It also occurs in some patches of Ti-oxide, probably as a replacement of Ti-oxide or parent ilmenite.

87-P-1 193.5 **Color-Banded Porphyritic Latite**

The rock contains phenocrysts of plagioclase and minor biotite, quartz, and hornblende in a groundmass of plagioclase with minor K-feldspar and quartz, commonly concentrated in lenses, patches of ankerite and minor disseminated pyrite. Color banding (in hand sample) from pale to medium greyish green probably is caused by variation in grain size of the groundmass, with the darker color existing in layers with the finer grained groundmass.

phenocrysts		
plagioclase	12-15%	
quartz	1- 2	(more in offcut block than in thin section)
biotite	Ø.5	
hornblende	Ø.5	
apatite	trace	
Ti-oxide	trace	
groundmass		
plagioclase	6Ø-65	
K-feldspar	1Ø-12	
quartz	3- 4	
sericite	4- 5	
dolomite	3- 4	
apatite	Ø.2	
pyrite	Ø.1	

Plagioclase forms subhedral to euhedral phenocrysts from Ø.7-1.5 mm in average size. It is altered slightly to locally moderately to sericite. Cores of many phenocrysts are replaced completely by patches of extremely fine grained kaolinite with minor to moderately abundant dusty Ti-oxide and/or hematite.

Quartz forms a few equant to elongate phenocrysts up to 2 mm in size. It is more abundant in the stained offcut block than in the thin section.

Biotite forms a few subhedral phenocrysts up to 1 mm in size. It is replaced completely by muscovite with patches of dolomite and disseminated euhedral grains of Ti-oxide.

Hornblende forms a few euhedral phenocrysts in clusters up to 1 mm across. It is altered completely to extremely fine grained sericite with patches of dolomite/ankerite, and disseminated, euhedral equant grains of Ti-oxide and prismatic apatite.

Apatite forms a few elongate prismatic phenocrysts up to Ø.3 mm long. Ti-oxide forms equant patches up to Ø.4 mm in size.

The groundmass is variable. At one end of the section, layers are dominated by extremely fine grained (Ø.Ø1-Ø.Ø2 mm) plagioclase, with moderately abundant sericite and irregular patches of ankerite/dolomite. At the other end, the groundmass is somewhat coarser grained, consisting of equant, slightly to strongly interlocking plagioclase and K-feldspar grains averaging Ø.Ø7-Ø.15 mm in size, with minor quartz averaging Ø.Ø3-Ø.Ø7 mm in size. Plagioclase is altered slightly to moderately to sericite, and dolomite forms irregular replacement patches. Dusty hematite is common, and is concentrated in certain grains. Apatite forms subhedral to euhedral prismatic grains averaging Ø.Ø3-Ø.Ø7 mm in length. Pyrite forms disseminated anhedral to subhedral grains averaging Ø.Ø3-Ø.15 mm in size.

Quartz is concentrated in a few pods and lenses up to Ø.3 mm in size. These are aggregates of very fine grains. A few of these patches also contain dolomite and/or K-feldspar.

87-P-1 197.3 **Siliceous Dolomite with Abundant Veins of Dolomite-Quartz: Probably Altered Ultramafic Rock**

The rock is an extremely fine grained aggregate of quartz and dolomite, with wispy, contorted seams of carbonaceous opaque with minor pyrite. It is cut by very abundant veins of dolomite and/or quartz of at least three ages. The original rock type is uncertain because of the absence of chromite. However, based on similarities with other samples, it probably was an ultramafic rock.

quartz	20-25%
dolomite	30-35
carbonaceous opaque	1
pyrite	0.1
veins	
dolomite	30-35
quartz	8-10

The rock consists of extremely fine grained (0.005-0.015 mm) cherty quartz intergrown with finer grained (0.002-0.01 mm) dolomite. The ratio of these two minerals varies moderately, and in places it appears that quartz-rich zones were replaced by dolomite.

The rock contains irregular, wispy, contorted seams up to 0.05 mm wide dominated by carbonaceous opaque with scattered anhedral grains of pyrite averaging 0.01 mm in size. Pyrite locally is concentrated in patches of quartz-rich rock up to 0.8 mm across as grains up to 0.02 mm in size. Elsewhere it forms anhedral to euhedral disseminated grains averaging 0.01 mm in size.

A few sets of veins range from less than 0.02 to over 2 mm in width. These consist of various combinations of dolomite and quartz. Grain size in the veins ranges from extremely fine to fine (locally up to 0.8 mm). Many of the veins are lensy and discontinuous on the scale of the thin section.

Some early-formed, banded, possibly replacement veins of cryptocrystalline dolomite up to 0.9 mm wide are cut by veins up to 0.4 mm wide of extremely fine grained (0.01-0.02 mm) dolomite.

The largest vein zone consists of very fine to fine grained dolomite with much less quartz; it was sheared strongly in a banded zone, in which dolomite was recrystallized to an extremely fine grained granular aggregate.

One vein up to 2 mm wide consists of fine grained quartz and dolomite in variable but overall about equal amounts. It has a center-line up to 0.15 mm wide of extremely fine grained dolomite.

87-P-1 223 **Brecciated Dolomite with Mariposite(Cr-mica)-Rich Seams: Probably Replacement of Ultramafic Rock; Two Unidentified Sulfides**

The rock is a fine to medium grained dolomite which was strongly brecciated and granulated. Seams rich in mariposite (Cr-mica) and lesser pyrite and carbonaceous opaque are common. The original rock probably was ultramafic, but no relic chromite is present to confirm this hypothesis. Two unidentified reflective minerals are present, one similar to chalcopyrite but strongly anisotropic (possibly cubanite), and the other with no distinctive properties, may be a sulfide or sulfo-salt.

dolomite	80-85%
mariposite	5- 7
quartz	3- 4
Mineral X	0.4
Mineral Y	0.1
carbonaceous(?) opaque	0.2
Ti-oxide	trace
veins	
dolomite-(quartz)	4- 5

Dolomite forms patches up to a few mm across of grains averaging 0.2-0.5 mm in size. These are strained strongly. and partly recrystallized to subgrain aggregates. They cut by abundant fractures of, and surrounded by extremely fine grained dolomite, which was formed by granulation of the coarser grained aggregate.

Quartz forms extremely fine grained patches scattered through the rock. Many of these have a chert texture.

A few coarser grained patches and veins consist of fine to very fine grained dolomite intergrown with minor to moderately abundant very fine grained, subhedral quartz.

Mariposite forms extremely fine grained aggregates concentrated in moderately crenulated seams up to 0.4 mm wide. It is pale green in color, with optical and textural prcperties similar to those of sericite. Associated with mariposite are seams of dusty opaque (carbonaceous?) and scattered patches up to 0.1 mm in size of Ti-oxide.

Mineral X forms lenses up to 0.2 mm in length of anhedral grains averaging 0.02-0.03 mm in size. In some patches it is intergrown coarsely with Mineral Y. Mineral X is light yellow in color, with low hardnese, moderately high reflectivity and strong anisotropism. The mineral which best fits these properties is cubanite

Mineral Y occurs with Mineral X as described above, and also is the major reflective minenal in one patch of coarser dolomite-(quartz), in which it forms one equant grain 0.13 mm across and several much smaller ones. It is light grey in color with moderate reflectivity, isotropic nature, and low hardness. Several sulfides and sulfo-salts have these properties.

The elemental components of these minerals could be determined using the electron microscope.

87-P-1 287 **Chert cut by Veins of Dolomite and Quartz, with Seams and Patches of Carbonaceous Opaque and of Pyrite, one Plagioclase-rich Lens**

The rock contains two main types of chert, which are replaced largely by patches and veins of dolomite and quartz. The rock is cut by seams up to as few mm wide dominated by sericite, carbonaceous opaque and cherty quartz. Plagioclase is concentrated in one lens up to 1.5 mm wide. Pyrite and carbonaceous opaque form disseminated patches.

chert	25-30%
quartz	20-25
dolomite	30-35
sericite	7- 8
plagioclase	2- 3
carbonaceous opaque	3- 4
pyrite	0.5
chalcopyrite	trace

Much of the original rock consisted of extremely fine grained, massive chert with grain size from 0.003-0.01 mm. It is strongly replaced and cut by coarser grained quartz and dolomite patches and veins, respectively. Replacement quartz is up to 0.5 mm in size, and contains abundant dusty opaque inclusions. Dolomite is mainly very fine to extremely fine grained.

At one end of the section, chert is cryptocrystalline (0.002-0.005 mm), and shows a prominent foliation marked by dusty seams of carbonaceous opaque. It is cut by abundant early veins of extremely fine grained dolomite from 0.02-0.3 mm in width, and some later veins of very fine to fine grained dolomite averaging 0.1-0.4 mm wide. The pink-brown mineral in hand sample is dolomite.

The rock is cut by irregular, in part crenulated seams up to a few mm wide dominated by extremely fine grained sericite mixed with dusty to very fine grained carbonaceous opaque and lesser quartz. Other seams and veinlike zones are dominated by very fine grained dolomite. Some contain minor grains of pyrite and of chalcopyrite up to 0.03 mm in size.

Pyrite is concentrated in disseminated patches up to 0.6 mm across, commonly surrounded by and intergrown with quartz. Pyrite forms anhedral to euhedral grains averaging 0.02-0.1 mm in size. Quartz commonly is oriented perpendicular to crystal faces of coarser pyrite grains. Chalcopyrite forms disseminated grains up to 0.03 mm in size in dolomite and quartz aggregates.

One large patch up to 3 mm across and a few smaller ones consist of very fine to extremely fine grained carbonaceous opaque. Along borders of the large patch and in the smaller patches opaque grains are intergrown with and surrounded by dolomite end quartz. Carbonaceous opaque also forms disseminated patches up to 0.2 mm in size away from the main clusters.

A lens up to 2 mm wide and 3 mm long contains abundant anhedral equant plagioclase grains averaging 0.1-0.2 mm in size. Intergrown with plagioclase is minor interstitial quartz. The lens is brecciated and replaced slightly to moderately by dolomite, with lesser sericite and carbonaceous opaque. Another lens up to 2 mm long consists of very fine grained prismatic to lathy plagioclase from 0.05-0.15 mm long in a groundmass of anhedral, equant plagioclase averaging 0.002-0.005 mm in size, with abundant dusty Ti-oxide concentrated in interstitial seams.

87-P-1 288 **Chert Replaced by Quartz-Dolomite, Cut by Seams of Sericite-Opaque-(Quartz) containing Lenses of Andesite; Veins of Dolomite-(Kaolinite)**

The sample is similar to Sample 87-P-1 287. Chert is replaced strongly by quartz and lesser dolomite patches. The rock contains seams of sericite-opaque, associated with which are lenses of andesite dominated by plagioclase, and veins of dolomite. A few late veins are of dolomite-(kaolinite).

chert	12-15%	
quartz	50-55	
dolomite	20-25	
sericite	5- 7	
carbonaceous opaque	1- 2	
plagioclase	3- 4	(andesite)
Ti-oxide	minor	
pyrite	minor	
chalcopyrite	trace	
veins		
dolomite-kaolinite	0.5	

Chert forms relic patches up to 2 mm across. These contain zones averaging 0.002-0.005 mm in grain size, which grade upwards in size to less abundant patches averaging 0.02-0.05 mm in grain size. Dolomite forms veinlets and replacement patches in chert. Chert is replaced in large patches by fine to medium grained quartz with lesser dolomite. Quartz shows strained extinction and contains moderately abundant dusty opaque.

The rock is cut by seams up to a few mm across containing seams of sericite-carbonaceous opaque-quartz, lenses of plagioclase-rich andesite, subrounded fragments of chert, and veinlike zones of dolomite. Plagioclase-rich lenses contain prismatic phenocrysts up to 0.2 mm long in a sparse to abundant groundmass of extremely fine grained plagioclase with locally minor to moderately abundant dolomite, sericite, and carbonaceous opaque.

Dolomite forms seams of very fine to extremely fine grain size parallel to and possibly in part replacing sericite-rich seams.

Pyrite forms disseminated grains up to 0.07 mm in size, mainly concentrated in sericite-rich seams. Chalcopyrite forms disseminated grains averaging 0.02-0.03 mm in size, with a few up to 0.1 mm long.

The rock is cut roughly perpendicular to foliation by veins up to 0.2 mm wide dominated by very fine grained dolomite, with a few patches up to 0.2 mm across of extremely fine grained kaolinite. Some dolomite veins cutting quartz are truncated against seams of sericite/carbonaceous opaque.

87-P-1 301.5 **Andesite Flow, Replaced by Dolomite, with Lenses of Dolomite and of Quartz-(Dolomite)**

The rock is a very fine grained andesite flow dominated by lathy plagioclase in a groundmass of extremely fine grained plagioclase with lesser chlorite, dolomite, and Ti-oxide. Pyrite is concentrated in wispy, contorted seams and patches. The rock is replaced by dolomite; where replacement is strong, the color of the rock is light grey. The rock contains replacement lenses (veinlets) of dolomite and of quartz-(dolomite).

plagioclase	50-55%
chlorite	5- 7
Ti-oxide	0.5
pyrite	1- 2
chalcopyrite	trace
dolomite	30-35
quartz	4- 5

Plagioclase forms unoriented, lathy grains from 0.1-0.3 mm in length. Some are slightly warped, and a few are replaced by quartz.

The groundmass is extremely fine grained (0.002-0.01 mm), and consists of plagioclase, dolomite, chlorite, and minor Ti-oxide. Chlorite forms clusters of colorless flakes with low birefringence. Dolomite forms irregular replacement patches throughout the rock. Where dolomite replacement is strong, chlorite is replaced completely, and the rock has a pale grey color. The outlines of zones of strong dolomite replacement are sharp in the hand sample, but much less obvious in thin section. Ti-oxide forms disseminated grains averaging 0.005-0.01 mm in size.

Pyrite is concentrated in wispy, in part strongly contorted seams averaging 0.05-0.1 mm in width. One patch up to a few mm scross contains very abundant pyrite, mainly as anhedral to subhedral grains averaging 0.02-0.04 mm in size, with a few up to 0.2 mm across.

Chalcopyrite forms a very few grains averaging 0.01-0.03 mm in size, mainly associated with dolomite.

Dolomite forms replacement lenses up to 1.5 mm wide of very fine grained aggregates. Quartz forms a few lenses up to 1 mm wide of very fine to fine grained aggregates, commonly partly replaced by dolomite and cut by veinlets of dolomite.

87-P-1 399 **Andesite Tuff with Dolomite Alteration and Dolomite-Calcite Veins**

The rock contains fragments of plagioclase phenocrysts, andesite flow, chlorite-(opaque), leucoxene, and minor andesite tuff in a groundmass of extremely fine grained dolomite. It is cut by discontinuous veins up to 1 mm wide of dolomite and/or calcite.

fragments	
plagioclase	10-12%
andesite flow	25-30
andesite tuff	minor
chlorite-rich	2- 3
chlorite-(opaque)	1- 2
leucoxene	1
groundmass	
dolomite	40-45
pyrite	1
veins	
dolomite	7- 8
calcite	2- 3
quartz	0.1

Plagioclase phenocrysts and crystal fragments average 0.3-0.5 mm in size, with a few up to 1 mm long. Some are relatively fresh, and others are altered slightly to moderately to dolomite. A few are altered moderately to sericite. Dolomite veinlets are common in larger phenocrysts.

Fragments of andesite flows are from 0.3-0.7 mm in size. They are characterized by an extremely fine grained groundmass of plagioclase and chlorite with minor Ti-oxide. Many contain phenocrysts of plagioclase from 0.1-0.3 mm in size. A few are dominated by very fine grained prismatic plagioclase.

Several fragments up to 1 mm long are dominated by extremely fine grained chlorite. Other fragments up to 0.2 mm across consist of chlorite and moderately abundant Ti-oxide; these probably are secondary after hornblende.

Leucoxene forms anhedral patches up to 0.3 mm in size.

Pyrite forms a few clusters averaging 0.2-0.3 mm across of grains averaging 0.05-0.1 mm in size. One much larger cluster up to 1.7 mm long and 0.8 mm wide contains abundant anhedral to subhedral pyrite grains and fragments surrounded by groundmass dolomite.

The original groundmass and parts of many of the fragments are replaced by a groundmass of extremely fine grained dolomite.

The rock is cut by numerous veins and veinlets of carbonate. Most of these are discontinuous on the scale of the thin section. Many show textures suggestive of shear deformation after vein emplacement. Veins range from dolomite-rich (commonly strongly sheared) to calcite rich (generally coarser grained and less strongly sheared). One calcite-rich vein contains a few patches of very fine grained quartz.

A few late seams of calcite up to 0.03 mm wide are post-deformation.

87-P-1 462 **Andesite Tuffaceous Sediment cut by Veinlets of Chlorite-Calcite**

The rock contains angular fragments of plagioclase in an aphanitic groundmass probably of andesitic composition, and containing dusty brown to opaque material which gives the rock its black color. It is cut by veins and veinlets dominated by chlorite and others dominated by calcite. Pyrite form lenses with framboidal textures.

fragments	
plagioclase	20-25%
quartz	0.5
silica (chert)	0.3
volcanic glass (?)	minor
groundmass	
plagioclase-(chlorite)(?)	60-65
brown semiopaque/opaque	5- 7
pyrite	0.3
chalcopyrite	minor
Ti-oxide	minor
veins	
chlorite-calcite	4- 5

Plagioclase forms angular fragments averaging 0.02-0.03 mm in size. These most probably are fragments of phenocrysts from an andesitic source. A few lenses contain much more abundant fragments averaging 0.03-0.08 mm in size. As well as plagioclase, these lenses contain fragments of brown volcanic glass(?), chert, and quartz grains. Elsewhere in the rock quartz forms scattered equant fragments averaging 0.02-0.03 mm in size.

The fragments are set in a groundmass of uncertain composition (because of its grain size [0.001-0.005 mm]), probably dominated by plagioclase and lesser chlorite. Brown semiopaque/opaque forms dusty disseminations of varying intensity, and is moderately concentrated in lensy patches and lenses in parts of the section. Locally it forms dense patches up to 0.3 mm in length.

The rock contains an unusual J-shaped lens 1 mm long and 0.12 mm wide of extremely fine grained silica.

Pyrite forms disseminated grains averaging 0.005-0.01 mm in size. A few lenses from 0.2-0.4 mm long, and one irregular veinlike zone up to 1.2 mm long contain framboidal pyrite aggregates ranging in diameter from 0.001-0.008 mm. A few patches up to 0.06 mm across contain subhedral cubic pyrite grains 0.008 mm in size in a sparse groundmass.

Chalcopyrite forms disseminated grains averaging 0.01-0.02 mm in size, both in the rock and in the veins.

Ti-oxide forms a few equant grains averaging 0.02 mm across.

The rock is cut by veins up to 0.8 mm wide of very fine to extremely fine grained chlorite with minor to moderately abundant patches of very fine grained calcite. Other veins are dominated by calcite; these are mainly less than 0.2 mm wide, but locally widen rapidly to 0.8 mm (at the edge of the section).

No evidence was seen to suggest that the rock was hornfelsed.

87-P-1 492.3 **Bedded Andesite Tuff cut by Calcite-(Chlorite-Quartz-Pyrite) Vein and Calcite Veinlets**

The rock contains three main beds of andesite tuff, ranging from extremely fine to fine grained. The central layer shows well developed graded bedding. The rock is cut by a vein of calcite with lesser chlorite and much less quartz and pyrite, and several veinlets of calcite.

coarse layer (fragments average 0.3-1 mm in size)

fragments	
plagioclase	15-20%
andesite/latite	15-20
sericite-altered andesite?	10-12
carbonate-altered andesite	5- 7
chlorite	3- 4
calcite	2- 3
groundmass	
plagioclase-chlorite	20-25
dusty opaque	2- 3

Plagioclase grains are phenocrysts from andesite flows. Alteration is variable, with most grains altered slightly to sericite and/or calcite.

Andesite fragments are of several types. Many have plagioclase phenocrysts in an extremely fine grained groundmass of plagioclase and much less chlorite and opaque. In some fragments, groundmass plagioclase is well oriented. Grain size of the groundmass ranges from extremely fine to very fine, and textures range from subhedral to moderately interlocking. Some andesite fragments are altered moderately to calcite, and others are replaced strongly to completely by sericite or carbonate. From the stained offcut block, several fragments are seen to contain K-feldspar. This mineral was not identified in thin section. Its presence indicates that some of the volcanic fragments are of latite composition.

A few fragments up to 1.7 mm in size are dominated by extremely fine grained chlorite. The largest contain patches up to 0.7 mm in size of slightly coarser grain size and which contain minor to abundant pyrite inclusions; these may represent original mafic phenocrysts. They are surrounded by finer grained chlorite.

A few fragments up to 1 mm across are of single grains of calcite/dolomite.

The groundmass is too fine to identify optically. It probably is dominated by plagioclase and lesser chlorite, with moderately abundant dusty opaque.

Pyrite occurs in several fragments as disseminated, extremely fine grains and aggregates, and forms a few patches of even finer grains in the groundmass. It is concentrated in one patch 1 mm long as anhedral grains and aggregates of grains from 0.01-0.03 mm in size.

(continued)

central layer

Grains are mainly of plagioclase composition, with a few of muscovite, chlorite, Ti-oxide and of apatite. Except at the bottom of the layer, grains are very angular. Grain size ranges from an average of 0.1-0.3 mm at the base of the layer rapidly to 0.05-0.1 mm, and then gradationally to 0.01-0.03 mm near the top. Plagioclase is fresh to slightly altered to sericite and/or calcite. Pyrite forms moderately abundant disseminated grains in the middle of the layer. The groundmass is aphanitic and probably composed of plagioclase and chlorite. Calcite forms minor to moderately abundant irregular replacement patches up to 0.1 mm in size. Dusty opaque is concentrated in a few wispy patches.

finest layer

This layer is slightly banded with minor gradation in grain size between sublayers. Angular fragments dominated by plagioclase average 0.03-0.07 mm in size, with a few grains over 0.1 mm long in the coarser grained sublayers. Sericite forms a few patches up to 0.2 mm in size; their origin is uncertain. The groundmass consists of plagioclase and chlorite with moderately abundant dusty brown semiopaque/opaque, and with minor to moderately abundant replacement patches up to 0.1 mm in size of calcite. Pyrite forms scattered framboidal clusters and seams parallel to foliation.

The rock is cut by several discontinuous veinlets from 0.02-0.15 mm in width of extremely fine grained calcite with scattered grains and clusters of pyrite up to 0.05 mm across.

The largest vein is mainly in the coarsest grained layer where it averages 0.8 mm wide. It is dominated by extremely fine to very fine grained calcite, with a core zone containing abundant very fine grained chlorite and lesser patches of very fine to extremely fine grained quartz. Pyrite forms several clusters of subhedral grains averaging 0.03-0.07 mm in size. One contains an inclusion of chalcopyrite 0.015 mm long. The vein narrows rapidly in the next bed, breaking into two braided, somewhat diffuse veinlets of calcite.

87-P-2 58.5 **Meta-dacite (?) with Quartz-Albite-Sericite-Ankerite Pyrite Alteration and Quartz-(Dolomite) Veins**

The rock was strongly replaced and deformed; as a result it is uncertain what if any of the present textures and minerals are original. Thus the origin of the rock is uncertain. It contains seams rich in sericite with lesser ankerite and pyrite-(chalcopyrite), and layers and patches dominated by coarser grained, generally strongly strained quartz and lesser albite and ankerite. Late veins are of quartz and minor dolomite.

quartz	50-55%
albite	12-15
sericite	8-10
ankerite-(dolomite)	12-15
pyrite	1- 2
chalcopyrite	minor
Ti-oxide	0.2
veins	
quartz	5- 7
dolomite	1

Quartz is most abundant as coarse grained replacement patches. These were strongly strained and partly recrystallized to very irregular subgrain aggregates. Some of the subgrain aggregates have a prominent foliation, indicating a high degree of shearing. Quartz also forms extremely fine to very fine grained patches intergrown with sericite and ankerite.

Albite forms anhedral grains averaging 0.2-0.7 mm in size. It is strained slightly, and albite twins commonly are discontinuous and slightly warped. Grains are fresh. Except for the presence of albite twins, albite is optically almost identical to quartz.

Ankerite forms extremely fine to very fine grained patches intergrown irregularly with finer grained, recrystallized quartz. Some of these have subhedral, rhombic outlines. Ankerite is characterized by very high relief. Dolomite forms coarser grained patches up to 1 mm across with grains up to 0.2 mm in size. It is tentatively distinguished from ankerite by lower relief.

Sericite is concentrated in irregular seams up to a few mm wide. In these it is intergrown with lenses and patches of extremely to very fine grained quartz and very fine grained albite, and patches and lenses of dolomite/ankerite. Carbonaceous opaque is concentrated in wispy seams and lenses.

Pyrite forms euhedral cubic grains averaging 0.1-0.2 mm in size, associated with sericite and extremely fine grained quartz, and less commonly with dolomite. Finer grained, anhedral pyrite forms irregular patches and lenses associated with sericite, and possibly associated with carbonaceous opaque. A few patches up to 1.5 mm across contain abundant extremely fine to very fine anhedral to euhedral grains of pyrite. A few larger pyrite grains contain an inclusion up to 0.02 mm across of chalcopyrite.

Ti-oxide forms a few equant grains up to 0.05 mm in size, and aggregates of much finer, anhedral grains, mainly associated with sericite. It is concentrated in a few lenses up to 0.4 mm long associated with sericite-rich seams.

Chalcopyrite forms disseminated grains up to 0.1 mm in size, commonly associated with pyrite.

The rock is cut by a few, late, subparallel veins up to 0.8 mm wide of fine to very fine grained quartz and minor to moderately abundant dolomite. Quartz grains are unstrained, indicating that the veins were formed after deformation.

87-P-2 65 **Sheared Cherty Dacite Tuff with Ankerite Alteration, cut by Quartz-Ankerite Veins**

The rock contains crystal fragments of quartz and plagioclase in an extremely fine grained, well foliated groundmass dominated by cherty silica, with lenses of sericite, patches of ankerite, and disseminated pyrite. Veins parallel and perpendicular to foliation consist of quartz and much less ankerite.

fragments			
plagioclase	3- 4		
quartz	1- 2%		
groundmass			
chert	45-50	Ti-oxide	0.2%
sericite	8-10	apatite	trace
ankerite	12-15	chalcopyrite	trace
pyrite	1- 2	Mineral Y	trace
veins			
1) quartz	5- 7	carbonaceous opaque	minor
ankerite	1- 2	chalcopyrite	trace
pyrite	minor		
2) calcite	trace		

Quartz and plagioclase form anhedral crystal fragments averaging 0.07-0.2 mm in size, with a few up to 0.3 mm across. Plagioclase is altered slightly to moderately to sericite. A few sericite-rich patches may represent completely altered plagioclase crystal fragments.

The groundmass is dominated by extremely fine grained quartz (0.003-0.008 mm). Sericite forms seams and lenses parallel to foliation. Coarser grained sericite (after plagioclase?) forms a few patches and lenses up to 0.3 mm wide. Ankerite forms extremely fine grained patches disseminated through the rock.

Pyrite forms a few euhedral grains averaging 0.07-0.15 mm in size, and more abundant anhedral to subhedral grains averaging 0.02-0.03 mm across. It is concentrated in a few lenses parallel to foliation as subhedral to euhedral grains from 0.03-0.1 mm in size. Chalcopyrite forms anhedral patches up to 0.05 mm in size. Associated with the largest cluster of chalcopyrite grains is a grain 0.04 mm across of an unknown sulfide(?). It is moderately reflective (slightly less than chalcopyrite), with low hardness, a light grey color, and isotropic nature. It may be the same mineral as Mineral Y in sample 87-P-1 223, and is grouped with it.

Ti-oxide forms lenses with subrounded outlines up to 0.15 mm in size, and disseminated, extremely fine grained patches and seams.

Apatite forms equant grains averaging 0.03-0.05 mm in size.

Opaque seams up to 0.05 mm wide are moderately abundant. Most are parallel to foliation, and those few which cross foliation are tightly crenulated. They contain minor patches of Ti-oxide and pyrite intergrown with non-reflective opaque (possibly carbonaceous).

The veins are up to 1.5 mm wide and are dominated by very fine to fine grained quartz, with moderately abundant ankerite and minor pyrite. The main vein which crosscuts foliation at about 90 degrees appears to be cut by the largest vein parallel to foliation. The latter contains patches which are strongly strained and in part recrystallized to foliated subgrain aggregates. Ankerite forms subhedral grains up to 0.3 mm long in the large vein parallel to foliation. Pyrite forms a few clusters uptown 0.25 mm in size of subhedral grains. Chalcopyrite forms a very few anhedral grains from 0.005-0.015 mm in size. Carbonaceous opaque forms a few equant patches up to 0.05 mm in size in one quartz-rich vein.

Calcite forms a few late veinlets up to 0.02 mm wide.

87-P-2 94.5 **Cherty Dolomite Replacement of Ultramafic Rock; cut by Veins of Dolomite-Quartz and of Quartz-Barite**

The rock consists of very fine grained dolomite with lenses and patches of extremely fine grained chert, with minor disseminated pyrite. Minor relic chromite patches indicate that the parent was an ultramafic rock. It is cut by veins up to a few mm wide of dolomite-quartz and veinlets up to 0.2 mm wide of quartz-barite.

dolomite	80-85%	
chert	10-12	
pyrite	0.5	
arsenopyrite	0.2	
chromite	0.7	
sericite	trace	
veins		
dolomite-(quartz)	4- 5	(17-20% in hand sample)
quartz-barite-(sulfide)	2- 3	

Dolomite forms anhedral aggregates averaging 0.03-0.1 mm in size.

Chert forms very irregular interstitial patches up to 1 mm in size; grains are strongly interlocking and average 0.01-0.02 mm in size. Some chert patches contain minor interstitial flakes of sericite/mariposite (suggested because po green color in hand sample; grains too small to show color in thin section).

Pyrite forms disseminated, subhedral grains averaging 0.02-0.05 mm in size, with a few up to 0.15 mm across.

Arsenopyrite forms disseminated subhedral cubic grains averaging 0.02-0.03 mm in size; it is distinguished from pyrite by its much white color. Anisotropism is too weak to recognize.

Chromite forms disseminated anhedral grains and clusters of grains averaging 0.1-0.3 mm in size, with a few up to 1 mm long. It is isotropic with a deep red-brown color. One cluster of chromite(?) 0.2 mm across consists of anhedral "grains" up to 0.15 mm in size. If it were originally chromite, it was altered to an unknown mineral (probably a variety of Fe oxide) which is opaque, with very low reflectivity, and very hard. "Grains" appear to be made up of cryptocrystalline aggregates.

The major vein in hand sample is present only in one corner of the section. It is dominated by medium to coarse grained dolomite with patches of very fine to locally fine grained quartz in fracture-filling seams and veinlets cutting across coarser grained dolomite.

Smaller veinlets up to 0.2 mm wide are dominated by very fine to fine grained quartz. One of these also contains abundant very fine grained barite, mainly in the core of the veinlet. This veinlet also contains scattered patches of pyrite and chalcopyrite-hematite(?) up to 0.06 mm in size. One lensy patch dominated by very fine grained quartz contains several ragged barite grains up to 0.3 mm in size.

87-P-2 120.1 **Sheared Cherty Ankerite/Dolomite Replacement of Ultramafic Rock;Disseminated Arsenopyrite and Pyrite; Quartz-Barite Veins**

The rock is a strongly sheared cherty carbonate rock dominated by ankerite/dolomite with seams of sheared quartz. It contains relic patches of chromite, which indicate that the parent rock was ultramafic. Arsenopyrite and pyrite form disseminated grains. Veins up to 0.3 mm wide of very fine to fine grained quartz-barite cut across the foliation.

ankerite/dolomite	87-90%
quartz	5- 7
chromite	1- 2
arsenopyrite	0.3
pyrite	0.3
mariposite	0.2
veins	
quartz-barite	2- 3

Ankerite/dolomite forms very fine to fine grained aggregates, which show a moderate to strong foliation, and commonly appears to have been very strongly sheared. Shearing is concentrated along wispy seams, in which carbonate is strongly granulated. These seams probably also contain minor mariposite, which accounts for the green-colored seams parallel to foliation. A few carbonate-rich layers up to a few mm across contain slightly coarser grained, generally unstrained grains; these may be metamorphic segregations, which were formed after much of the shearing occurred.

Quartz occurs in wispy seams and patches. Most patches show a very strong foliation produced by intense shearing, with extremely fine grains in parallel orientation. Textures in some of these patch are more typical of sericite than quartz. Other patches are unstrained and consist of extremely fine grained cherty aggregates with moderately interlocking grain borders. A few patches show texturee suggestive of tight folds.

Chromite forms ragged lenses and equant grains from 0.05-1 mm in size. Grains have a deep red-brown color, and are fractured and in part corroded.

Mariposite forms a patch 0.15 mm leng of extremely fine grain size (0.002-0.005 mm) enclosed in a lens of quartz.

Arsenopyrite and pyrite form anhedral to locally euhedral grains averaging 0.02-0.1 mm in size. These are moderately concentrated in seams parallel to foliation.

Late veins up to 0.3 mm in width are dominated by very fine grained quartz, with several patches of very fine grained barite.

87-P-2 138 **Altered Ultramafic Rock: Ankerite-Quartz-Sericite-Magnetite-(Chromite-Barite-Phlogopite-Chlorite); veins of Quartz-(Barite) and of Ankerite/Dolomite**

The sample is a well foliated and strongly altered ultramafic rock. Relic patches (dark in hand sample) are dominated by quartz, sericite, and Fe-oxides. Lighter colored replacement patches and veinlike zones are dominated by ankerite. Chromite forms relic grains and clusters of grains. The rock is cut by a few late veins of quartz-(barite) and of ankerite/dolomite.

ankerite	65-70%
quartz	10-12
sericite	10-12
magnetite/hematite	4- 5
chromite	1
barite	0.3
phlogopite	0.2
chlorite	0.2
veins	
quartz-(barite)	1- 2
ankerite/dolomite	0.3

Ankerite forms aggregates of very fine to locally fine grains. Many finer grained aggregates show moderate to strong shearing. Some coarser grained veinlike zones are probably late metamorphic segregations; these are very fine to fine grained, and generally unsheared. Some of these contain minor patches of quartz and of barite.

Quartz, with sericite and Fe-oxides, is concentrated in lensy patches showing a prominent foliation. Quartz commonly is extremely fine grained, and commonly appears to have been sheared strongly. A few patches of very fine grained quartz are unfoliated and unstrained.

Sericite forms extremely fine to very fine grained aggregates, generally unfoliated and in part with grains oriented perpendicular to foliation. A few fine grained seams of sericite are oriented parallel to foliation. Phlogopite forms a few ragged grains from 0.1-0.3 mm in size; pleochroism is from colorless to pale brown.

Chlorite forms slender flakes up to 0.1 mm long intergrown in some patches of extremely fine grained quartz.

Magnetite forms equant grains averaging 0.03-0.08 mm in size, strongly concentrated in lenses with quartz and sericite. In a few lenses, magnetite averages 0.01-0.03 mm in size. Magnetite is altered moderately to strongly to hematite; alteration is in irregular patches and is concentrated along borders of grains.

Chromite forms a few ragged, fractured grains up to 0.9 mm in size, some of which are concentrated in clusters up to 2.5 mm across. It ranges in color from deep red brown to opaque. It is altered slightly along grain borders and fractures to hematite.

Barite forms anhedral, commonly ragged grains from 0.1-0.3 mm in average size, commonly intergrown with ankerite.

The rock is cut by a few late veinlets up to 0.15 mm wide of quartz, mainly parallel to foliation, and up to 0.1 mm wide of ankerite/dolomite cutting foliation.

87-P-2 160 **Dunite/Peridotite altered to Serpentine-Magnetite; Patchy Alteration to Magnesite-(Talc)**

The rock is dominated by serpentine with irregular patches of magnetite, formed by alteration of olivine (and possibly pyroxene), and minor relic chromite. Later alteration to carbonate (magnesite?) and talc is concentrated in seams and patches.

serpentine	75-80%
magnetite	4- 5
chromite	0.5
carbonate (magnesite?)	10-12
talc	5- 7

Serpentine forms extremely fine to medium grained aggregates. Finer grained, more irregular serpentine aggregates are secondary after olivine. Some coarser grained patches may represent original phenocrysts of pyroxene. Other coarser grained zones form veins up to a few mm wide. Some veins show extremely finely laminated growth zoning in serpentine crystals or aggregates. Serpentine veins are common loci for later veins of carbonate and/or talc.

Magnetite is concentrated in veinlike lenses and patches averaging 0.05 mm wide, and in irregular lenses. Grains are very fine to extremely fine, and are replaced slightly to moderately by hematite.

Chromite forms clusters up to 1.5 mm long of anhedral grains averaging 0.2-0.4 mm in size. It ranges in color from deep red-brown to opaque. Commonly it is altered slightly along grain borders to hematite.

Carbonate (probably magnesite - based on composition of rock) is concentrated in veinlike zones up to 0.5 mm wide and in patches averaging 0.1-0.3 mm across. Some veinlike zones have thin borders of extremely fine grained talc. Elsewhere, talc forms similar veinlike zones of extremely fine grain size. It also occurs as thin selvages along fractures in masses of serpentine. In coarser grained serpentine patches and veinlike zones, talc appears to replace serpentine gradually; this is indicated by a gradual increase in birefringence of the mineral from 1st-order white typically of serpentine to 1st-order yellow and red and low 2nd-order colors more typical of talc.

87-P-2 223 **Dunite: Altered to Serpentine-Magnetite; Late Patches and Veins of Magnesite-(Talc)**

The rock is a dunite (or possibly peridotite) which was altered completely to serpentine-magnetite with minor relic chromite and local concentrations of chlorite. The serpentine appears to have been sheared and recrystallized, in part forming coarser veinlike zones. Later veins and replacement patches are of carbonate (magnesite) and minor talc.

serpentine	83-87%
magnetite	5- 7
chromite	Ø.5
arsenopyrite	Ø.2
pyrite	Ø.1
chlorite	1
carbonate (magnesite?)	7- 8
talc	Ø.1

Serpentine forms extremely fine to very fine grained aggregates in random orientation and extremely fine to medium grained aggregates in parallel orientation. None of these appears to preserve the original texture of the ultramafic rock, suggesting that the rock was strongly sheared and recrystallized. The interference color of serpentine ranges from 1st-order grey to bright 1st-order yellow, the latter occurring in some of the coarser grained recrystallized zones. It may suggest a slight alteration of serpentine towards talc.

Magnetite forms disseminated grains, moderately concentrated in clusters and lenses up to a few mm long. Grain size averages Ø.Ø2-Ø.1 mm. Greins are relatively fresh, with local alteration to hematite. Locally serpentine forms rims up to Ø.1 mm wide of subparallel grains growing perpendicular to some large patches of magnetite.

Chromite forms a few anhedral, corroded grains up to Ø.6 mm in size. Color ranges from very dark red-brown to opaque. It is altered slightly to moderataly on grain borders to hematite.

Arsenopyrite and lesser pyrite form disseminated grains averaging Ø.Ø1-Ø.Ø3 mm in size, and wispy lenses up to Ø.2 mm long along cleavage in coarser grained serpentine.

Chlorite is concentrated in one patch 2.5 mm across as a few subhedral grains up to Ø.8 mm long and much more abundant, very fine grains surrounded by and intergrown with serpentine. Textures suggest that an original mafic mineral (possibly phlogopite was replaced by chlorite, which was then deformed partly replaced by serpentine.

Carbonate (probably magnesite) forms irregular, braided, extremely fine grained veins up to Ø.4 mm wide. Locally associated with carbonate are lenses up to Ø.Ø5 mm wide and Ø.2 mm long of extremely fine grained talc.

87-P-2 245 **Altered Dunite: Serpentine-Magnetite, and Carbonate (Magnesite?)-Talc**

The rock is sheared and recrystallized, with development of a strong foliation and abundant microscopic drag folds. It contains lenses dominated by serpentine and others dominated by carbonate-talc. Magnetite is concentrated in lenses in both types of alteration assemblage. Chromite forms relic grains surrounded by serpentine.

serpentine	20-25%
magnetite/hematite	3- 4
chromite	1- 1.5
carbonate (magnesite?)	30-35
talc	35-40

Serpentine forms lenses up to 1 mm wide of extremely fine to fine grained aggregates. One shows tight folding. Some larger lenses are cut by veinlets up to 0.1 mm wide of carbonate.

Magnetite forms lenses and seams up to 0.7 mm wide of grains from 0.03-0.2 mm in size. Most are altered moderately to strongly to hematite. Finer grained (0.01-0.03 mm) magnetite is concentrated in seams parallel to foliation; it is altered strongly to completely to hematite.

Chromite forms corroded, relic grains from 0.2-0.8 mm in size, alone or in clusters of a few grains, mainly surrounded by serpentine. It is deep red-brown in color. Many grains have irregular cores of chromite surrounded by secondary magnetite, which in turn is altered slightly to moderately to hematite along grain borders.

Talc forms lenses and seams paralleled to foliation. Grain size ranges widely, from extremely fine grained aggregates to flakes up to 1 mm in size. Some coarser grained flakes show internal folding.

Carbonate is concentrated in seams parallel to foliation as very fine to extremely fine grains. In some it is intergrown intimately with extremely fine grained talc. Some seams of carbonate, with or without talc interlayers, show tight folds.

87-P-2 247 **Cherty Carbonate Alteration of Ultramafic Rock; Late Veinlets of Quartz-(Barite)**

The rock is strongly folded, and dominated by carbonate with much less cherty quartz and minor pyrite. Folds are outlined by bands of differ composition and/or texture, and are up to several mm across. Scattered grains of chromite indicate that the parent was an ultramafic rock. The dark grey color of seams (in hand sample) is caused by extremely fine grained carbonate with minor pyrite. A few late veinlets up to 0.1 mm wide are of quartz and lesser barite.

carbonate	85-87%
quartz	7- 8
chromite	1
pyrite	1- 2
Ti-oxide	minor
apatite	trace
late patches	
quartz-carbonate	2- 3
veinlets	
quartz	0.3
barite	0.1

Carbonate (magnesite or dolomite/ankerite) forms very fine to locally fine grained aggregates. Extremely fine grained ankerite(?) is concentrated in lenses with quartz and in recrystallized seams; it is distinguished from the main carbonate by higher relief (although this may be partly apparent because of the fine grain size). A few late veinlike zones of coarser carbonate (white in hand sample) are slightly coarser grained; in some grains are oriented subperpendicular to the length of the "vein".

Quartz forms wispy lenses of extremely fine grain size. In some, grains are strongly sheared and recrystallized parallel to foliation. In others, grains are equant and moderately interlocking with typical cherty textures. One lensy zone 5 mm long and up to 1 mm wide consists of extremely fine grained cherty silica with a banded texture; intergrown with it parallel to foliation are lenses and veinlets of carbonate. A few patches and dissemination grains of quartz 0.05 mm in size are intergrown with coarser grained carbonate.

Chromite forms relic, commonly fractured and corroded, equant grains up to 0.6 mm in size. It is red brown in color. Some grains are altered along borders slightly to moderately to magnetite. Patches of pyrite occur in some fractures.

Pyrite forms clusters and disseminated grains averaging 0.02-0.05 mm in size, with a few up to 0.1 mm across. These commonly are concentrated in lenses with extremely fine grained carbonate.

A few patches up to 2 mm across are of very fine to fine grained quartz and lesser carbonate; these probably formed during late recrystallization.

Ti-oxide forms scattered equant grains up to 0.03 mm in size.

Apatite occurs in a very few patches of quartz as anhedral, equant grains averaging 0.01-0.02 mm in size.

The rock is cut by a late veinlet up to 0.1 mm wide of very fine grained quartz and lesser barite.

87-P-2 272.5 **Breccia: Carbonate-Quartz Altered Ultramafic Rock Fragments in a Groundmass of Quartz-(Carbonate) with minor Chalcedony and Arsenopyrite**

The rock contains angular fragments from 0.3-2 mm in size of several types, mainly carbonate-(chert). The presence of scattered chromite grains indicates that the parent was ultramafic.

The groundmass is dominated by extremely fine to very fine grained quartz and lesser carbonate, with minor patches of chalcedony and disseminated grains of arsenopyrite. A late veinlet is of quartz.

fragments	
carbonate-cherty quartz	35-40%
quartz-(carbonate) vein	3- 4
chromite	0.1
groundmass	
quartz	40-45
carbonate	7- 8
vein quartz	3- 4
chalcedony	0.4
arsenopyrite	0.2
pyrite	trace
hematite	trace
veins	
quartz-carbonate seam	1- 2
quartz	0.4

Fragments up to 2 mm in size are of carbonate or carbonate-cherty quartz. Carbonate is mainly very fine grained, and commonly shows a preferred orientation. Cherty quartz shows textures similar to those in other samples of carbonate-quartz alteration. These include mainly unoriented grains averaging 0.002-0.005 mm, and patches with strong foliation and similar to slightly coarser grain size. Some foliated chert contains lenses of carbonate.

A few patches from 1 to 3 mm across of very fine to fine grained quartz and minor carbonate appear to be fragments.

Chromite forms angular grains up to 0.3 mm in size, either as fragments or as relic grains in chert-carbonate alteration. Chromite is fractured strongly.

The groundmass of the breccia is dominated by extremely fine to very fine grained quartz with minor to moderately abundant carbonate. In slightly coarser grained patches, subhedral prismatic quartz grains up to 0.15 mm long are common. A few patches up to 1.5 mm across of very fine to locally medium grained quartz appear to be late-formed replacement patches. Locally, chalcedony forms patches up to 1 mm in size of radiating to subparallel aggregates of grains averaging 0.05-0.1 mm in length.

Arsenopyrite forms disseminated subhedral to euhedral grains averaging 0.03-0.07 mm in size. Pyrite forms anhedral to subhedral grains averaging 0.02-0.03 mm in size.

A few interstitial patches consist of dense, dark red-brown hemetite(?) showing very low reflectivity.

The rock is cut by a seam up to 0.3 mm wide of extremely fine grained chert and carbonate.

Late veinlets up to 0.2 mm wide are of very fine grained quartz.

87-P-2 363 **Metamorphosed Dacite Tuff, Brecciated and cut by Veins of Ankerite**

The rock contains scattered fragments of quartz and lesser plagioclase in an extremely fine grained groundmass dominated by cherty quartz and sericite with lesser ankerite. The rock is brecciated along seams dominated by dusty opaque. It is cut by veinlets up to Ø.5 mm wide (Ø.5 mm in hand sample) of enkerite.

fragments	
quartz	2- 3%
plagioclase	1
Ti-oxide	minor
apatite	trace
groundmass	
cherty quartz	4Ø-45
sericite	2Ø-25
ankerite	17-2Ø
pyrite-marcasite	1
chalcopyrite	trace
dusty opaque	4- 5
veinlets	
1) early quartz	1
2) late ankerite	3- 4

Quartz and lesser plagioclase form angular to subrounded fragments from Ø.1-Ø.2 mm in average size. Ti-oxide forms a few equant fragmenta up to Ø.13 mm across. Apatite forms a very few equant fragments up to Ø.Ø5 mm in size.

The groundmass is dominated by extremely fine grained, chert quartz and sericite, with lesser patches and seams of ankerite. Dusty opaque (possibly carbonaceous) forms wispy seams and irregular patches. In hand sample, these appear to be concentrated in the matrix of an irregular breccia, and in part are associated with early-formed seams and veinlets of ankerite.

Pyrite is concentrated in a few clusters up to Ø.9 mm long as subhedral to euhedral grains up to Ø.2 mm in size. Many grains contain abundant tiny silicate inclusions. Some similar clusters up to Ø.3 mm across are aggregates of anhedral, extremely fine grained marcasite.

Chalcopyrite forms anhedral grains from Ø.Ø1-Ø.Ø2 mm size, and is concentrated locally in clusters of grains up to Ø.Ø5 mm across associated with very fine grained carbonate.

A few early, discontinuous veinlike zones and patches are of very fine grained quartz with much less carbonate.

Late, somewhat irregular, replecement and crosscutting veins averaging Ø.2-Ø.3 mm wide are of extremely fine grained ankerite.

87 -B-3 266 **Peridotite: Olivine and Orthopyroxene Altered to Serpentine-Magnetite; Veins of Carbonate and Talc**

The rock is a medium to coarse grained peridotite dominated by olivine with lesser orthopyroxene and minor intercumulus chromite. Olivine is altered completely to serpentine and patches of magnetite, orthopyroxene is altered to serpentine, and chromite is altered to hematite. Original textures are well preserved. Early veinlets are of serpentine and late veins are of carbonate and of talc.

olivine (serpentine)	65-70%	veins	
orthopyroxene (serpentine)	17-20	serpentine	1- 2%
chromite	1- 2	carbonate-talc	
magnetite (secondary)	3- 4	(chalcopyrite)	3- 4
pyrite	0.3	talc	1- 2
chlorite	minor		

Olivine forms an aggregate of fine to medium grains; these are replaced by serpentine showing typically replacement textures controlled by fractures in olivine grains. Magnetite (after olivine) occurs in disseminated grains in, and interstitial patches between altered olivine grains.

Clinopyroxene forms clusters of anhedral to subhedral prismatic grains up to 3.5 mm in length. They are replaced by pseudomorphic serpentine. Some are slightly bent and broken.

Chromite forms interstitial (intercumulus) grains between olivine grains. Size ranges widely from 0.1-2.5 mm. Chromite is altered completely to opaque Fe-oxides of extremely fine grain size and low reflectivity. These in turn are replaced by wispy veinlets of hematite with higher reflectivity. Locally surrounding the largest two patches of chromite is minor chlorite showing brown interference color. This is bordered by larger zones of serpentine/chlorite showing bright blue anomalous interfereuce color,

Magnetite is concentrated in seams and patches as anhedral grains averaging 0.02-0.1 mm in size. Although the optical properties suggest that magnetite is unaltered, the low magnetism of the rock suggests thailand is moderately replaced by hematite.

Pyrite and marcasite/pyrite form disseminated anhedral grains and clusters averaging 0.02-0.05 mm in size.

Veins are of four main types. Early veins averaging 0.1-0.3 mm in width are of fine to medium grained serpentine.

Carbonate (ankerite or magnesite) forms extremely fine to very fine grained veins up to 1.3 mm wide. Some of these veins contain minor to abundant patches of a pale to light brown mineral (probably a phyllosilicate) which forms "flakes" up to 1.5 mm in size of cryptocrystalline aggregates in subparallel orientation. The mineral has very low apparent birefringence, but that may be because it is so fine grained. A patch a few mm across near the largest carbonate vein consists of coarse grained serpentine-talc, with intetference color ranging from 1st-order grey (typical of serpentine to 2nd order yellow (typical of talc). A few of the veins contain a trace of chalcopyrite as grains up to 0.05 mm in size.

A few veins up to 0.2 mm wide are dominated by very fine to fine grained talc. Talc also forms extremely fine grained veinlets and seams, in part associated with carbonate; in these, talc is pale brown in oolor, suggesting that the brown mineral described above also may be talc.

One banded veinlet up to 0.1 mm wide consists of finely banded, light brown, cryptocrystalline talc(?). Apparent age relations are ambiguous. This vein cuts a vein of coarser grained talc and itself is cut by an extremely fine grained carbonate vein, which appears to be cut by the coarser grained talc vein!

87-B-3 301 **Metamorphosed Dacite Crystal Tuff, cut by Quartz-Dolomite Veins**

The rock contain fragments of plagioclase and quartz crystals in an extremely fine grained groundmass of plagioclase-quartz and lesser sericite and ankerite. It is cut by a few veins of quartz-dolomite. In the hand sample (not in the thin section) are veins up to 2.5 mm wide of fine grained dolomite-quartz.

fragments	
plagioclase	30-35%
quartz	8-10
cherty andesite(?)	0.3
Ti-oxide	0.3
zircon	trace
groundmass	
plagioclase-quartz	35-40
sericite	4- 5
ankerite	4- 5
pyrite	0.3
carbonaceous opaque	0.5
graphite	minor
chalcopyrite	trace
veins	
quartz-dolomite-(apatite-kaolinite)	5- 7

Plagioclase and quartz form subangular grains averaging 0.1-0.25 mm in size, with a few up to 0.5 mm across. Plagioclase is altered slightly to moderately to sericite.

A few fragments are of extremely fine grained plagioclase/quartz with minor to moderately abundant dusty opaque; these may be fragments of intermediate volcanic rocks.

Zircon forms a very few anhedral grains up to 0.05 mm in size.

The groundmass is dominated by extremely fine grained plagioclase and lesser quartz, with minor to moderately abundant sericite and lesser ankerite.

Pyrite forms patches up to 0.2 mm long of extremely fine grained aggregates, and disseminated grains averaging 0.03-0.08 mm across. A few spheroidal patches up to 0.5 mm across are of framboidal, extremely fine grained pyrite (less than 0.002 mm). One patch 0.1 mm across consists of abundant tiny framboidal aggregates.

Ti-oxide forms lenses from 0.1-0.25 mm long of extremely fine grained to locally very fine grained aggregates.

Carbonaceous opaque forms wispy seams up to 0.05 mm wide concentrated in a zone up to 1 mm wide. In this zone, graphite forms a few seams up to 0.5 mm in length of flakes up to 0.07 mm across.

Several veins averaging 0.2-0.7 mm wide consist of very fine grained quartz and carbonate in varying proportions. One vein contains a few grains of apatite up to 0.25 mm long, and a few patches up to 0.15 mm aoross of extremely fine grained kaolinite. A few veins contain minor chalcopyrite grains up to 0.05 mm in size. Numerous veinlets up to 0.1 mm in width are of extremely to very fine grained carbonate.

87-B-3 481 **Dolomite-Quartz Alteration of Ultramafic Rock; Replaced by Quartz and cut by Quartz-Dolomite Veins**

The rock is patchy in texture and consists of dolomite with much less, commonly cherty quartz. Minor relic chromite patches indicate that the parent rock was ultramafic. The rock is replaced by irregular patches of very fine to fine grained quartz, and cut by a few veins up to 1 mm wide of coarser grained quartz and dolomite.

dolomite	60-65%
quartz	4- 5
chromite	0.2
pyrite	0.2
arsenopyrite	0.1
magnetite/limonite	0.2
Ti-oxide	minor
veins	
quartz	25-30
dolomite	3- 4
chalcedony	minor

Dolomite forms a very fine grained, moderately to well foliated aggregate, with local coarser grains up to 0.3 mm in size. Intergrown with dolomite are minor patches of cherty to very fine grained quartz up to 1 mm in length.

Chromite occurs in one lensy patch 1.2 mm long as fragments up to 0.1 mm in size surrounded by soft, non-reflective, extremely fine grained opaque. Its presence indicates that the original rock was ultramafic. A second lens 0.6 mm long contains abundant fragments of magnetite averaging 0.005-0.02 mm in size surrounded by dense, non-reflective opaque. Textures are similar to those in the chromite-rich lens, suggested that the magnetite may have been formed by replacement of chromite.

Pyrite and arsenopyrite each form disseminated anhedral to euhedral grains averaging 0.02-0.05 mm in size. A few euhedral pyrite grains are up to 0.18 mm across. Pyrite is concentrated moderately in one patch up to 0.6 mm across, in which it forms anhedral grains from 0.01-0.07 mm in size. Arsenopyrite is concentrated moderately in a few wispy seams as grains from 0.005-0.01 mm in size.

Ti-oxide is concentrated in a cluster 0.3 mm across of anhedral grains up to 0.04 mm across.

Veins up to 1 mm in width consist of fine to very fine grained quartz and dolomite. Finer grained quartz forms replacement patches, in part association with and grading textural and spatially into the veins. One vein contains a band of extremely fine grained dolomite and quartz; associated with dolomite is a seam containing abundant extremely fine grained arsenopyrite.

Locally, veins contain patches of very fine grained chalcedony up to 0.3 mm in size.

87-B-3 487 **Dolomite-Quartz-Sericite-Altered Ultramafic Rock; Cut by Dolomite-(Quartz-Kaolinite) Veins**

The rock is strongly sheared and moderately warped to locally tightly folded. It consists of very finely banded dolomitic and much less quartz, with a few seams rich in sericite. A few relic lenses of chromite indicate that the parent rock was ultramafic. Veinlets are dominated by dolomite, with lesser quartz and/or kaolinite.

dolomite	70-75%
quartz	12-15
sericite	5- 7
chromite	0.1
pyrite/marcasite	0.3
arsenopyrite	0.1
Ti-oxide	0.1
veins and veinlets	
dolomite	7- 8
kaolinite	1
quartz	1
marcasite/pyrite	minor

Dolomite forms extremely fine to very fine grained aggregates variably intergrown with seams rich in quartz and/or sericite. Dolomitic forms irregular coarser grained patches and lenses averaging 0.1-0.2 mm in grain size.

Quartz forms a variety of textures. Many seams and lenses are extremely fine grained, and show textures indicative of strong shearing. Quartz forms a few very fine grained patches averaging 0.3-0.8 mm in size; the origin of these is uncertain.

Sericite is concentrated in a few seams up to 1 mm wide, mainly intergrown with quartz. Tight folde on the scale of 0.3-1 mm are best defined by thin interbanded zones of quartz-sericite and dolomite.

Chromite forms a few lenses up to 1 mm long containing equant angular fragments from 0.02-0.07 mm in size. The matrix between the fragments is extremely fine grained dolomite.

Pyrite and much less arsenopyrite form disseminated anhedral to euhedral grains averaging 0.02-0.07 mm in size. A few lenses up to 0.4 mm long consist of extremely fine grained aggregates of arsenopyrite and marcasite. A few opaque-rich seams parallol te foliation contain abundant pyrite grains averaging 0.005 mm in size.

Ti-oxide forms scattered grains up to 0.1 mm in size, and clusters up to 0.15 mm in size of extremely fine grains.

The rock is cut by numerous veinlets averaging 0.05-0.4 mm in width of dolomite. A few of these at one end crosscut the foliation, and appear to be slightly strained. Larger veins up to a few mm across occur in the hand sample.

One lensy vein up to 1 mm wide has an outer zone of very fine grained dolomite, and a core up to 0.6 mm wide of extremely fine grained (0.002-0.005 mm) kaolinite with scattered to moderately abundant patches of dolomite. Furthered along this vein are clnsters up to 0.4 mm long of very fine grained marcasite/pyrite.

A few veins are of very fine grained dolomite and quartz.

One vein averaging 0.1-0.2 mm wide and dominated by very fine grained quartz contains a few patchas up to 0.1 mm across of extremely fine grained kaolinite.