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AURCHEM

EXPLORATIONS
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VIA COURIER

November 2, 1987

Vancouver Petrographics Ltd.
P. O. Box 39
8887 Nash Street
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Attn: Mr. James Vinnell

Enclosed are a set of instructions with sample and geology descriptions for laboratory studies of polished thin sections. I had phoned you on October 29, 1987, to discuss the sending of these samples to you.

We would like you to proceed on these samples at "regular" handling using the 26 x 46 mm polished thin section size. We would like photomicrographs of each slide also.

If you have any questions at all regarding these samples, please feel free to call.

Yours truly,

AURCHEM EXPLORATIONS LTD.

Mark Langdon

Mark Langdon
Manager - Geological Projects

ML/joc

Enclosure

Polished Thin Sections - Aurchem Explorations Ltd.

I will attempt to give you a general geology of the sample's source and other details relevant for your proper identification and description of the polished thin sections.

General

The general setting is one of epithermal silver/gold/lead/zinc veins from our property in the Yukon.

The samples can be divided into three basic categories due to their purpose;

1) A set of samples basically for rock type analysis hoping to confirm the intrusive source of extrusive samples.

2) A set of samples of various alteration assemblages through one rock type caused by the epthermal system. I have logged our drill core using these alteration assemblages and am now looking for confirmation of these assemblages. We use these assemblages as an exploration tool so we would like to feel confident in our initial assessment.

3) A set of samples of various vein materials. We are working on a present theory of the differing veins having different paleo-elevations with some telescoped veins. If the thin sections also suggest this may be true by their mineral suites, it will help us to form new drill targets. The metallic minerals in the veins can also be quite diverse so the identification of them will help us considerably.

General Geology

The samples are taken from four basic litholgies through which the veins run.

a) Grandiorite

- a hornblende rich grey to orange coloured granodiorite.
- derived from the Cretaceous juring widespread granite/ granodiorite/ monzonite intrusive activity.
- epithermal alteration of our property of this lithology is quite intense and widespread.

b) Dacite to Ryolite Dykes & Sills (generally rhyodacite)

- highly variable in composition
- epithermal alteration varies from none to highly altered
- can be fined grained and siliceous or prophyritic
- generally believed to be the extrusive component of the granodiorite (Cretaceous and or later)

c) Quartz Diorite

- Jurassic age
- sub-intrusive Horblende Quartz Diorite
- very siliceous

d) Andesitic to Basaltic Extrusive Flows

- generally believed to be the extrusive phase of the quartz diorite.

Veins

Work to date and work done on other properties nearby suggest two phases of epithermal veining. An early stage with low Au and Ag values and a later stage of high Au and Ag values. This may have contributed to the highly compositionally erratic nature (including assays) of the veins as the later solutions enriched earlier veins as well as forming new veins.

1) Samples for rock type analysis

Sample #	Au (oz/ton)	Ag (oz/ton)	Pb (ppm)	Zn (ppm)	As (ppm)
D12-87-13	<.001	.01	17	131	54
D8-87-205	<.001	.01	34	203	21
D8-87-114	<.001	.01	35	140	20
D9A-87-43	<.001	.02	33	275	96
D4-87-264	<.001	.00	27	77	25
D1A-87-163	.002	.02	37	13	7
D8-87-144	<.001	.04	103	171	86
85-87-6	.001	.02	39	374	--

Note: Assays are from 1-5 ft. drill core sections

D4-87-264

- quartz diorite (typical sample)
- sample for basic composition of this lithology
- located about 20 feet from granodrite contact

D-8-87-114

- quartz diorite near contact with andesitic/basaltic extrusives
- possibly from the cap of the diorite intrusive
- general lithographic description is wanted

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D8-87-205

- calcareous intermediate/basaltic volcanic flow
- located 100 feet from D8-87-114 diorite
- other than basic mineral lithology we are trying to find out if this lithology does appear to be the extrusive of the diorite by a similar mineral suite.

D8-87-144

- possibly a bleached diorite
- at the diorite/int. volcanic flow contact we get an alternating or intermixing zone. Within this zone we get a series of white "bleached" veins that sometimes have a qtz/galena/sphalerite vein (<6 cm)in the centre. We would like to find out if (1) what the original rock type of the bleached zone was (2) if the alteration is probably from an epithermal source or if it is from a primary source of the intrusive (diorite)/extrusive (volcanic) contact metamorphism. (3) Many epithermal papers say that bleached zones on the surface that show advanced argillic (sulphate) assemblage alteration are a good sign for vein enlargement at depth. Therefore, we want to know which alteration assemblage this "bleaching" falls into. At the back of this description of samples is a description of the five alteration assemblages that we have attempted to place our grandiorite alterations in. If you could place this "bleached" zone in one of the categories it may be of great use to us in our future drilling.

The next four samples are all from the general rock type of rhyodacite. The rhyodacite group intruded up the diorite/granodiroite contact and then spread out from there as dykes down fault structures.

D12-87-13

- calcareous rhyodacite? (from within the granodiorite)
- is the granodiorite a probable source?
- epithermal alteration?

D1A-87-163

- probable rhyodacite (from withing the granodorite)
- is this a rhyodacite or a silicified and altered granodiorite?

D9A-87-43

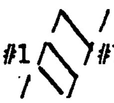
- rusty altered rhyolite? (from within the granodiorite)
- alteration?
- possible source?

85-6

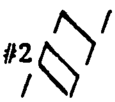
- this is a trench sample of a "feldspar-quartz-porphyritic rhyolite bordering a vein within the diorite.
- is this from the same source as the other rhyolites and rhyodacites
- would it possibly have come in before or after or during vein emplacement (alteration?)

2) Samples for alteration assemblages

All the following samples were originally granodiorite. As mentioned earlier, a paper at the back shows the five alteration assemblages that we attempted to classify our granodiorite into. I have sent at least one sample for each of our alteration assemblages. If possible I would like a confirmation of our alteration assemblage groups or changes that you would suggest. Assemblages #5 through #1 occur on both sides of our veins although some veins only show alterations #5 though to #3. Alterations are more intense (larger) on the hanging wall.

Eg. #5 #4 #3 #2 #1  #1 #2 #3 #4 #5

↑ vuggy qtz/sulphide/sulfosalt vein

Eg. #5 #4 #3 #2  #3 #4 #5

↑ cherty qtz/sulphide vein

We would also like to see the changes in metallic minerals that occurs through the assemblages.

Sample #	Au (oz/ton)	Ag (oz/ton)	Pb (ppm)	Zn (ppm)	As (ppm)
D12-87-34	.080	.01	25	100	30
D12-87-79	<.001	.06	32	214	10
D12-87-94	.001	.03	76	308	105
D1A-87-62	.043	.01	17	69	20
D4-87-226	.003	.11	609	463	896
D12-87-104	.006	.34	797	195	412

Note: samples part of a 5 foot core assay

D12-87-34

- potassium silicate assemblage (5)

D12-87-79

- propylitic assemblage (4)

D12-87-94

- argillic assemblage (3)

D1A-87-62

- argillic assemblage (3)

D4-87-226

- phyllic/sericitic assemblage (2)

D12-87-104

- advanced argillis (sulphate) assemblage (1)
- this sample surrounds vein sampled D12-87-106, D12-87-111, and D12-87-112
- the black/grey colouration showed up in fresh core as a ruby red/magenta purple colour.

3) Samples of vein material

What we would like to get from these samples is:

1) Metallic and gangue mineral identification.
2) Any evidence of later enrichment (stockwork veinlets) from a secondary source.
3) Possible order of crystallization of sulphides (this is often not possible in epithermal veins due to pulsating solutions).
4) Any possible clues to precious metal association (there is free gold and silver in the veins and testwork has shown some to be associated with lead, but the bulk associated with arsenopyrite. A test three years ago by Lakefield said the gold was associated with pyrrhotite; but I find that hard to believe because of the lack of pyrrhotite in our veins.

5) Any possible comments you may have on the relative distance from the paleosurface of the various veins (i.e. increasing temperature and pressure of the formation).

Sample #	Au (oz/ton)	Ag (oz/ton)	Pb (ppm)	Zn (ppm)	As (ppm)
D8-87-145	.026	.62	7,520	16,050	>2,000
D12-87-106	.019	1.35	5,700	185	1,112
D12-87-111	.250	14.02	9,610	14,300	>2,000
D12-87-112	.080	19.56	12,180	>20,000	>2,000
D4-87-76	.103	.26	303	276	936
D3A-87-114	.005	.19	108	162	242
D9C-87-13	.052	.26	315	323	72,000

These samples are taken from 4 different veins where we feel vein 1 is closest to the source and veins 2, 3 and 4 get progressively farther away from the source or closer to the paleosurface.

Vein 1 - we believe to be a "telescoped" vein from depth (within granodiorite).

(a) D12-87-106

- oxidized vuggy quartz/hematite/manganese oxides/other vein from within the advanced argillic (sulphate) alteration zone
- sample D12-87-104 surrounds this vein
- fresh this sample was a purple/red/magenta colour

(b) D12-87-111

- same vein as above
- from the centre of the vein
- very black "sooty" vein material

(c) D12-87-112

- same vein as above
- the bulk of the vein is this material
- vuggy quartz sulphide/sulphosalt? vein
- possible gangue minerals of quartz, adularia, alunite, etc.

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<u>Vein 2</u> - within granodiorite

(a) <u>D4-87-76</u>

- brecciated quartz/sulphide (minor carbonate)
- possible stockwork within hydrofractured vein from secondary epithermal
- found within sericite/phyllic alteration assemblage
- vein is fairly oxidized

<u>Vein 3</u> - within granodiorite

(a) <u>D3A-87-114</u>

- similar style of vein as vein 2
- associated with sericitic alteration
- appears to have a more cherty quartz

(b) <u>D9C-87-13</u>

- probably the same vein as above but about 1 km away
- cherty quartz/carbonate/silicified carbonate vein
- dark grey cherty quartz -- quartz/pyrite/arsenopyrite mixture?

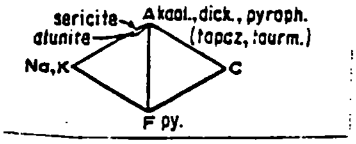
<u>Vein 4</u> - at diorite/int. volcanic contact

(a) <u>D8-87-145</u>

- quartz/galena/sphalerite/pyrite vein
- found within "bleached" lithology as in sample D8-87-144
- epithermal vein?
- differences of this type of vein to other veins (possible implications of distance from source relative to other veins

Epithermal Alteration Types

(1) Advanced Argillic (Sulphate) Assemblages



- all feldspars converted to dickite, kaolinite, pyrophyllite, diaspore, alunite or other aluminum rich phases

- majorly composed of quartz, alunite, pyrophyllite, kaolinite-dickite opal, K-mica, no carbonate present, minor sericite-illite-montmorillonite

- usually exhibits an intense oxidation halo

- rare sulphides (usually oxidized)

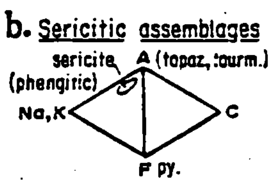
- commonly referred to as bleaching

- forms a halo around and above individual ore shoots within and above the precious metal horizon

- low pH alteration (sulphate or sulphuric acid solutions by water mixing with oxidized H_2S)

(Aurchem rocks; white mud vein around and above the smoky-vuggy quartz-sulphide-sulphosalt vein).

(2) Phyllic/Sericitic Assemblages



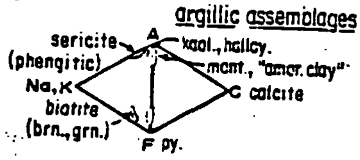
- both potassium feldspar and plagioclase is converted to sericite

- minor kaolinite may be present

- major minerals are quartz, sericite and pyrite with minor carbonate

(Aurchem rocks; blue mud veins).

(3) <u>Argillic Assemblages</u>



- presence of important amounts of kaolinite, montmorillonite or amorphous clay principally replacing plagioclase

- sericite may accompany clays

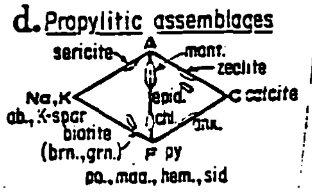
- potassium feldspar unaltered or argillized

- appreciable leaching of calcium, sodium and magnesium

- major minerals are quartz, kaolinite, chlorite and montmorillonite

  (Aurchem rocks; granodiorite altered to baby blue/green granodiorite with optional brown coloured kaolinite).

(4) <u>Propylitic Assemblages</u>



- major minerals of albitized plagioclase (Na rich), chlorite, epidote at depth, carbonate, montorillonite, pyrite, illite

- presence of epidote and/or chlorite and lack of appreciable cation metasomatism or leaching of alkalies or alkaline earths

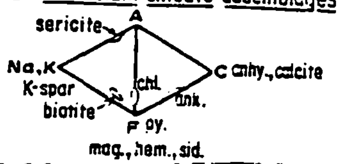
- H_2O, CO_2 and sulphur may be added

- commonly occurs as large halos around the veins to a greater amount in the hanging wall

- often this alteration is pre-ore

(5) <u>Potassium Silicate Assemblages</u>

e. Potassium silicate assemblages



- potassium feldspar and/or biotite formed as an alteration of plagioclase or mafic minerals

  (Aurchem rocks; competant and usually siliceous granodiorite showing pink feldspars).

Overlapping alterations on the above

(1) <u>Silicification</u>

- silicification and/or silica flooding appears to be found overlapping any or all of the Argillic, Propylitic and Potassium Silicate Assemblages. It appears most dominant in the Potassium Silicate Assemblage.

- if silicification has occurred Aurchem has classified as:

  (a) silightly silicified
  (b) silicified
  (c) highly silicified

(2) <u>Carbonatization</u>

- the only assemblage that the carbonate is not found within is the Advanced Argillic (Sulphate) Assemblage. In many cases the carbonate appears to be a late stage "overprint" also showing to be more abundant near fault zones.

- Carbonate alteration (enrichment) can appear as:

  (1) pervasive carbonate
  (2) as distinct "vein bedded" veins
  (3) as "stockwork like" veinlets

  Note: both types (2) and (3) can occur as either carbonate (calcite) veins or as quartz-carbonate veins.

(3) Oxidation

- strong oxidation of the Fe minerals can occur in all but the Advanced Argillic Assemblage (here the irons have all been leached from the material)

- oxidation is rare in the Phyllic/Sericitic Assemblage

VP

Vancouver Petrographics Ltd.

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JOHN G. PAYNE, Ph. D. Geologist

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Report for: **Mark Langdon,**
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Invoice 6944
November 1987

Samples: D-1A-87- 62, 163
D-3A-87- 114
D-4 -87- 76, 226, 264
D-8 -87- 114, 144, 145, 205
D-9A-87- 43
D-9C-87- 13
D-12-87- 13, 34, 79, 94, 104, 106, 111, 112,
85-6

Summary:

1. Samples for rock type identification

D4-87-264: porphyritic diorite with phenocrysts of plagioclase and minor ones of clinopyroxene and biotite, and very minor ones of orthopyroxene; strong fractionation indicated by presence of groundmass quartz and K-feldspar.

D8-87-114 quartz-bearing diorite, early formed plagioclase and clinopyroxene, later biotite, hornblende, and magnetite, and interstitial quartz, K-feldspar, and chlorite. Clinopyroxene is altered strongly to amphibole or chlorite-calcite; biotite is replaced by chlorite and plagioclase is replaced slightly by sericite.

D8-87-205 porphyritic andesite; plagioclase phenocrysts altered slightly to sericite-epidote; hornblende phenocrysts altered completely to chlorite-calcite. Somewhat similar to diorite samples, but lacks pyroxene, which would be expected in phenocrysts from same magmatic source as diorites.

D8-87-144 quartz diorite (argillic alteration); plagioclase replaced by kaolinite-carbonate; hornblende is replaced by quartz-ankerite; magnetite is replaced by hematite; biotite is fresh to replaced completely by chlorite.

D12-87-13 porphyritic andesite (phyllic alteration); plagioclase altered to sericite-(quartz); hornblende replaced by chlorite-calcite-sericite.

D1A-87-163 leucocratic quartz diorite (phyllic alteration); plagioclase altered moderately to strongly to sericite-calcite; biotite replaced by muscovite/sericite-quartz

D9A-87-43 andesite (phyllic-carbonate alteration); plagioclase replaced by kaolinite-calcite; mafic minerals destroyed

85-6 leucocratic quartz diorite (argillic-carbonate alteration); plagioclase replaced by kaolinite-calcite; biotite replaced by chlorite-calcite-muscovite; hornblende replaced by quartz/plagioclase-carbonate-limonite-(tremolite)

2. Samples for Alteration Assemblages — My Name

D12-87-34 porphyritic granodiorite (weak propylitic alteration); plagioclase altered slightly to sericite-calcite; hornblende slightly altered to chlorite-actinolite; biotite altered completely to chlorite-(epidote); magnetite altered slightly to hematite — Pot. Silc.

D12-87-79 porphyritic granodiorite (propylitic alteration); plagioclase altered slightly to sericite-(calcite); biotite altered completely to chlorite-epidote; hornblende altered completely to carbonate-(opaque-chlorite); magnetite is altered strongly to hematite — Propylitic

D12-87-94 porphyritic granodiorite (argillic alteration); plagioclase replaced by kaolinite-(sericite-carbonate); biotite is replaced completely by chlorite-(Ti-oxide-limonite); hornblende is replaced completely by tremolite and/or carbonate-opaque-limonite. — Argillic

D1a_87-62 granodiorite (phyllic alteration); plagioclase is replaced completely by sericite-carbonate with patches of kaolinite; biotite is altered completely to chlorite-ankerite/calcite; hornblende is altered completely to quartz/plagioclase or chlorite-ankerite — Argillic

D4-87-226 granodiorite (phyllic-carbonate alteration; original texture largely destroyed); secondary sericite-carbonate after feldspars; hornblende replaced completely by quartz/plagioclase-pyrite — Phyllic/Sericitic

D12-87-104 granodiorite (advanced argillic alteration[?]); feldspars replaced completely by sericite; hornblende replaced completely by quartz-(sericite-Ti-oxide); pyrite replaced completely by hematite — adv. Argillic

3. Samples of Vein Material

Vein 1

D12-87-1Ø6 quartz-sericite-pyrite-pyrrhotite/marcasite/ hematite-galena vein in altered rock

D12-87-111 galena-pyrite-quartz-sphalerite-chalcopyrite-arsenopyrite vein; minor silver-bearing mineral included in galena; trace of electrum in pyrite; galena partly replaced by cerusite, pyrrhotite replaced by pyrite, chalcopyrite locally replaced by covellite.

D12-87-112 quartz-pyrite vein cut by late vein of galena- sphalerite-(arsenopyrite-chalcopyrite); minor argentite in pyrite; galena partly replaced by cerusite secondary covellite associated with cerusite.

Vein 2

D4-87-76 brecciated quartz-pyrite vein, trace pyrrhotite, chalcopyrite, galena, argentite as inclusions in pyrite; minor sphalerite, tetrahedrite interstitial to pyrite

Vein 3

D3A-87-114 altered granodiorite replaced by quartz-pyrite-(arsenopyrite); late veins and replacement patches of carbonate-quartz-tetrahedrite-chalcopyrite

D9C-87-13 silicified rock replaced by pyrite-arsenopyrite-sphalerite-(chalcopyrite); rock is brecciated and healed by quartz-carbonate veins; pyrite contains minor inclusions of galena and lesser chalcopyrite and pyrrhotite

Vein 4

D8-87-145 altered quartz diorite cut by vein of sphalerite-calcite-arsenopyrite-galena-(chalcopyrite); texture much different from other veins, especially extremely fine grained arsenopyrite intimately intergrown with galena and to a lesser extent with sphalerite. Textures suggest lower temperature than other veins.

General Comments:

1. The host rocks show a moderately wide variation in compositions and textures, suggesting that more than one magmatic source is present. This is suggested by the strong differences between the diorite samples and the leucocratic quartz diorite samples.

2. The andesites appear to be more likely related to the leucocratic quartz diorite than to the strongly fractionated diorite.

3. Assay values for altered samples probably represent background values, because, for example, no sphalerite was seen in any of the samples with assays up to 374 ppm.

4. Some of the samples show at least two ages of vein formation, which in some samples were separated by a period of brecciation.

5. Late alteration of sulfides produced cerusite from galena, and covellite from remobilized copper produced from alteration of chalcopyrite. Iron and iron-copper sulfides are locally replaced by hematite, especially in the zone of advanced argillic alteration, where only those grains enclosed in quartz escaped alteration.

6. In most samples, sulfides of one stage of vein formation appear to have crystallized together. Where more than one set of veins are contain sulfides, pyrite and to a lesser extent, arsenopyrite are abundant in early formed veins, whereas base-metal sulfides are more common in later veins.

7. Precious metals were seen in samples D12-87-111 and D12-87-112. Argentite, electrum, and an unknown silver-bearing(?) mineral (possibly pyrargyrite) form minor inclusions in pyrite grains. Tetrahedrite is present in samples D4-87-76 and D3A-87-114. It is probable that a large amount of the silver occurs in the crystal structure of galena.

John G. Payne

Photographs

Representative photographs were taken to illustrate textures. All except Photo S are about 100X magnification (length of photo represents 1.2 mm in thin section). Photo S is magnified about 135X. Numbers on photographs refer to corresponding numbers on the film negative and on the reverse of the photograph.

Abbreviations used on the photographs are as follows

plag	plagioclase	ct	calcite
Q	quartz	py	pyrite
K-f	K-feldspar	cpy	chalcopyrite
Bio	biotite	gl	galena
Hb	hornblende	marc	marcasite
cpx	clinopyroxene	apy	arsenopyrite
chl	chlorite	cer	cerusite
ap	apatite	po	pyrrhotite
zr	zircon	tet	tetrahedrite
mt	magnetite		

Photo	Sample	Description
S	D4-87-264	corroded clinopyroxene, partly surrounded by biotite; zoned plagioclase, minor interstitial quartz. Crossed nicols.
1	D4-87-264	same as Photo S, lower magnification.
2	D8-87-114	hornblende, biotite (altered to pseudomorphic chlorite- Ti-oxide), opaque magnetite and ilmenite, plagioclase, minor interstitial quartz. Plane light.
3	D8-87-205	plagioclase phenocryst, hornblende phenocrysts (altered to chlorite), groundmass dominated by lathy plagioclase with much less chlorite and disseminated magnetite. Plane light.
4	D8-87-144	plagioclase altered to kaolinite with veinlets of ankerite, biotite altered to chlorite-Ti-oxide-limonite, interstitial quartz. Plane light.
5	D12-87-13	plagioclase phenocryst altered to sericite, groundmass dominated by plagioclase altered to sericite-calcite, minor chlorite, apatite, interstitial patch of quartz. Plane light.
6	D1A-87-163	plagioclase strongly altered to sericite, quartz (white and black), veinlet of calcite. Crossed nicols.
7	D9A-87-43	lathy plagioclase in a groundmass of anhedral plagioclase, calcite, quartz, and hematite (after pyrite). Plane light.

8	85-6	plagioclase altered to kaolinite, interstitial quartz, mafic grains altered to limonite-rich patches. Crossed nicols.
9	D12-87-34	plagioclase (light grey) and hornblende (orange), with interstitial quartz (white, grey, black) and K-feldspar (dark grey). Crossed nicols.
10	D12-87-79	plagioclase, biotite (altered to chlorite), magnetite (altered to hematite), with interstitial K-feldspar and quartz. Plane light.
11	D12-87-94	plagioclase (altered to kaolinite, minor sericite, limonite). biotite (altered to chlorite, minor Ti-oxide, limonite), interstitial K-feldspar and quartz. Zircon grain in biotite. Plane light.
12	D1A-87-62	plagioclase (altered to sericite-carbonate, minor kaolinite), hornblende (altered to quartz/plagioclase, carbonate, Ti-oxide), interstitial quartz. Crossed nicols.
13	D4-87-226	plagioclase (altered to sericite), quartz laced with calcite veinlets. Original texture largely destroyed. Crossed nicols.
14	D12-87-104	plagioclase (altered to sericite), hornblende (altered to quartz-sericite- Ti-oxide), patches of quartz, pyrite (opaque) altered to hematite.minor zircon. Crossed nicols.
15	D12-87-106	fragments of pyrite, galena corroded and replaced by cerusite, marcasite/hematite after pyrrhotite. Reflected light.
16	D12-87-111	fractured arsenopyrite enclosed in galena (altered on borders to cerusite). Reflected light.
17	D12-87-111	galena replaced concentrically by cerusite; sphalerite surrounded by pyrite/pyrrhotite. Reflected light.
18	D12-87-112	pyrite on border of vein; late vein of galena (altered partly to cerusite), sphalerite (dark grey patch), arsenopyrite, quartz (black), and minor covellite (dark grey enclosed in light grey galena near left side of photo). Reflected light.
19	D4-87-76	brecciated pyrite, surrounded by quartz. Reflected light.

20	D3A-87-114	tetrahedrite with inclusions of pyrite and of chalcopyrite, chalcopyrite grains included in quartz (dark grey). Reflected light.
21	D3A-87-114	veinlets of quartz-tetrahedrite-chalcopyrite-pyrite in sericite-carbonate altered rock. Much of the chalcopyrite is rimmed by tetrahedrite. Reflected light.
22	D9C-87-13	sphalerite with blebs of chalcopyrite surrounded by carbonate. Reflected light.
23	D9C-87-13	pyrite with inclusions of chalcopyrite, sphalerite, and galena; arsenopyrite on border of pyrite patch, with minor inclusions of galena. Reflected light.
24	D4-87-76	very fine grained carbonate vein with minor, extremely fine grained pyrite fragments; coarser earlier vein of quartz-pyrite, with minor interstitial galena. Reflected light.
25	D8-87-145	subhedral to euhedral, tiny arsenopyrite grains with interstitial galena, surrounded by sphalerite with only minor arsenopyrite inclusions. Reflected light.

John G. Payne

D4-87-264 Porphyritic Diorite

The rock contains phenocrysts of plagioclase, pyroxene, and biotite in a very fine grained groundmass dominated by plagioclase with lesser quartz, biotite, hornblende, and magnetite. Strong fractionation is indicated by plagioclase zonation and the presence of phenocrysts of pyroxene and interstitial quartz-(K-feldspar). The rock is cut by a few veinlets of calcite-(pyrrhotite)

phenocrysts	
plagioclase	20-25%
clinopyroxene	2- 3
orthopyroxene	0.3
biotite	3- 4
groundmass	
plagioclase	55-60
quartz	3- 4
biotite	4- 5
hornblende	1- 2
magnetite	1- 2
ilmenite	0.2
K-feldspar	minor
apatite	minor
veinlets	
calcite-(pyrrhotite)	0.1

Plagioclase forms ragged phenocrysts and a few clusters of phenocrysts averaging 0.5-1.7 mm in size. Many are strongly concentrically zoned gradationally towards more sodic rims. Some are altered slightly to extremely fine grained secondary plagioclase and epidote spots.

Clinopyroxene forms anhedral, pale green, equant to prismatic grains averaging 0.3-0.8 mm in size. A few clusters of clinopyroxene grains are up to 1.2 mm long. It commonly is partly rimmed by or replaced by secondary hornblende and/or biotite. Some grains are replaced by extremely fine grained secondary amphibole and moderately abundant opaque (magnetite?). A few patches up to 1.5 mm in size of extremely finely intergrown hornblende and biotite probably are secondary after original pyroxene. A few clinopyroxene grains are altered completely to a dense, extremely fine grained aggregate of an unknown, brownish-grey, semiopaque mineral.

Orthopyroxene forms a few subhedral to anhedral, equant to slightly prismatic grains averaging 0.2-0.5 mm in size. They are distinguished from clinopyroxene by parallel extinction and pleochroism from pale green to pink.

Biotite forms subhedral phenocrysts(?) up to 0.5 mm in size. These grade in texture into ragged interstitial grains and aggregates, and into irregular rims on clinopyroxene grains and intergrowths with hornblende.

In the groundmass, plagioclase forms anhedral equant to prismatic, moderately interlocking grains averaging 0.05-0.15 mm in size. Quartz forms interstitial patches up to 0.5 mm in size, generally skeletal between abundant plagioclase grains, and locally more continuous with less abundant plagioclase inclusions. Associated with quartz is minor K-feldspar. The latter was not identified in thin section, but its presence is inferred from the pale yellow stain on the offcut block.

Biotite and hornblende occur as irregular interstitial grains averaging Ø.Ø3-Ø.1 mm in grain size

Apatite forms scattered subhedral to euhedral, short prismatic grains averaging Ø.Ø7-Ø.Ø8 mm in length, and a few anhedral grains up to Ø.2 mm across.

Magnetite forms anhedral grains and clusters of grains averaging Ø.Ø3-Ø.5 mm in grain size. A few patches up to Ø.7 mm in size consist of coarse aggregates of magnetite and ilmenite. Some magnetite grains are surrounded by thick rims of biotite. Magnetite also occurs as disseminated, extremely fine grains in clusters of biotite-hornblende intergrowths. and in a few grains of clinopyroxene, mainly along borders of grains.

The rock is cut by a few veinlets from Ø.Ø1-Ø.Ø5 mm wide of extremely fine grained calcite with scattered patches up to Ø.1 mm long of pyrrhotite/pyrite.

D8-87-114 Quartz-bearing Hornblende-Biotite Diorite

The rock is a medium to fine grained quartz-bearing diorite, with early-formed plagioclase and clinopyroxene, later biotite, hornblende, and magnetite, and interstitial quartz and minor K-feldspar and chlorite. Clinopyroxene is replaced strongly by secondary amphibole and/or chlorite and calcite. Biotite is replaced almost completely by chlorite and plagioclase is replaced slightly by sericite.

plagioclase	60-65%	
hornblende	15-20	
clinopyroxene	7- 8	
quartz	4- 5	
biotite	4- 5	
magnetite	0.7	
K-feldspar	0.3	
chlorite	0.3	
ilmenite	0.2	(+/-hematite)
calcite	minor	
pyrite	trace	
chalcopyrite	trace	

Plagioclase forms subhedral, prismatic grains averaging 0.5-1.2 mm in size. Grains are compositionally zoned, especially near their margins, towards more-sodic rims. Alteration is slight to disseminated, extremely fine grained flakes of sericite.

Clinopyroxene forms pale green, anhedral, prismatic grains up to 1 mm in size. These are overgrown and partly replaced by medium to light green to brownish green hornblende. In some aggregates, magnetite is concentrated in hornblende surrounding clinopyroxene. Some clinopyroxene grains are altered to extremely fine grained tremolite(?) associated with moderately abundant patches of extremely fine to very fine grained magnetite. One mafic patch contains abundant calcite in very irregular intergrowths with hornblende; calcite appears to mainly replace clinopyroxene.

Hornblende forms anhedral to subhedral prismatic grains up to 1.5 mm long overgrown on clinopyroxene, and others intergrown with and partly interstitial to plagioclase.

Biotite forms grains up to 2 mm long, in part interstitial to plagioclase. It also occurs in irregular aggregates up to 2.5 mm across with hornblende. Almost all biotite grains are altered completely to pale to light green, pseudomorphic chlorite and minor Ti-oxide, with a few grains also containing moderately abundant patches of epidote. A few grains of biotite are fresh, with pleochroism from light to medium-dark brown.

Quartz occurs in irregular, interstitial patches from 0.05-0.5 mm in average size. A few of these patches also contain anhedral grains up to 0.2 mm across of K-feldspar.

Magnetite forms anhedral grains averaging 0.03-0.1 mm in size, with a few up to 0.25 mm across. Commonly it is concentrated in clusters of grains in mafic minerals. Ilmenite occurs in a few patches with or without magnetite, as grains from 0.1-0.4 mm in size. Some ilmenite grains contain patches of extremely fine grained intergrowths of ilmenite-hematite.

Chlorite forms a few interstitial aggregates from Ø.Ø5-Ø.15 mm in average size in part associated with quartz. These grains are free of Ti-oxide inclusions and do not appear to be pseudomorphic after biotite. Some patches show radiating textures.

Apatite forms prismatic grains up to Ø.15 mm in length and equant, anhedral to subhedral grains up to Ø.1 mm in size.

Calcite forms a very few equant grains from Ø.Ø3-Ø.Ø5 mm in size associated with plagioclase..

Pyrite forms a few anhedral grains up to Ø.1 mm in size, in part associated with interstitial chlorite.

Chalcopyrite forms a few clusters of grains averaging Ø.Ø1-Ø.Ø3 mm in size in biotite and in hornblende.

D8-87-205 **Porphyritic Andesite**

The rock contains phenocrysts of plagioclase and hornblende in a groundmass dominated by plagioclase with lesser chlorite and moderately abundant accessory magnetite. Hornblende is altered completely to chlorite-calcite-(semiopaque). Chlorite-(calcite) forms patches in the groundmass interstitial to plagioclase. Calcite forms replacement patches in the groundmass.

phenocrysts		
plagioclase	12-15%	
hornblende	7- 8	
groundmass		
plagioclase	60-65	(+ up to 3% K-feldspar?)
chlorite	7- 8	
magnetite	1- 1.5	
calcite	4- 5	
quartz	minor	
epidote	minor	

Plagioclase forms subhedral prismatic phenocrysts from 0.5-1.5 mm in length. These are altered slightly to extremely fine grained, disseminated flakes of sericite and patches of epidote.

Hornblende forms anhedral to subhedral, equant grains averaging 0.2-0.7 mm in size, and a few prismatic phenocrysts up to 2.5 mm long. It is altered completely to intimate intergrowths of chlorite and calcite, which in some grains are oriented parallel to the c-axis of the original hornblende grain. Associated with these minerals is moderately abundant, dusty to extremely fine grained semiopaque. Some phenocrysts are altered completely to chlorite with or without minor calcite and free of semiopaque; except for the well developed crystal outlines of the original hornblende grain, these are texturally similar to irregular interstitial patches of chlorite-(calcite). Some phenocrysts are altered completely to irregular aggregates of calcite, commonly with moderately abundant disseminated, dusty semiopaque (Ti-oxide?).

Groundmass plagioclase ranges from prismatic grains averaging 0.1-0.15 mm in length to anhedral, interstitial grains averaging 0.05 mm in size. The light yellow color in the stained offcut block suggests that the groundmass contains interstitial K-feldspar. This mineral was not identified in thin section.

Chlorite occurs in interstitial patches from 0.05-1 mm in size. The larger patches commonly contain a few anhedral, equant grains of calcite up to 0.1 mm across.

In the groundmass are irregular replacement patches up to 2 mm across of strongly interlocking, very fine grained calcite. Locally calcite forms coarser grained replacement patches of equant grains from 0.2-0.5 mm in size. These commonly are surrounded by extremely fine grained aggregates of calcite.

Magnetite forms disseminated, anhedral to subhedral, equant grains averaging 0.01-0.03 mm in size. and much fewer equant grains from 0.05-0.1 mm in size. Some of the latter are altered slightly to patches of extremely fine grained hematite.

Quartz forms scattered interstitial grains averaging 0.02 mm in size.

Epidote forms scattered patches averaging 0.02-0.03 mm in size.

D8-87-144 Hornblende-Biotite Quartz Diorite (Argillic Alteration)

The rock is a medium to fine grained quartz diorite dominated by plagioclase with lesser hornblende, quartz and biotite. Plagioclase is altered completely to kaolinite. Hornblende is altered completely to quartz-carbonate-semiopaque. Biotite is partly altered to chlorite-carbonate- Ti-oxide. Magnetite is replaced by hematite, and ilmenite is replaced by leucoxene. The alteration assemblage is argillic.

plagioclase	60-65%
quartz	10-12
hornblende	12-15
biotite	8-10
magnetite	0.5
Ti-oxide	0.2
pyrite	0.1
apatite	minor
chalcopyrite	trace

Plagioclase forms anhedral to subhedral grains from 0.5-12 mm in size. It is altered completely to extremely fine grained (0.005-0.01 mm) kaolinite with minor wispy veinlets of and patches of extremely fine grained carbonate, and scattered flakes of sericite.

Hornblende forms equant, anhedral grains averaging 0.3-0.7 mm in size. It is altered completely to extremely fine to very fine grained aggregates of quartz(?), with minor to very abundant, extremely fine grained ankerite. In a few grains, relic amphibole cleavage is preserved by seams of ankerite.

Biotite forms ragged flakes averaging 0.3-1 mm in size. It is variably altered, with some grains relatively fresh with pleochroism from light to dark brown or reddish brown, and other grains altered moderately to completely to pseudomorphic chlorite with wispy patches and lenses of Ti-oxide, and extremely fine grained patches and streaks of calcite.

Quartz forms grains with skeletal to irregular outlines, commonly interstitial to subhedral to euhedral plagioclase. Grains average 0.3-0.8 with a few up to 1.7 mm across.

Magnetite forms equant grains averaging 0.03-0.1 mm in size. It is replaced completely by strongly interlocking aggregates of very fine grained hematite.

Pyrite forms disseminated, anhedral to locally subhedral grains from 0.05-0.15 mm in size.

Chalcopyrite forms a few patches up to 0.07 mm across with pyrite, a very few equant grains up to 0.03 mm in size in quartz, and one elongate grain 0.04 mm long along biotite cleavage plane in biotite.

Ti-oxide (leucoxene) forms irregular patches up to 0.4 mm in size associated with biotite; it probably is secondary after ilmenite.

Apatite forms equant grains averaging 0.02-0.04 mm in size, and a very few acicular grains up to 0.2 mm long.

D12-87-13 Slightly Porphyritic Andesite

The rock contains minor phenocrysts of plagioclase and hornblende(?) in a moderately foliated groundmass dominated by lathy plagioclase.

phenocrysts	
plagioclase	4- 5%
hornblende	3- 4
apatite	minor
groundmass	
plagioclase	80-85
calcite	3- 4
magnetite/hematite	0.5
patches	
quartz-calcite	4- 5
chalcopyrite	trace

Plagioclase forms subhedral to euhedral prismatic to equant phenocrysts up to 1.2 mm in size. It is altered completely to extremely fine to very fine grained aggregates of sericite and minor patches of quartz.

Hornblende forms subhedral prismatic phenocrysts and a few clusters of phenocrysts up to 1.7 mm across, averaging 0.5-1 mm in grain size. A few elongate prismatic phenocrysts are up to 3.5 mm in length, averaging 0.5-1 mm long. Alteration is complete to very fine grained chlorite with intergrowths of very fine grained calcite and extremely fine grained sericite. Some aggregates contain moderately abundant magnetite or apatite intergrown with chlorite and calcite.

Apatite forms one euhedral prismatic phenocryst 0.4 mm long.

The groundmass is dominated by moderately oriented, lathy to prismatic plagioclase grains averaging 0.1-0.15 mm in length. These are altered moderately to extremely fine grained sericite and calcite. Calcite also forms irregular replacement patches up to 0.3 mm in size. Foliation in lathy plagioclase commonly is warped or contorted around phenocrysts.

Magnetite forms disseminated, equant grains averaging 0.01-0.02 mm in size. It is altered moderately to hematite.

Apatite forms anhedral to euhedral equant grains up to 0.15 mm across and a few elongate prismatic grains up to 0.22 mm long.

Quartz forms interstitial grains averaging 0.03-0.05 mm in size. It also occurs in very fine grained interstitial patches up to 1 mm in size. Some of the patches contain fine grains of calcite intergrown coarsely with quartz.

Chalcopyrite forms a patch 0.03 mm across in secondary quartz.

DlA-87-163 Altered Leucocratic Quartz Diorite

The rock is a fine to medium grained, leucocratic quartz diorite in which biotite is altered completely to muscovite- Ti-oxide, and plagioclase is altered moderately to strongly to sericite and calcite.

plagioclase	55-60%
quartz	40-45
biotite	1
Ti-oxide	0.2
veinlets	
quartz-calcite	trace

Plagioclase forms mainly anhedral, equant grains averaging 0.3-1 mm in size. Alteration is moderate to locally strong to extremely fine grained sericite and irregular, very fine grained patches of calcite. Dusty semiopaque inclusions are very common is some grains. A few patches consist of very fine grained aggregates of quartz/plagioclase intergrown with sericite and calcite; these may be secondary after original hornblende.

Quartz forms anhedral grains up to 1.5 mm in size, mainly interstitial to plagioclase, and commonly containing several inclusions of plagioclase. Locally quartz was recrystallized to extremely fine to very fine grained aggregates along incipient shear zones.

Biotite forms ragged flakes form 0.2-1 mm in average size. It is replaced by pseudomorphic muscovite/sericite and minor to moderately abundant Ti-oxide. In a few grains, muscovite is replaced by quartz, leaving only Ti-oxide as an indication of the original mineral and texture.

Ti-oxide also forms a few patches up to 0.7 mm in size of extremely fine, semiopaque grains (probably leucoxene).

Apatite forms anhedral, equant grains averaging 0.02-0.04 mm in size, commonly associated with biotite.

The rock is cut by a few wispy veinlets up to 0.02 mm in width of calcite-quartz.

D9A-87-43 **Altered Andesite (Phyllic-Carbonate Alteration)**

The rock is dominated by fine to locally medium grained, lathy plagioclase with interstitial plagioclase, calcite, quartz, hematite, and pyrite. Plagioclase is altered completely to kaolinite and calcite. Replacement patches or amygdules up to 2 mm across are dominated by calcite with lesser ankerite and limonite.

plagioclase	75-80%
carbonate	7- 8
quartz	3- 4
hematite	0.5
pyrite	0.1
Ti-oxide	minor
carbonate patches	5- 7
limonite	2- 3

Plagioclase forms lathy prismatic grains averaging 0.2-0.4 mm in length, and anhedral, equant, interstitial grains up to 0.07 mm in size. A few patches up to 0.5 mm across may represent plagioclase phenocrysts. All are altered to extremely fine grained (0.005-0.01 mm) aggregates of equant flakes of kaolinite, with minor to moderately abundant patches of calcite. Some plagioclase grains contain moderately abundant dusty semiopaque of unknown composition.

One equant plagioclase or hornblende phenocryst 1.5 mm in size is replaced in the core by a patch of extremely fine grained kaolinite surrounded by very fine grained calcite and quartz. Outwards from this is an extremely fine grained aggregate of quartz, kaolinite, and calcite.

Groundmass minerals interstitial to plagioclase laths include very fine grained (0.03-0.08 mm) quartz, extremely fine to very fine grained patches of carbonate, and abundant disseminated, equant hematite grains averaging 0.01-0.02 mm in size, with scattered grains of hematite up to 0.1 mm across. Associated with carbonate, and in part replacing carbonate are moderately abundant patches of limonite.

The rock contains patches up to 2 mm in size of submosaic aggregates of fine grained calcite with minor grains of quartz, mainly near or along borders of the patches. Some patches contain zones of higher-relief, commonly subhedral carbonate associated with moderately abundant limonite; these may be ankerite. A few patches are dominated by very fine grained, anhedral aggregates of ankerite (0.03-0.07 mm grain size), with abundant limonite, mainly along grain borders.

Pyrite forms disseminated subhedral to euhedral, equant grains averaging 0.01-0.02 mm in size.

Ti-oxide forms disseminated grains averaging 0.01-0.02 mm in size.

A few wispy veinlets up to 0.015 mm wide consist of calcite.

85-6 Leucocratic Quartz Diorite (Argillic-Carbonate Alteration)

The sample is a leucocratic quartz diorite which is moderately similar to sample DlA-87-163. Quartz is interstitial to plagioclase. Mafic minerals are altered completely to chlorite, carbonate, limonite, and Ti-oxide. The rock contains replacement patches and veinlets of calcite.

plagioclase	60-65%	
quartz	20-25	
biotite	2- 3	
hornblende	2- 3	
carbonate	5- 7	
apatite	minor	
hematite	0.3	
pyrite	trace	
limonite	0.5	
veinlets		
carbonate-(limonite)		2- 3%

Plagioclase forms anhedral to subhedral grains from 0..3-1.2 mm in size. It is altered completely to extremely fine grained kaolinite and patches and veinlets of calcite.

Quartz forms irregular, commonly skeletal grains up to 1 mm in size interstitial to plagioclase. The texture suggests rapid cooling in a hypabyssal environment.

Biotite forms ragged flakes up to 1 mm in size. They are altered completely to extremely fine grained pseudomorphic chlorite with locally abundant calcite and lesser muscovite and quartz. Original texture is outlined by extremely fine grained disseminated Ti-oxide.

Hornblende (?) forms equant grains averaging 0.3-0.7 mm in size. It is altered completely to extremely fine grained aggregates of quartz/plagioclase with moderately abundant, extremely fine grained carbonate, limonite, and Ti-oxide. One prismatic grain up to 1 mm long contains a core of subparallel tremolite grains surrounded partly by carbonate-limonite.

Calcite and ankerite-limonite form irregular replacement patches and veinlets; some of these are partly replaced by limonite. Pyrite forms a few patches up to 0.15 mm in size in one large vein, which is up to 0.2 mm wide.

Limonite also forms dusty replacements in kaolinite, giving the latter a pale to light yellow color.

Hematite forms subhedral to euhedral grains and clusters of grains averaging 0.07-0.12 mm in size. These probably are secondary after magnetite. Internally, many of these consist of extremely fine grained intergrowths.

Ti-oxide forms scattered patches up to 0.08 mm in size, commonly associated with hematite.

Pyrite forms a few equant grains and patches up to 0.2 mm in size; many have irregular outlines.

Apatite forms scattered clusters of acicular grains up to 0.12 mm in length, mainly associated with quartz.

D12-87-34 **Porphyritic Hornblende-(Biotite) Granodiorite**
(Weak Propylitic Alteration)

The rock is a medium to locally coarse grained granodiorite with moderately abundant hornblende and lesser biotite. Biotite is altered completely to chlorite-(epidote).

plagioclase	50-55%
quartz	17-20
hornblende	10-12
K-feldspar	8-10
biotite	7- 8
magnetite	1- 2
calcite	minor
sphene	trace
zircon	trace
pyrite	minor
calcite veinlets	minor

Plagioclase forms anhedral grains averaging 0.7-1.5 mm in size with moderately abundant phenocrysts up to 4 mm long. Many grains are compositionally zoned, with oscillatory zones in the cores of andesine composition (An_{40-48}) grading outwards towards more-sodic rims. Alteration is slight to extremely fine grained sericite flakes and calcite patches.

Quartz forms anhedral grains up to 2 mm across intergrown with plagioclase, and finer, commonly subrounded grains averaging 0.1-0.2 mm in size intergrown with K-feldspar interstitial to plagioclase.

Hornblende forms anhedral grains up to 2.5 mm in size. Pleochroism is from light to medium green. Grains locally are slightly altered to chlorite and secondary amphibole.

Biotite forms anhedral to subhedral, equant flakes up to 1.5 mm in size and a few clusters up to 2 mm across of flakes up to 1 mm in size. Some clusters consist of intimate intergrowths of biotite and plagioclase, with lesser magnetite and hornblende. Biotite is altered completely to pseudomorphs of chlorite with minor to moderately abundant patches of epidote.

K-feldspar forms interstitial grains from 0.5-2 mm in size, mainly intergrown with quartz. K-feldspar typically has abundant dusty, semiopaque to opaque inclusions.

Magnetite forms equant grains averaging 0.07-0.2 mm in size with a few up to 1 mm across. Some are slightly altered thir margins to very fine grains and aggregates of hematite.

Pyrite forms scattered anhedral grains up to 0.07 mm in size in quartz; one patch of quartz contains moderately abundant grains of this type. A very few subrounded pyrite grains up to 0.02 mm in size are included in magnetite.

Calcite forms a few patches up to 0.2 mm in size, in part probably after hornblende.

Zircon forms a few equant, subhedral grains up to 0.12 mm in size.

Sphene forms a very few anhedral to subhedral grains up to 0.15 mm in size.

Chlorite forms a few subradiating, interstitial patches up to 0.1 mm in size associated with quartz.

Calcite forms a few veinlets up to 0.02 mm in width.

D12-87-79 **Porphyritic Granodiorite (Propylitic Alteration)**

The rock is a medium to very coarse grained granodiorite with phenocrysts of plagioclase and hornblende and interstitial quartz, K-feldspar, and biotite.

plagioclase	50-55%	Ti-oxide	minor
quartz	20-25	chlorite	minor
K-feldspar	8-10	apatite	trace
biotite	7- 8	zircon	trace
hornblende	7- 8	pyrite	minor
magnetite	0.5	chalcopyrite	trace
veins			
calcite-(chlorite)	1		

Plagioclase forms a few phenocrysts up to several mm across, and finer grains averaging 1-1.5 mm across. Some show slight to moderate compositional zoning. Alteration is slight to moderate to disseminated flakes, patches, and veinlets of sericite and much less abundant patches of calcite.

Quartz forms anhedral interstitial grains and patches up to 2 mm in size.

K-feldspar forms anhedral, interstitial grains up to 1 mm in size. Dusty semiopaque-opaque inclusions are common.

Biotite forms ragged flakes up to 2 mm in size. Most grains are altered completely to pseudomorphic chlorite and moderately abundant, extremely fine grained epidote, with a few lenses of carbonate parallel to cleavage. A few grains are partly altered to chlorite; they contain cores of biotite which is pleochroic from straw to medium brown.

Hornblende(?) forms anhedral grains from 0,5-1 mm in average size. It is altered completely to extremely fine grained aggregates of carbonate with lesser opaque and chlorite.

Magnetite forms anhedral grains and clusters of grains averaging 0.05-0.15 mm in size, commonly associated with biotite It is strongly altered to very fine grained, moderately interlocking aggregates of hematite.

Ti-oxide (leucoxene) forms scattered patches up to 0.2 mm in size of extremely fine grained aggregates, commonly associated with magnetite.

Chlorite forms a few interstitial, subradiating patches up to 0.25 mm in size.

Apatite forms scattered anhedral to subhedral, stubby prismatic grains up to 0.1 mm in size.

Zircon forms a very few anhedral prismatic to equant grains up to 0.08 mm long.

Pyrite forms scattered anhedral to locally euhedral grains up to 0.07 mm in size, and a few discontinuous veinlets up to 0.01 mm wide in fractures in large quartz grains.

Chalcopyrite forms a few clusters of grains up to 0.2 mm in size. They are replaced along grain borders by thin to moderately thick rims of hematite.

The rock is cut by a vein up to 0.2 mm wide of very fine grained calcite-(ankerite-limonite-chlorite). Near this vein are abundant wispy veinlets and replacement patches of carbonate in plagioclase.

D12-87-94 Porphyritic Granodiorite (Argillic Alteration)

The rock contains moderately abundant very coarse grained phenocrysts of plagioclase in a medium grained groundmass of plagioclase-quartz- K-feldspar-hornblende-biotite. Plagioclase is replaced by kaolinite-(sericite), hornblende is replaced by carbonate-tremolite-chlorite-(kaolinite), and biotite is replaced by chlorite-(Ti-oxide).

plagioclase	50-55%	pyrite	minor
quartz	20-25	apatite	minor
K-feldspar	10-12	zircon	trace
biotite	7- 8	chalcopyrite	trace
hornblende	5- 7		
Ti-oxide	0.2		
veinlets			
calcite	minor		

Plagioclase forms anhedral to subhedral prismatic grains up to 2.5 mm in size. It is altered completely to extremely fine grained (0.005 mm) kaolinite with much less abundant flakes of sericite and patches and seams of carbonate and limonite.

Quartz forms anhedral grains and patches from 0.3-1 mm in grain size.

K-feldspar forms anhedral grains from 0.5-1.5 mm in average size. It contain moderately abundant dusty opaque/semiopaque inclusions and is slightly altered to extremely fine grained sericite.

Biotite forms flakes up to 2 mm in size. It is replaced completely by pseudomorphs or relatively unoriented aggregates of extremely fine grained chlorite with moderately abundant Ti-oxide and limonite.

Hornblende forms anhedral to subhedral prismatic grains up to 1 mm in size. It is altered completely to very fine grained, feathery aggregates of tremolite and/or carbonate, opaque, and limonite. A few grains are replaced by very fine grained quartz, extremely fine grained kaolinite, and much less, extremely fine grained carbonate-limonite.

Apatite forms scattered subhedral prismatic grains up to 0.4 mm in length.

Ti-oxide forms patches up to 0.2 mm in size of extremely fine grained aggregates.

Zircon forms scattered subhedral to euhedral grains up to 0.2 mm in length.

Pyrite forms scattered to locally abundant, anhedral grains and aggregates from 0.03-0.1 mm in average size. Locally it is concentrated in quartz.

Chalcopyrite forms a very few grains up to 0.1 mm in size. Most grains are in quartz and are unaltered. A few grains are altered strongly to hematite, which shows concentric alteration rings about a tiny core of chalcopyrite.

The rock is cut by a discontinuous veinlet up to 0.15 mm in width of very fine grained calcite.

D1A-87-62 Biotite Granodiorite (Phyllic Alteration)

The rock contains scattered plagioclase phenocrysts in a fine to medium grained groundmass dominated by altered feldspar and quartz, with much less biotite (replaced by chlorite-carbonate- Ti-oxide). Feldspars are altered completely to extremely fine grained aggregates of sericite-carbonate with patches of kaolinite. Veins are dominated by calcite with much less quartz. Minor veinlets are of sericite-pyrite.

feldspar	55-60%	(dominated by plagioclase)	
quartz	30-35		
biotite	3- 4		
hornblende	2- 3	veins and veinlets	
hematite	0.5	1) calcite-quartz	1- 2%
Ti-oxide	0.1	2) calcite	1- 2
apatite	minor	3) sericite-pyrite	0.2
zircon	trace		

Plagioclase forms anhedral grains from 0.7-1.5 mm in size, with a few phenocrysts up to 4 mm across. Plagioclase is altered completely to extremely fine grained aggregates of sericite-carbonate or much less commonly to patches of extremely fine grained kaolinite. Kaolinite patches commonly are surrounded by aggregates of sericite-carbonate. Original K-feldspar was altered completely to the same assemblages, and cannot be distinguished from plagioclase.

Quartz forms anhedral grains from 0.3-1.5 mm in average size.

Biotite forms flakes from 0.5-1 mm in average size. It is altered completely to very fine grained aggregates of chlorite with moderately abundant lenses of ankerite and lesser calcite, and minor Ti-oxide.

Hornblende forms anhedral grains up to 1.2 mm in size. It is altered completely to extremely fine to very fine grained aggregates of quartz/plagioclase(?) or chlorite-ankerite with minor to moderately abundant carbonate and Ti-oxide.

Biotite and hornblende are concentrated in a few clusters up to 3 mm across with lesser Ti-oxide (after ilmenite) patches from 0.1-0.2 mm in size..

Hematite forms anhedral patches up to 0.1 mm in size.

Ti-oxide forms anhedral grains up to 0.1 mm in size, and clusters up to 0.2 mm in size of extremely fine grained aggregates, probably after ilmenite.

Zircon forms subhedral to euhedral prismatic grains up to 0.22 mm in length.

Pyrite forms anhedral grains from 0.05-0.4 mm in size.

Apatite forms anhedral ti euhedral grains up to 0.1 mm in size associated with hornblende and biotite.

The rock is cut by a diffuse vein up to 0.2 mm wide of extremely fine grained chlorite with much less carbonate and with one pyrite grain up to 0.25 mm across.

A few discontinuous wispy veinlets consist of extremely fine grained sericite with scattered grains of pyrite from 0.05-0.25 mm in length.

One discontinuous vein up to 0.5 mm wide is dominated by fine grained calcite with lesser quartz. It is cut by one of a set of very fine grained calcite veinlets up to 0.06 mm wide.

D4-87-226 Granodiorite (Phyllic-Carbonate Alteration)
[Original Texture Largely Destroyed]

The sample is very crumbly, and partly leached. It contains patches of sericite after feldspars, and much less abundant patches of original(?) quartz, intensely laced by calcite veinlets. Pyrite forms disseminated patches and is concentrated in irregular seams.

feldspars	55-60%
quartz	25-30
hornblende	4- 5
Ti-oxide	minor
zircon	trace
calcite	5- 7
pyrite	3- 4%
galena	trace
marcasite	minor

Original textures of feldspars and mafic minerals are almost completely destroyed. These minerals, dominated by plagioclase, are replaced by extremely fine grained aggregates of sericite, with locally abundant dusty opaque, and locally abundant patches and veinlets of calcite.

Quartz occurs in patches up to a few mm across as fine to medium grained aggregates. Probably much of the quartz is original. Quartz is laced by abundant calcite veinlets and veins averaging 0.03-0.07 mm in width. Calcite also forms irregular replacement patches associated in origin with the veins.

Several anhedral grains of hornblende up to 1.2 mm in length were recognized from their alteration assemblage and nature of inclusions. Alteration is complete to very fine grained aggregates of plagioclase/quartz, with moderately abundant extremely fine to very fine disseminated pyrite grains. Some hornblende grains contain a few anhedral inclusions of apatite up to 0.05 mm in size. Apatite also forms scattered anhedral prismatic grains up to 0.1 mm in size.

Ti-oxide forms a few patches up to 0.12 mm in size, mainly associated with sulfides.

Zircon forms subhedral prismatic grains up to 0.07 mm long and anhedral grains up to 0.1 mm long.

Pyrite forms disseminated, subhedral to euhedral equant grains averaging 0.02-0.05 mm in size, with a few patches up to 0.4mm across.

Galena forms one anhedral patch 0.08 mm across in quartz.

Marcasite forms wispy, discontinuous veinlets up to 0.01 mm in width and a few patches up to 0.25 mm across. It is extremely fine grained (0.002 mm).

D12-87-104 Granodiorite (Phyllic Alteration) Calls Advanced Argillic in photo description.

The rock is a medium to coarse grained granodiorite which was strongly altered. Plagioclase and K-feldspar were replaced by sericite, hornblende was replaced by quartz-(sericite), biotite was replaced by muscovite-(Ti-oxide), and pyrite was replaced by hematite.

feldspar	50-55%	
quartz	30-35	
hornblende	7- 8	
biotite	1- 2	
Ti-oxide	0.1	
zircon	trace	
pyrite	4- 5	(strongly altered to hematite)
marcasite	trace	
chalcopyrite	trace	

Plagioclase (and lesser K-feldspar) are altered completely to extremely fine grained to locally very fine grained aggregates of sericite. A few patches show subhedral to euhedral outlines against quartz, but generally original textures are not recognizable. Some grains also contain abundant subhedral to euhedral grains of pyrite (altered to hematite) averaging 0.02-0.05 mm in size. Surrounding many of the hematite patches, sericite is stained light to medium orange by limonite.

Quartz forms anhedral grains from 0.3-2 mm in size. It is recrystallized slightly along wispy seams to very fine grained aggregates.

Hornblende forms anhedral grains up to 1 mm in size and a few subhedral prismatic grains up to 2 mm long. These are replaced completely by very fine grained, moderately interlocking aggregates of quartz with minor to moderately abundant sericite and minor Ti-oxide.

Clusters of biotite grains up to 2 mm in size are altered to very fine grained sericite intergrown with moderately abundant Ti-oxide and lesser hematite (after pyrite). One wispy biotite grain 0.8 mm across and another 0.3 mm across are replaced by pseudomorphic muscovite with minor Ti-oxide in lenses along cleavage.

Ti-oxide forms scattered anhedral, equant grains from 0.05-0.15 mm in size.

Zircon forms a subhedral prismatic grain 0.1 mm in length.

Pyrite forms clusters of subhedral to euhedral cubic grains averaging 0.05-0.1 mm in size. Most are altered completely to hematite. A few in quartz are fresh. Hematite also forms scattered anhedral grains and clusters up to 1.5 mm in size.

Chalcopyrite forms a very few grains up to 0.02 mm in size enclosed in quartz grains.

Marcasite forms a very few, extremely fine grained clusters up to 0.03 mm in size.

D12-87-106 Quartz-Sericite-Pyrite-Pyrrhotite/Marcasite-Galena Altered Rock and Vein

Note: The sample is very crumbly, and was examined in two pellets, on of larger fragments and one of smaller fragments.

The rock contains quartz and sericite in a variety of secondary textures, with disseminated patches of sulfides dominated by pyrite and by pyrrhotite altered progressively to marcasite and then to hematite. Minor galena is partly corroded and altered to secondary Pb-minerals and hematite.

quartz	50-55%	pyrrhotite/marcasite	2- 3%
sericite	30-35	hematite	3- 4
Ti-oxide	minor	galena	0.3
pyrite	5- 7%		

Quartz occurs in three main modes. It forms a few patches of extremely fine grained (0.01-0.03 mm), moderately interlocking, cherty aggregates. Most commonly it occurs with minor to abundant sericite in very fine grained (0.02-0.05 mm) aggregates. In a few of these, sericite is oriented giving the rock a weak foliation. A third type of occurrence of quartz is as fine grains 0.2-0.5 mm in size with textures typical of vein quartz, including locally slightly radiating prismatic grains. Textures are somewhat gradational between types, especially the first two. Dusty opaque inclusions are common in some patches of very fine grained quartz-(sericite).

Sericite forms extremely fine grained patches alone or associated with quartz as described above. Borders between the two types are moderately gradational. Limonite locally forms bright yellow stains in sericite patches.

Ti-oxide forms patches up to 0.05 mm across, and a few discontinuous seams up to 0.4 mm long and 0.03 mm wide. Locally it is concentrated in patches of very abundant, extremely fine, disseminated grains in fine grained quartz.

Pyrite forms subhedral to euhedral grains averaging 0.1-0.5 mm in size. Some grains are strongly corroded, and have very irregular outlines within subhedral to euhedral casts. Cubic casts averaging 0.02-0.05 mm across are common in some sericite-(quartz) aggregates. A very few pyrite grains contain inclusions up to 0.02 mm in size of galena, and up to 0.15 mm in sized of pyrrhotite with or without chalcopyrite and galena.

Galena forms slightly to moderately corroded grains up to 0.5 mm in size. Corroded grains have an extremely fine texture produced during replacement of galena by secondary Pb-minerals, which appear to have been leached from the section. Some grains are partly replaced in patches along their borders by extremely fine grained, red-brown hematite.

Pyrrhotite forms patches up to 0.5 mm in size. It is altered strongly to completely to extremely fine grained marcasite showing secondary replacement textures. Marcasite commonly is altered moderately to strongly to hematite.

Hematite forms extremely fine grained, secondary patches up to 1.5 mm in size; textures suggest that these are strongly altered pyrrhotite/marcasite.

Mn-oxide forms dense patches and abundant veinlets and disseminations in some patches of very fine to fine grained quartz (gradational between type 2 and type 3 quartz).

D12-87-111 Galena-Pyrite-Quartz-Sphalerite-Chalcopyrite-Arsenopyrite Vein

The rock is a fine to coarse grained sulfide-quartz vein dominated by galena with lesser pyrite and quartz,and much less sphalerite, chalcopyrite, pyrrhotite, and arsenopyrite. Galena is variably altered to cerusite. Pyrrhotite is altered to pyrite.

quartz	10-12%
sericite	minor
pyrite	20-25
galena	40-45
cerusite	7- 8
sphalerite	4- 5
chalcopyrite	4- 5
arsenopyrite	1
pyrrhotite	minor
covellite	0.2
calcite	0.1
electrum	trace

Quartz forms patches up to 2 mm across of fine to very fine grained aggregates, locally with minor interstitial patches of extremely fine grained sericite. A few patches of quartz contain moderately abundant, subhedral to euhedral grains of pyrite averaging 0.1-0.3 mm in size.

Pyrite forms anhedral grains averaging 0.1-0.2 mm in size, with a few up to 1.5 mm across. Some are moderately corroded. A few large grains contain numerous tiny inclusions of galena and lesser ones of pyrrhotite and chalcopyrite. Some pyrite patches consist of very fine to fine grained aggregates, with minor interstitial quartz. Some patches up to 1.5 mm in size consist of aggregates of fine grained sphalerite surrounded by very fine grained patches of pyrite. This pyrite has slightly lower reflectivity than pyrite grains away from sphalerite. It may be secondary after pyrrhotite.

Galena forms fragments up to 1.5 mm in size. Some grains are relatively fresh. Others are fresh with a rim of extremely fine grained galena replaced by cerusite. Many galena grains are strongly replaced by extremely fine grained cerusite. Some patches of cerusite show a well developed concentric structure. Some galena grains contain wispy veinlets and disseminated patches of chalcopyrite and an unknown, silver-bearing(?) mineral averaging 0.005-0.01 mm in size. The latter is bluish grey in color, and appears to have reddish internal reflection.

Sphalerite forms grains up to 0.7 mm in size. It commonly contains trains and irregular exsolution blebs of chalcopyrite and less commonly of pyrrhotite. Some patches up to 1.5 mm across consist of intergrowths of fine grained sphalerite surrounded by very fine grained aggregates of pyrrhotite/pyrite.

Chalcopyrite forms anhedral patches averaging 0.1-0.5 mm in size, with a few from 1 to 1.7 mm across. Some patches are surrounded by wispy rims of corroded galena. Along the border of the largest patch are moderately abundant anhedral pyrite grains from 0.1-0.3 mm in size.

Covellite forms extremely fine grained patches up to 0.06 mm across enclosed by galena. In a few patches covellite is surrounded by and intimately intergrown with extremely fine grained chalcopyrite and minor bornite(?).

Arsenopyrite forms anhedral grains up to 0.5 mm in size enclosed in galena. These are moderately fractured and slightly corroded along fractures. One is altered along fractures to an intergrowth of light grey and brown minerals of unknown composition.

Electrum (light yellow) forms one equant, subrounded grain 0.003 mm in size in a pyrite grain, and an adjacent grains 0.001 mm across.

Calcite forms one veinlike zone up to 0.3 mm wide in cerusite. Associated with calcite are patches of galena up to 0.1 mm in size. some of which surround extremely fine grained patches of covellite-chalcopyrite up to 0.05 mm in size.

Locally, pyrrhotite forms veinlets up to 0.03 mm wide in pyrite.

D12-87-112 Quartz-Pyrite Vein cut by late vein of Galena-Sphalerite-(Arsenopyrite)

The vein contains a broad core dominated by quartz bordered by zones dominated by pyrite-quartz.

host rock	
quartz	25-30%
sericite	3- 4
zircon	trace
Ti-oxide	trace
veins	
1) quartz	35-40
pyrite	17-20
other sulfides	minor
2) galena	5- 7
sphalerite	2- 3
arsenopyrite	0.1
chalcopyrite	minor
covellite	trace

The sample contains irregular patches of quartz-sericite altered host rock. These consist of aggregates of very fine grained quartz with irregular patches up to 1 mm in size of extremely fine grained sericite to very fine grained muscovite. Zircon forms one subhedral equant grain 0.12 mm across. Ti-oxide forms clusters of a few subhedral grains from 0.03-0.07 mm in average size.

The altered rock is gradational to and partly replaced by coarser grained, commonly subhedral quartz, which shows textures more typical of vein quartz. Locally, coarse grained quartz is slightly recrystallized to extremely fine to very fine grained aggregates. In places, euhedral quartz grains are surrounded by altered rock.

Pyrite forms anhedral to euhedral grains from 0.5-1.5 mm in average size. Several contain abundant inclusions from 0.01-0.05 mm in size of galena and lesser ones of sphalerite, chalcopyrite, and pyrrhotite. One pyrite grain contains a very few inclusions of argentite from 0.02- 0.05 mm in size, in part associated with galena. A few large patches of pyrite consist of very fine to fine grained aggregates of equant, anhedral to subhedral grains with minor interstitial quartz. Scattered pyrite grains in quartz are subhedral to euhedral in outline. Many pyrite grains are slightly corroded along their borders.

A major crosscutting vein up to 1.5 mm wide at one end of the section and a few much smaller veinlets along the border of the section are dominated by galena with lesser sphalerite and much less arsenopyrite.

Galena forms subhedral patches up to 0.35 mm in size which were unaffected by alteration. Much galena is replaced moderately to strongly extremely fine grained cerusite. Locally, cerusite forms patches up to 0.6 mm in size. Galena forms a few patches up to 0.3 mm in size interstitial to euhedrally terminated quartz grains. These patches are replaced strongly by hematite with wispy dendritic to irregular patches of covellite.

Sphalerite forms anhedral grains up to 0.8 mm in size. Some smaller grains contain minor exsolution blebs and trains of chalcopyrite.

Arsenopyrite forms subhedral, in part corroded grains from 0.1-0.2 mm in size, mainly enclosed by galena.

Chalcopyrite forms scattered interstitial grains up to 0.03 mm in size in the galena-sphalerite vein.

Covellite forms a few patches up to 0.1 mm in size surrounded by galena.

D4-87-76 Brecciated Quartz-Pyrite Vein; Late Carbonate Veins and Patches

The rock is a replacement to fracture filling vein of quartz-pyrite, which was brecciated, and the fragments cemented and partly replaced by calcite veinlets and patches, some of which contain abundant angular fragments of pyrite.

calcite	40-45%
quartz	30-35
sericite	0.5
pyrite	20-25
galena	minor
chalcopyrite	trace
tetrahedrite(?)	trace
hematite	0.5

Quartz forms aggregates ranging widely in grain size. Very fine grained patches commonly have strongly interlocking grains borders and irregular outlines. Some of these contain minor to locally moderately abundant sericite as concentrations of disseminated flakes in quartz and a few patches up to 0.1 mm in size of unoriented flakes. In places, sericite-quartz intergrowths form thin interstitial selvages between coarser grained quartz. Textures suggest that quartz-sericite aggregates represent strongly altered and silicified host rock. Coarser grained patches of quartz averaging 0.2-1 mm in grain size have textures suggestive of veins.

Calcite occurs in patches and veins, mainly of very fine grain size. Extremely fine grained concentrations of angular pyrite fragments are common in some veins. One large veinlike zone of calcite-pyrite has a border zone of extremely fine grained calcite containing abundant angular fragments of pyrite, and a core of very fine to fine grained calcite, relatively free of pyrite. Late calcite veinlets up to 0.2 mm wide cut fractured pyrite grains and quartz.

Pyrite forms subhedral to euhedral grains averaging 0.1-0.5 mm in size. Some are fractured moderately to strongly, and in several patches of these, quartz fills narrow, wispy fractures. One grain contains a few inclusions up to 0.02 mm in size of pyrrhotite-chalcopyrite, and another contains a few inclusions up to 0.03 mm in size of galena with lesser argentite. One strongly brecciated veinlike zone of pyrite up to 0.2 mm wide is replaced moderately to strongly by hematite.

Galena and much less tetrahedrite form interstitial patches up to 0.15 mm in size in pyrite-rich clusters. Tetrahedrite forms a few irregular patches up to 0.1 mm in size. It is moderately hard, with low reflectivity and brownish grey color against galena.

One patch 0.03 mm across in quartz contains a grain of chalcopyrite adjacent to a slightly smaller grain of galena. Both minerals are slightly corroded.

D3A-87-114 **Altered Granodiorite replaced by Quartz-Pyrite; cut by late veins and replacement patches of Carbonate-Quartz-Tetrahedrite-Chalcopyrite**

The rock is a medium to coarse grained granodiorite which was strongly altered to quartz-sericite-muscovite, and replaced by quartz-pyrite-(arsenopyrite). Late veins and patches consist of carbonate (ankerite and calcite), quartz, with patches of tetrahedrite-chalcopyrite-(pyrite).

sericite	30-35		
quartz	40-45%		
biotite	3- 4		
Ti-oxide	0.5		
pyrite	12-15		
arsenopyrite	0.1		
carbonate	5- 7	pyrrhotite	trace
tetrahedrite	1.5-2	covellite	trace
chalcopyrite	1		

Sericite (after plagioclase and probably much less K-feldspar) forms extremely fine grained to locally very fine grained aggregates in patches up to 2 mm in size. Original feldspar outlines are almost completely destroyed. Sericite patches grade into aggregates of sericite and very fine grained quartz.

Quartz mainly occurs as medium to coarse, anhedral grains intergrown coarsely with sericite and sericite/quartz patches. Locally it forms extremely fine grained, cherty patches and lenses, in part along thin fractures between medium grained pyrite grains, and elsewhere cutting patches of sericite.

Biotite forms ragged, strongly corroded flakes up to 1.7 mm in size. It is altered completely to pseudomorphic muscovite with irregular patches of extremely fine grained Ti-oxide.

Ti-oxide forms clusters from 0.05-0.25 mm in size intergrown with quartz and sericite. In places, Ti-oxide appears to have been a nucleus for replacement by pyrite, and some pyrite grains contain abundant inclusions of Ti-oxide. Minor Ti-oxide grains up to 0.08 mm in size occur in carbonate.

Zircon forms a very few subhedral prismatic grains up to 0.1 mm in length.

Pyrite forms clusters of anhedral to euhedral grains ranging from 0.03-1.5 mm in size. One grain contains two inclusions, 0.1 mm and 0.03 mm long, respectively, composed of slightly intergrown chalcopyrite and pyrrhotite.

Arsenopyrite forms a few grains 0.05-0.2 mm in size on the border of a cluster of pyrite. One arsenopyrite grain is rimmed by a zone up to 0.01 mm in width containing minor extremely fine grained covellite. Arsenopyrite also forms a very few subhedral grains up to 0.1 mm in size enclosed in pyrite.

Carbonate forms irregular replacement patches, mainly associated with the carbonate-bearing vein. The moderately high relief of much of the carbonate suggests that it is ankerite. One discontinuous vein up to 3 mm long consists of medium to coarse grained calcite partly rimmed by very fine grained quartz, whose grains commonly are in subparallel orientation perpendicular to the wall of the vein.

The rock is cut by a diffuse branching veinlike zone up to 1 mm wide containing subhedral to euhedral quartz, with interstitial patches of carbonate, tetrahedrite, and chalcopyrite, with minor pyrite.

Tetrahedrite forms anhedral patches up to 1 mm across, commonly associated with lesser chalcopyrite. Some of the patches contain inclusions of fine grained pyrite and extremely fine grained chalcopyrite. Nearby in quartz are grains of chalcopyrite up to 0.2 mm across. Chalcopyrite forms patches up to 0.7 mm long mm across intergrown with lesser very fine grained tetrahedrite. Many chalcopyrite grains are partly surrounded by thin rims of tetrahedrite. A few patches of chalcopyrite contain inclusions of very fine grained pyrite.

D9C-87-13 **Silicified Rock replaced by Pyrite-Arsenopyrite, and cut by Quartz and Carbonate Veins**

The original rock was strongly altered to the assemblage quartz-pyrite-arsenopyrite-sericite. It was brecciated and healed by veins dominated by calcite and quartz.

quartz	50-55%
sericite	1- 2
Ti-oxide	0.2
apatite	0.1
carbonate	20-25
pyrite	15-17
arsenopyrite	3- 4
sphalerite	0.3
galena	0.1
chalcopyrite	trace

The rock contains patches up to a few mm across of extremely fine to very fine grained, moderately interlocking quartz, with minor to moderately abundant disseminated euhedral to subhedral grains of arsenopyrite and/or pyrite averaging 0.01-0.03 mm in size. Sericite is concentrated in patches up to 0.5 mm in size, which may be relics from original feldspar grains. Ti-oxide and apatite commonly are concentrated together; textures suggest that they were inclusions in original hornblende grains which have since been altered completely to quartz. Ti-oxide forms subhedral stubby prismatic grains averaging 0.05-0.07 mm in size. and local anhedral patches up to 0.25 mm in size. Apatite forms anhedral grains up to 0.05 mm across. It is concentrated in a few clusters of very irregular grains up to 0.2 mm in size, associated with the large Ti-oxide patches. Calcite forms irregular, very fine grained patches replacing the host rock.

The rock was brecciated, and fragments healed by irregular veins of calcite and quartz. Calcite ranges from very fine to very coarse grained. Quartz commonly forms subparallel aggregates oriented perpendicular to vein walls. In cores of veins, quartz forms euhedral prismatic grains surrounded by interstitial calcite. Some very fine grained calcite aggregates were slightly strained and recrystallized from coarser grained aggregates.

Pyrite forms anhedral grains up to 2 mm in size. Some grains contain abundant tiny inclusions of one or more of galena and lesser chalcopyrite and sphalerite. Pyrite is variably brecciated, with most grains cut only by coarse fractures, and a few intensely granulated.

Arsenopyrite forms abundant disseminated subhedral, rhombic grains averaging 0.02-0.05 mm in size in the very fine grained altered host rock. It also forms subhedral to euhedral cubic grains from 0.1-1 mm in size associated with pyrite and possibly partly pseudomorphic after pyrite.

Sphalerite occurs in one main patch up to 1 mm across, in which it is intergrown finely with calcite. Sphalerite is mainly red-brown in color, with minor orange colored patches. It contains moderately abundant exsolution blebs of chalcopyrite averaging 0.002-0.003 mm in size.

Galena forms a few anhedral, equant inclusions in pyrite up to 0.6 mm in size. More commonly it forms moderately abundant inclusions averaging 0.01-0.03 mm in size with a few elongate ones up to 0.2 mm in length.

Chalcopyrite forms minor grains up to 0.05 mm in size in fractures and inclusions in pyrite, and forms a very few grains up to 0.05 mm in size along borders of sphalerite.

Late fracture-filling calcite veinlets cut the rock; these vary in thickness from 0.02-0.2 mm along the length of a vein. Some calcite grains are strongly strained. Some of these contain minor pyrite grains up to 0.4 mm in size.

D8-87-145 **Altered Quartz Diorite cut by Sphalerite-Galena-Arsenopyrite-Calcite-Quartz Vein**

The sample is a medium grained diorite which was altered to a phyllic assemblage, and cut by a vein up to 1 cm wide dominated by sphalerite with lesser calcite, arsenopyrite, galena and quartz.

rock		arsenopyrite	0.1%
plagioclase	30-35%	Ti-oxide	0.1
quartz	8-10	apatite	minor
biotite	4- 5	zircon	trace
hornblende	2- 3		
pyrite	3 -4		
vein			
sphalerite	20-25		
arsenopyrite	7- 8		
galena	3- 4		
calcite	10-12		
quartz	2- 3		
chalcopyrite	trace		

Plagioclase forms subhedral prismatic grains averaging 0.2-0.8 mm in size. It is altered completely to extremely fine grained sericite

Quartz forms interstitial grains averaging 0.05-0.3 mm in size.

Biotite forms ragged flakes up to 1.5 mm in size. It is replaced completely by pseudomorphic muscovite with abundant extremely fine grained Ti-oxide oriented in cleavage planes of mica.

Hornblende forms a few phenocrysts up to 2 mm across. It is altered completely to very fine grained quartz with interstitial to porphyroblastic sericite and moderately abundant dusty Ti-oxide. Disseminated cubic pyrite is common in hornblende.

Pyrite occurs in clusters up to 1 mm in size and as disseminated grains averaging 0.03-0.07 mm in grain size. Most grains are subhedral to euhedral cubes. Nearer the vein, some patches up to 1 mm across consist of dense intimate intergrowths of very fine grained pyrite and arsenopyrite. Arsenopyrite also forms a few disseminated patches of a few to several subhedral to euhedral grains averaging 0.02-0.05 mm in size.cleavage planes .

Ti-oxide (after ilmenite) forms extremely fine grained patches up to 0.3 mm in size.

Apatite forms scattered subhedral to euhedral prismatic grains averaging 0.07-0.12 mm in length.

Zircon forms subhedral equant to prismatic grains up to 0.07 mm in size.

Near the main vein are patches of very fine grained quartz with lesser sphalerite and carbonate, and a few disseminated patches of arsenopyrite.

Bordering the vein is a discontinuous halo averaging 0.03-0.05 mm in size composed of extremely fine grained arsenopyrite with lesser pyrite.

vein

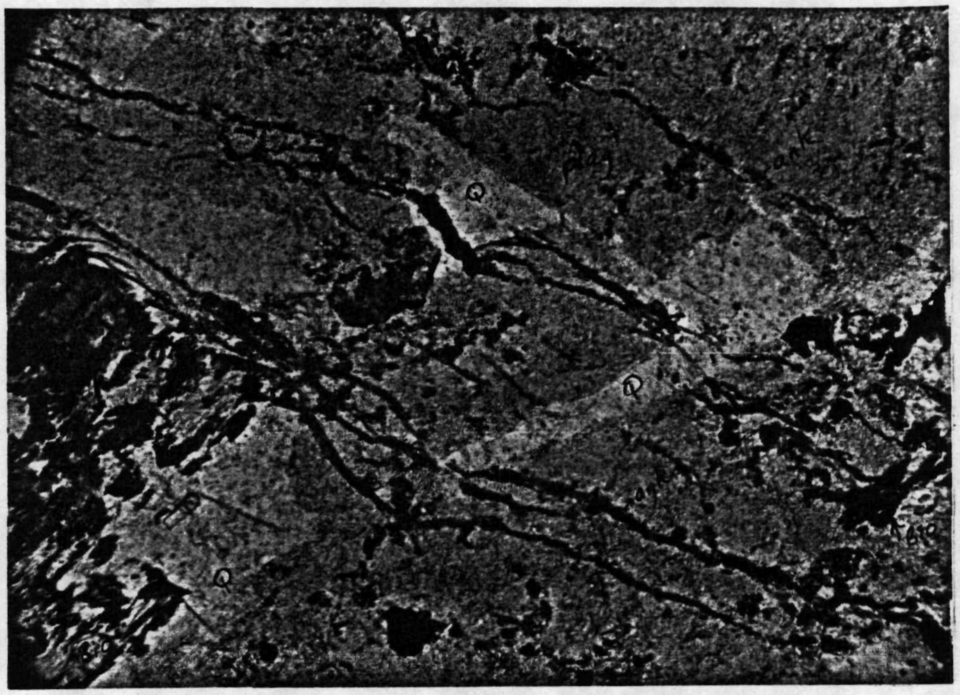
Sphalerite forms anhedral grains up to 2 mm in size. It commonly is color zoned, with medium to dark orange cores grading outwards towards light to pale orange rims. Sphalerite locally contains exsolution blebs of chalcopyrite averaging 0.002 mm in size.

Arsenopyrite forms clusters of subhedral to anhedral rhombic to irregular grains averaging 0.02-0.04 mm in size. These grade outwards into disseminated subhedral to euhedral grains of similar habit with interstitial patches of galena, and less commonly of one of sphalerite, quartz, carbonate, and sericite. In some patches, early formed arsenopyrite and pyrite are fractured, with fractures filled by galena.In a few patches, elongate euhedral arsenopyrite grains are up to 0.3 mm in length.

Galena forms anhedral patches up to 0.5 mm in size, locally coarsely intergrown with sphalerite, and is common interstitial to arsenopyrite.

Pyrite forms scattered subhedral to euhedral grains averaging 0.05-0.1 mm in size enclosed in other sulfides.

Calcite and lesser quartz form very fine grained to locally fine grained patches interstitial to sulfide aggregates, and locally containing abundant inclusions of arsenopyrite. Near the border of the vein sulfides are much less abundant. Here the vein is dominated by very fine grained calcite with lesser patches of extremely fine to very fine grained quartz, disseminated patches of sulfides, and minor sericite.Sericite forms patches up to 0.8 mm in size, and may be secondary after original plagioclase.



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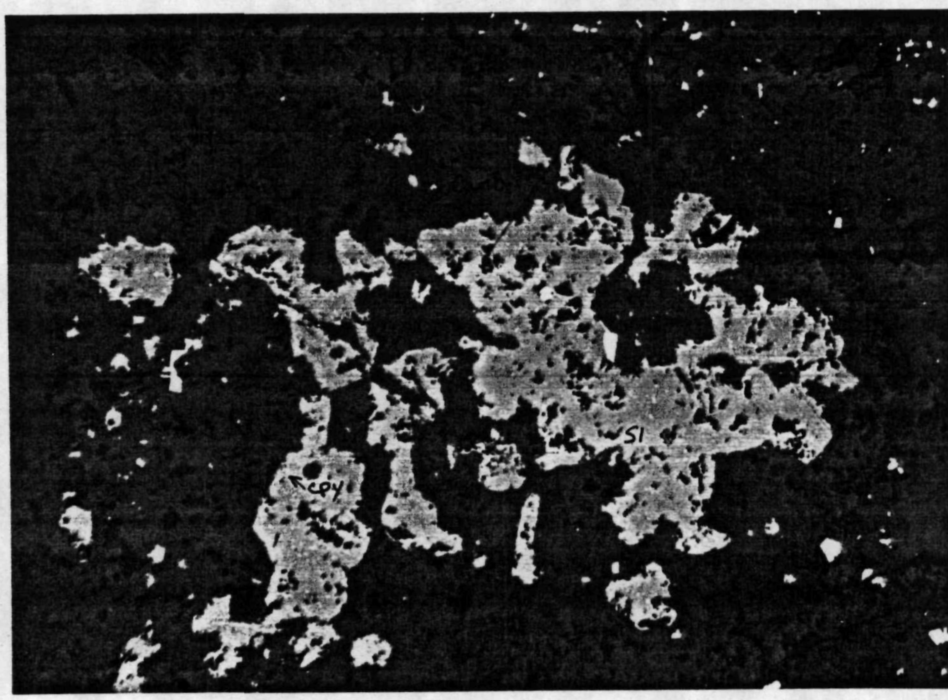

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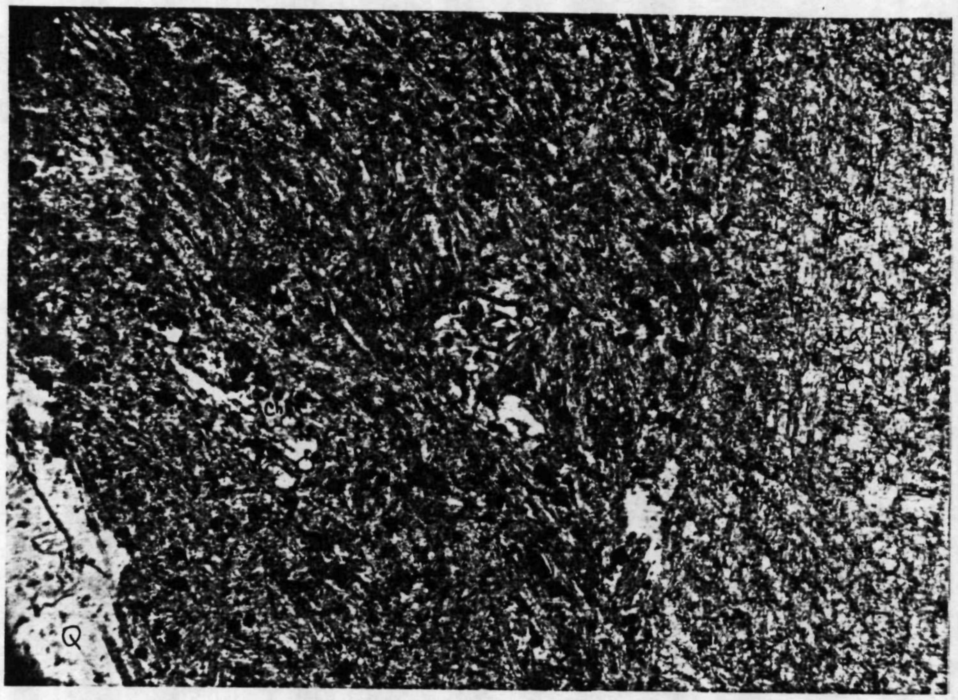
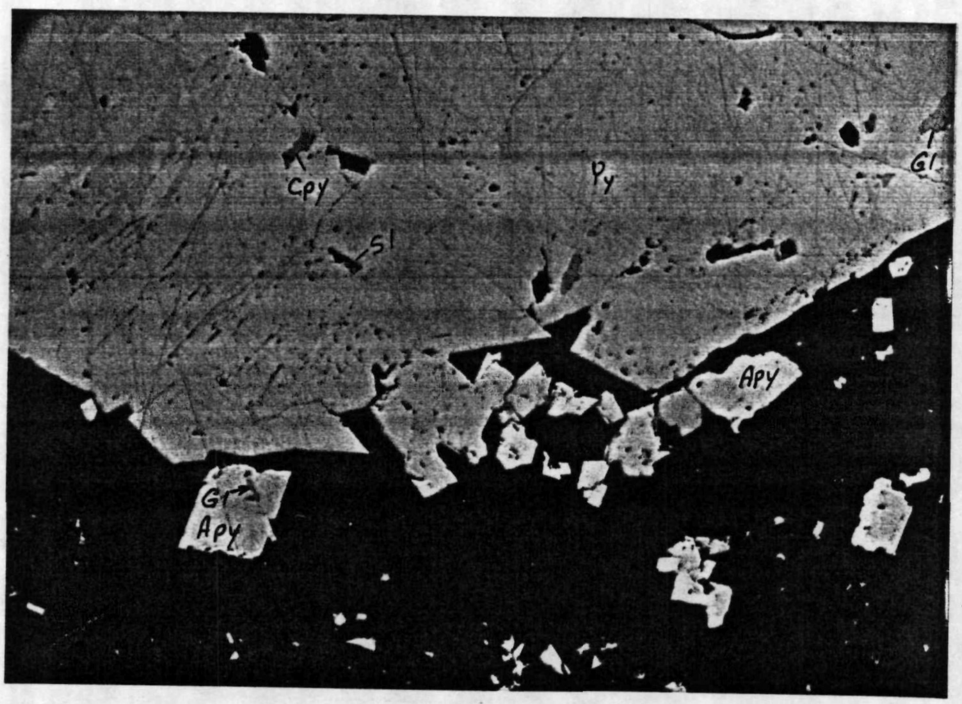


D12-87-13



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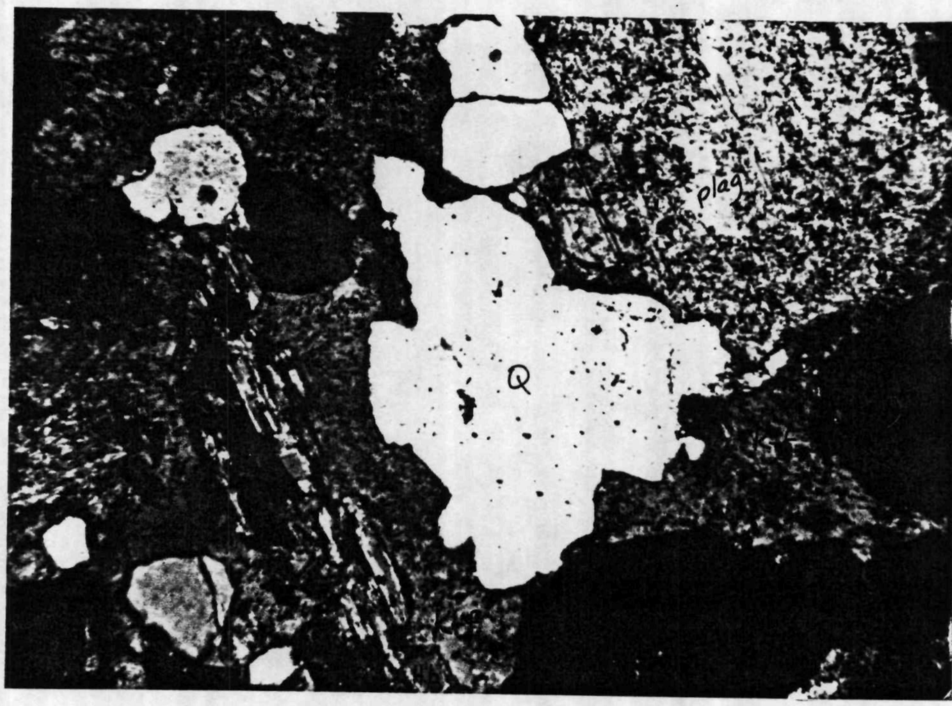

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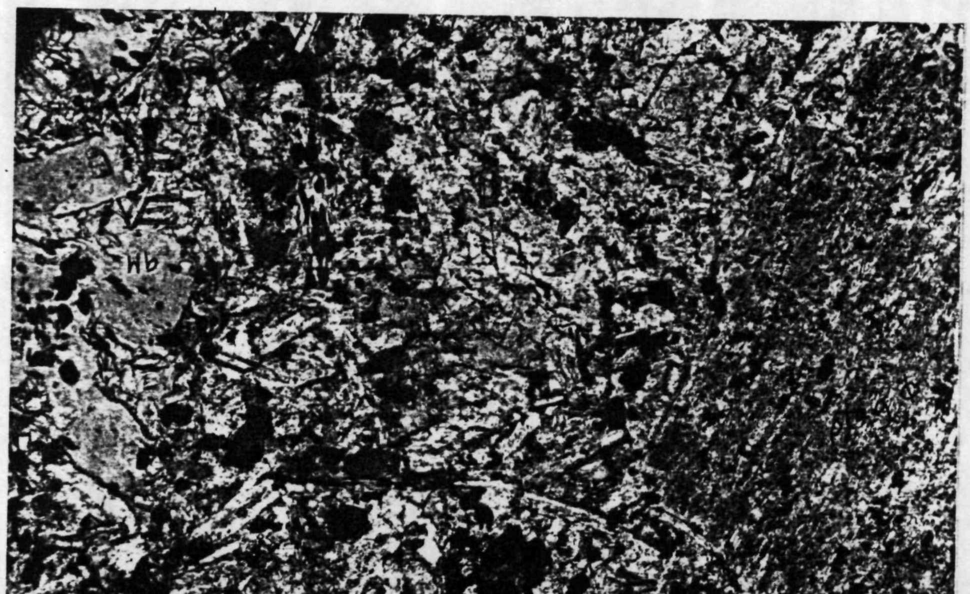

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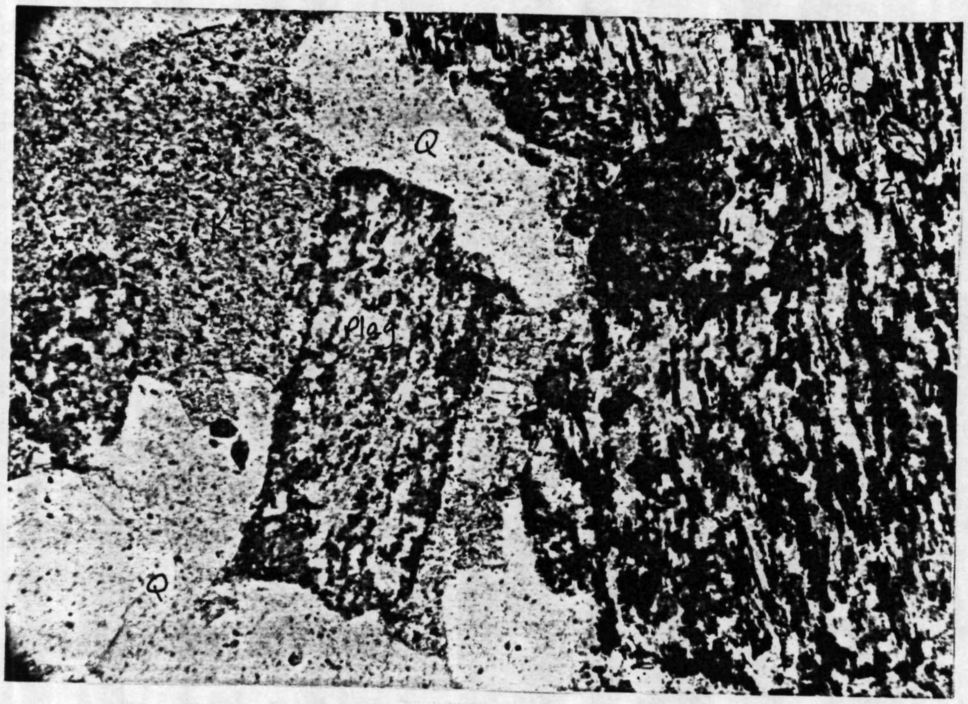

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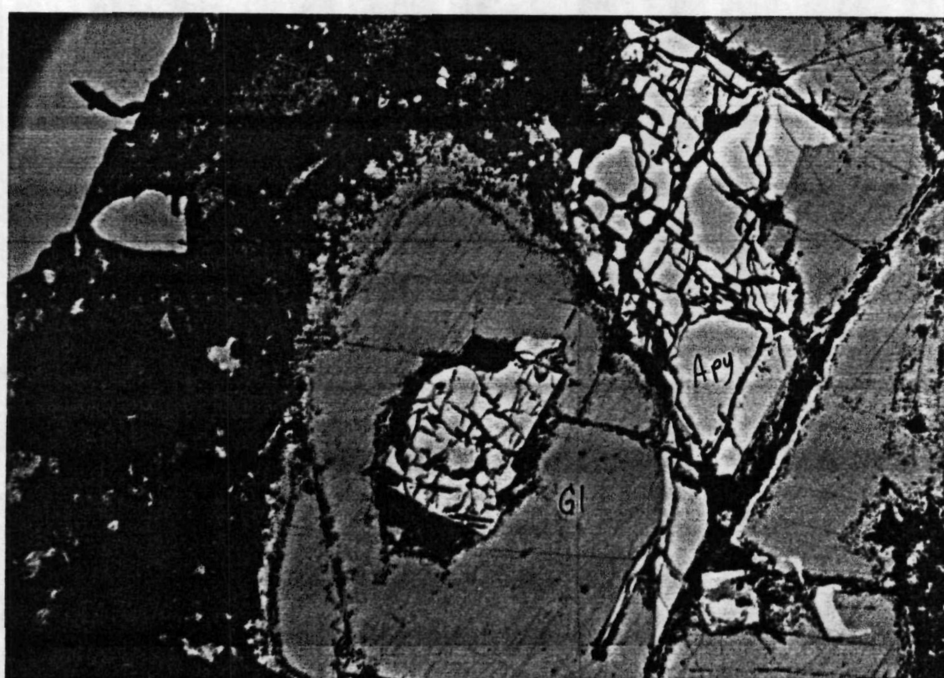

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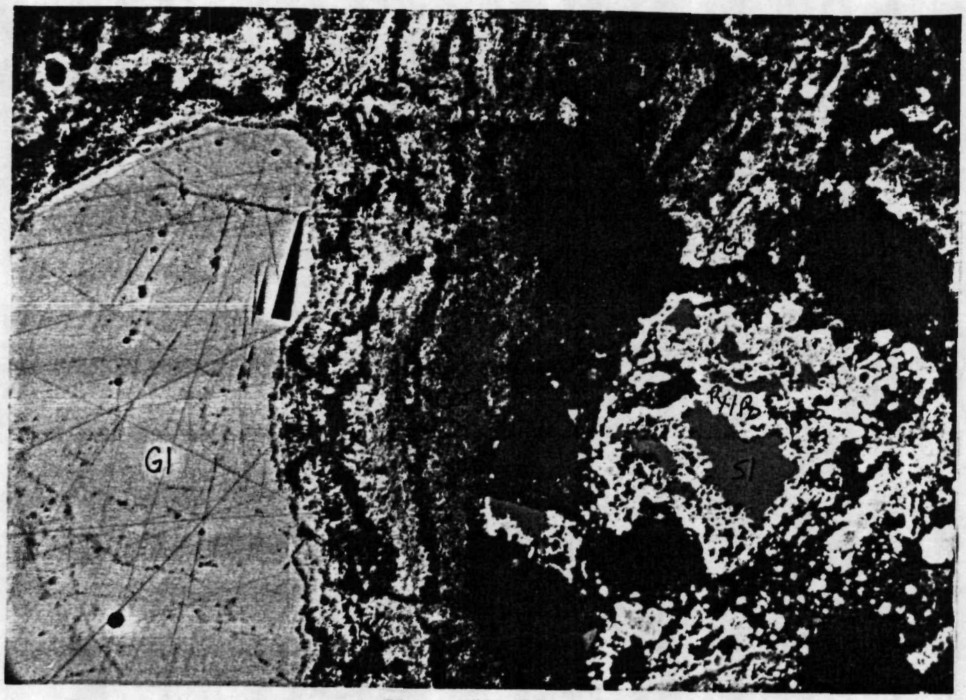

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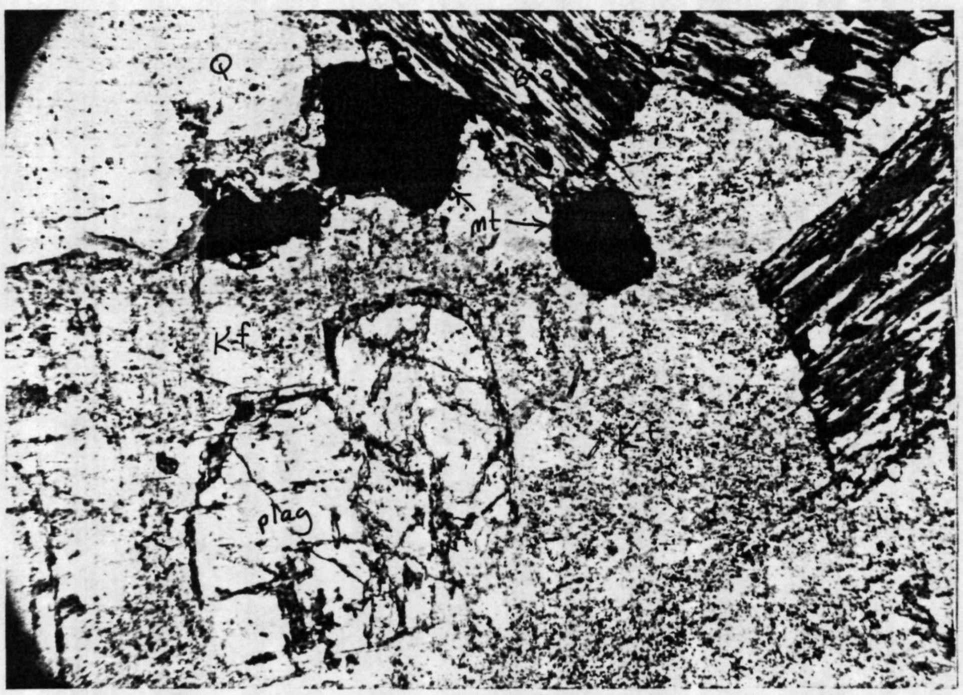

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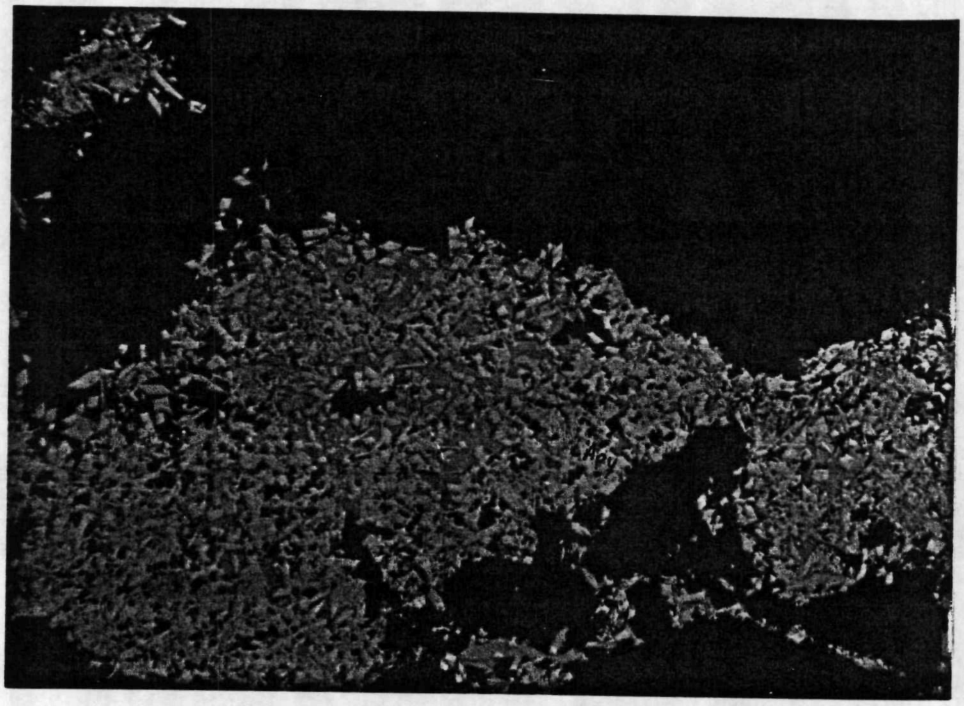

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D4-87-264

D4-87-264

D8-87-114

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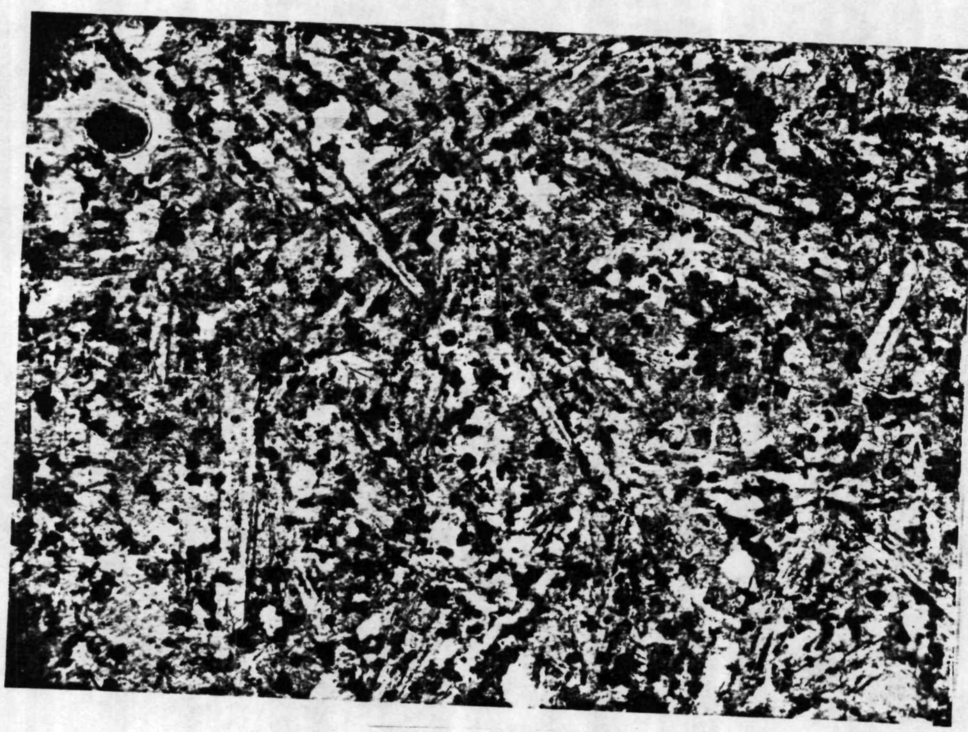

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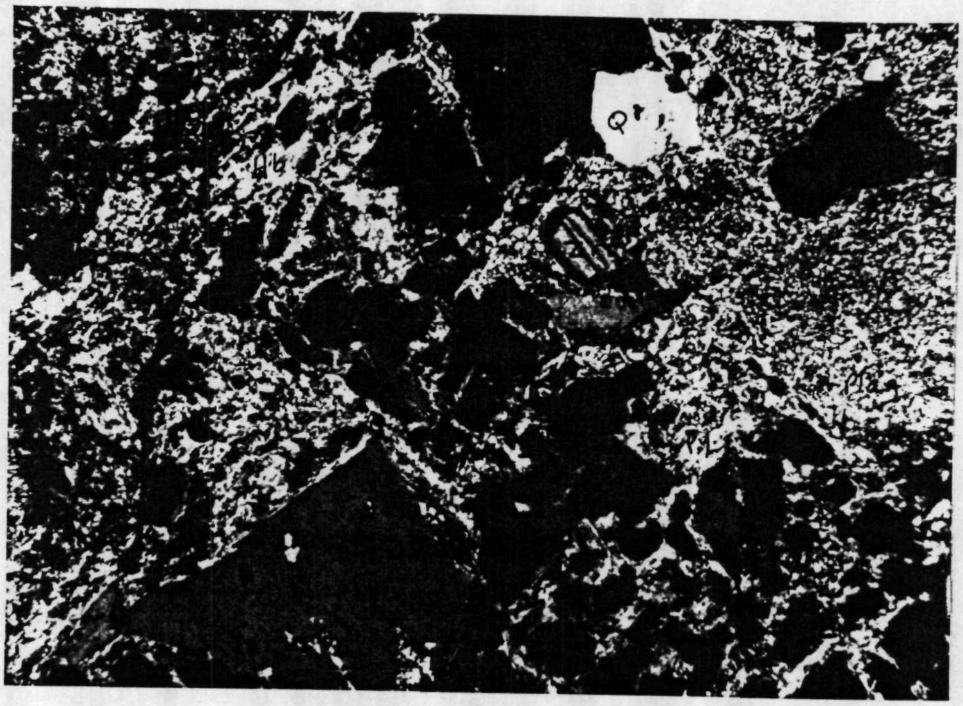

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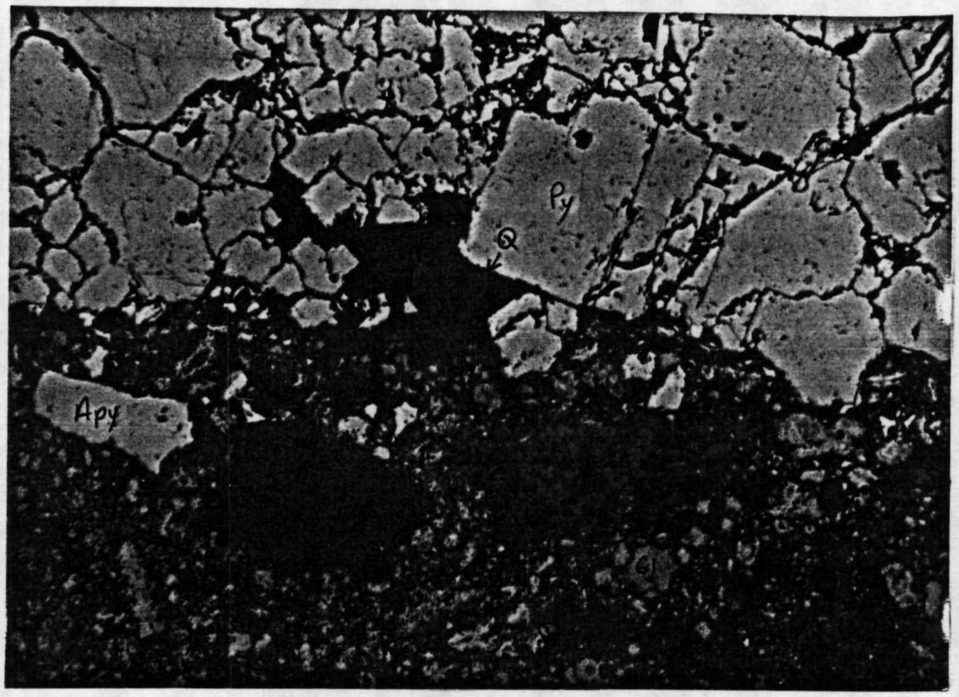

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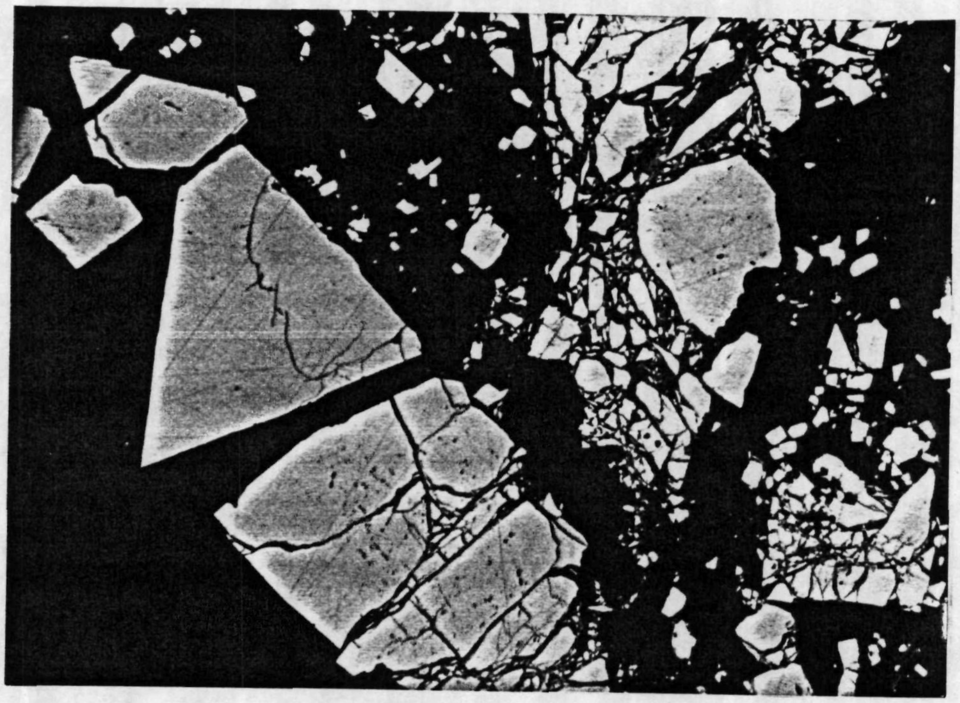

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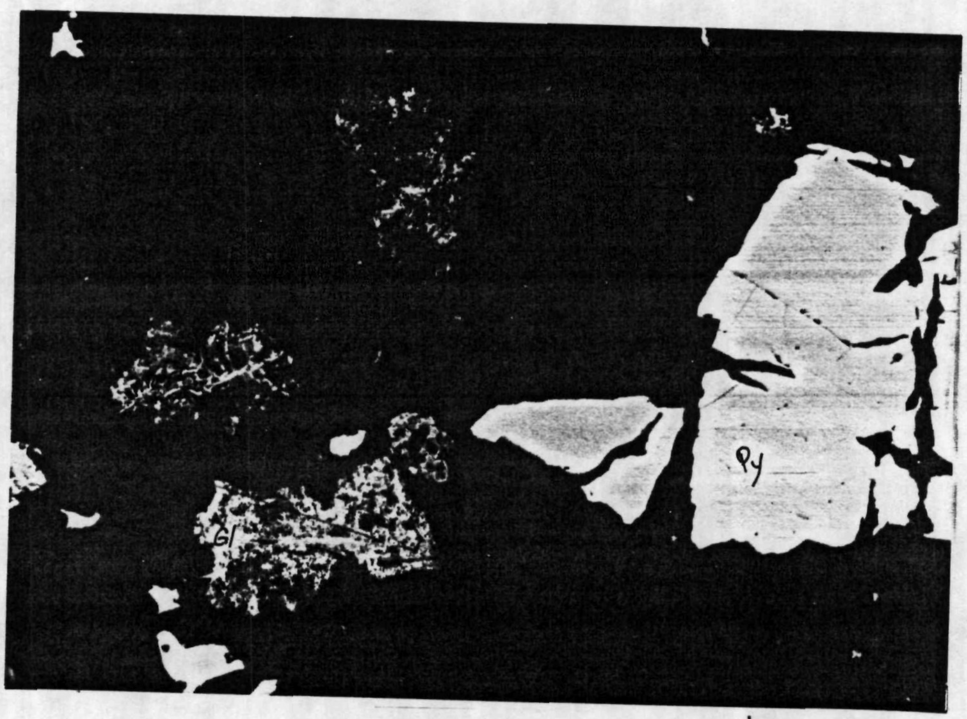

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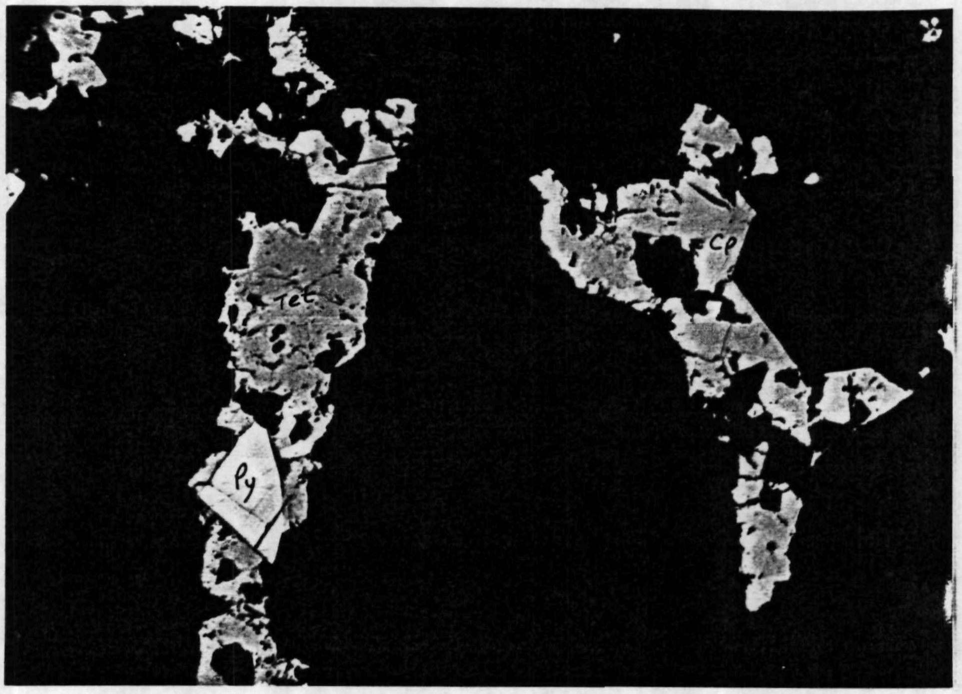

D3A-87-114

D3A-87-114