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Mining District File Summary Sheet

DISTRICT	Rosebud
DIST_NO	4010
COUNTY If different from written on document	Pershing
TITLE If not obvious	Petrography of an unusual high-grade sample from the Rosebud Mine, Nevada, (Sample 13-4904-54), 28 February 2000
AUTHOR	Clark J; Allen K
DATE OF DOC(S)	2000
MULTI_DIST Y / N? Additional Dist_Nos:	
QUAD_NAME	Sulphur 7½'
P_M_C_NAME (mine, claim & company names)	Rosebud Mine; Applied Petrographics
COMMODITY If not obvious	gold; silver
NOTES	Petrographic report; photographs; geology; mineral list 34p.

Keep docs at about 250 pages if no oversized maps attached
(for every 1 oversized page (>11x17) with text reduce
the amount of pages by ~25)

SS: DP 9/10/08
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PETROGRAPHY OF AN UNUSUAL HIGH-GRADE SAMPLE FROM THE ROSEBUD MINE, NEVADA (Sample 13-4904-S4)

By

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APPLIED PETROGRAPHICS
Tucson, Arizona

28 February 2000

Prepared for
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INTRODUCTION

Two unusual high-grade samples from the Rosebud mine were submitted to APPLIED PETROGRAPHICS for petrographic analysis. Both samples were collected from the same location in stope 13, panel S4, on the 4904 elevation. One of the samples contains pieces of silicate-bearing hydrothermal breccia dispersed in an unusual, porous black matrix, while the other contains predominantly pyrargyrite and marcasite encompassed by the same fine black matrix. Both samples were given the same field sample number designation, 13-4904-S4. This report presents the results of the petrographic analyses.

METHODOLOGY

The samples were sent to Quality Thin Sections of Tucson, Arizona for polished thin section preparation. Four sections were prepared from the pyrargyrite-marcasite-black matrix sample, two of which were prepared as polished thick sections. Three polished thin sections were prepared from the other sample. The thin (or thick) sections from each sample were given designations based on the sample number and the slot number in the thin section box. The section numbers are as follows:

13-4904-S4/#1	pyrarg-mc in black matrix	
13-4904-S4/#2	pyrarg-mc in black matrix	
13-4904-S4/#3	pyrarg-mc in black matrix	(thick section)
13-4904-S4/#4	pyrarg-mc in black matrix	(thick section)
13-4904-S4/#5	hydrothermal bx pieces in black matrix	
13-4904-S4/#6	hydrothermal bx pieces in black matrix	
13-4904-S4/#7	hydrothermal bx pieces in black matrix	

Owing to a somewhat friable and fractured nature, both samples were impregnated with resin prior to sample preparation. Even so, the samples were extremely hard to prepare and did not polish well. Much material may have been plucked.

Each section was examined using standard transmitted and reflected light petrographic methods on an Olympus BX-60 polarizing microscope. Samples 13-4904-S4/#5, #6, and #7 were examined also under cathodoluminescence using a Nuclide ELM-2 Luminoscope mounted on a Nikon SMZ-1 stereo zoom microscope. Photomicrographs of significant features were taken for documentation with an Olympus OM-2 photo system mounted on each microscope.

RESULTS

A summary description for each sample is presented in this section, while individual section descriptions are found at the end of this report in Appendix 1.

13-4904-S4/#1 - #4 (pyrargyrite-marcasite in black matrix)

Representative photomicrographs from this sample type are given in Figures 1 through 6. Hand lens examination of the billets from this sample shows it to consist primarily of coarse to fine pyrargyrite and marcasite, and minor small devitrified tuffaceous volcanic fragments packed in a very fine-grained, porous, sooty black matrix. Pyrargyrite makes up perhaps 30 - 40% of

the sample, while marcasite abundance is about 7 - 10%. Thin section examination shows the sample to consist predominantly of opaque phases. The black matrix, which generally makes up about 50% of the sample, is a fine-grained network of opaques, quartz, and minor clay or fine sericite. In transmitted light the black matrix appears finely granular with an average crystal size of about 0.004mm diameter for the opaque phases and 0.02mm diameter for the granular quartz. Locally the black matrix shows fine laminations, with the laminated zones disrupted along fractures. Pyrargyrite has characteristic red internal reflections in transmitted light. It forms coarse to fine, subhedral to anhedral crystals to nearly 15mm in diameter. Recognizeable morphologies include rectangular and crude hexagonal, and the larger crystals show abundant internal fracturing. In transmitted light the marcasite is completely opaque and tends to form elongate crystal aggregates to several millimeters in length. The devitrified tuffaceous volcanic fragments are not abundant in this sample type. Where present they form angular to subround pieces to 2.5mm diameter. They consist of very fine-grained xenomorphic polycrystalline quartz and sericite-clay.

RL: Based on detailed examination under reflected light of the two polished thin sections and two polished thick sections of this sample type, the opaque phases present and estimated abundance ranges are as follows:

black matrix (stannite III-Q-minor clay)	40 - 50%
pyrargyrite	30 - 40%
marcasite	7 - 10%
pyrite	<0.5%
pearceite/polybasite group	<1 -5%
native gold	< 0.05 - 0.2%

The most unusual feature of the sample is the fine black matrix, which hosts abundant coarse to fine, subhedral to anhedral crystals and crystal aggregates of pyrargyrite, pearceite/polybasite, and marcasite. The silver sulphosalts and marcasite are packed in a very fine-grained sponge-textured intergrowth of a grayish brown opaque phase, quartz, and minor fine sericite-clay. Very fine-grained quartz probably constitutes no more than 15-20% of the matrix material. The quartz forms xenomorphic-granular crystals that range in size from about 0.005mm to 0.06mm in diameter. The very fine opaque phase forms a network that appears to crystallize along quartz grain boundaries, enveloping individual xenomorphic quartz crystals or, less commonly, very fine polycrystalline quartz aggregates. Minor very fine sericite or clay occurs also along quartz crystal boundaries. The opaque component of the black matrix is highly unusual and appears to be composed primarily of a porous, sponge-textured phase identified tentatively as stannite III ($CuSnS_2$-$AgSnS_2$ series). The phase is characterized by a grayish brown to brownish gray color, low to moderate reflectance (R<28), weak anisotropism, and very poor polishing characteristics. The poor polishing characteristics lead to an apparent matrix reflectance much less than the polished mineral, and much of the material may also have been plucked. Less likely possibilities for the identity of this phase include tetrahedrite, stephanite, or a canfieldite-argyrodite series mineral, although the porous texture is considered diagnostic of stannite III. Locally the stannite III contains native gold as

partial thin rims and narrow internal filaments, perhaps filling microfractures. Locally the black matrix has a finely laminated appearance, primarily adjacent to large sulfide-sulphosalt phases and devitrified tuffaceous volcanic fragments. An amorphous gray brown material present throughout as irregular patches appears to be the impregnation media.

Pyrargyrite is present as coarse to fine, irregular to rectangular to crudely hexagonal crystals to nearly 15mm in length/diameter. The larger crystals exhibit significant fracturing. The pyrargyrite is characterized by a light gray color with a weak bluish tint and strong red internal reflections. Some of the pyrargyrite crystals contain blebs of a second silver sulphosalt that has a similar gray color, but with a slight brownish tint and slightly higher reflectance. This phase is identified tentatively as belonging to the pearceite/polybasite group. It displays weak anisotropism and weak to non-existent red internal reflections. The pearceite/polybasite group mineral occurs also in edge contact with the pyrargyrite and as discrete crystals dispersed in the black matrix. In these modes the pearceite/polybasite phase forms generally anhedral, irregular crystals to 0.9mm in length. Some of these crystals are intergrown with another silver sulphosalt that is gray with a purplish to brownish tint and may be stephanite. The pearceite/polybasite phase is notable because it commonly carries very fine blebs and narrow filaments of native gold. Fine blebs of native gold are found only rarely within the pyrargyrite. The pyrargyrite sometimes contains small inclusions of marcasite, as well.

Marcasite is the second most abundant phase dispersed in the black matrix. The marcasite forms subhedral to anhedral crystals and crystal aggregates to 4mm length. The crystals are commonly somewhat porous and locally contain small inclusions of pyrite. Marcasite is commonly, although not universally, in edge contact with pyrargyrite or the pearceite/polybasite group mineral. Marcasite may have crystallized later than the silver minerals; it locally forms discontinuous, irregular rims on some pyrargyrite crystals. In many instances, however, the marcasite and silver minerals are intergrown, and the relative parageneses are not clear. Minor pyrite is present, as well. The pyrite occasionally forms small inclusions within marcasite crystals and occurs also as subhedral crystals to 0.03mm in diameter dispersed in the black matrix.

Native gold forms partial thin rims and narrow internal filaments on stannite III in the fine black matrix and is common in the same occurrence modes in the pearceite/polybasite group mineral. It occurs only rarely as tiny blebs within, or at the margin of, pyrargyrite crystals.

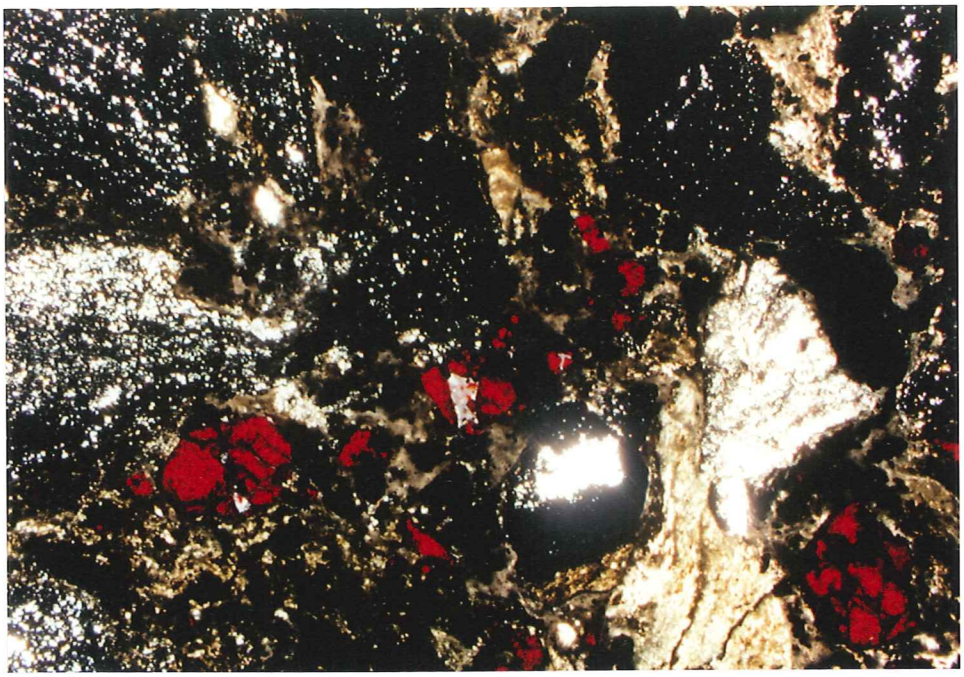

Figure 1a. 13-4904-S4/#1. Pyrargyrite, marcasite, and tuffaceous volcanic rock fragments in fine black matrix. The black matrix is composed of stannite III, quartz, and minor sericite-clay and looks very finely granular in the photo. Note the laminated texture in the left half of the photo. Pyrargyrite has strong red internal reflections, and the crystal in the lower left quadrant shows hexagonal form. The volcanic fragments in the right half ogf the photo are composed of fine quartz and sericite-clay. TLX; 1cm on the photo= 0.532mm.

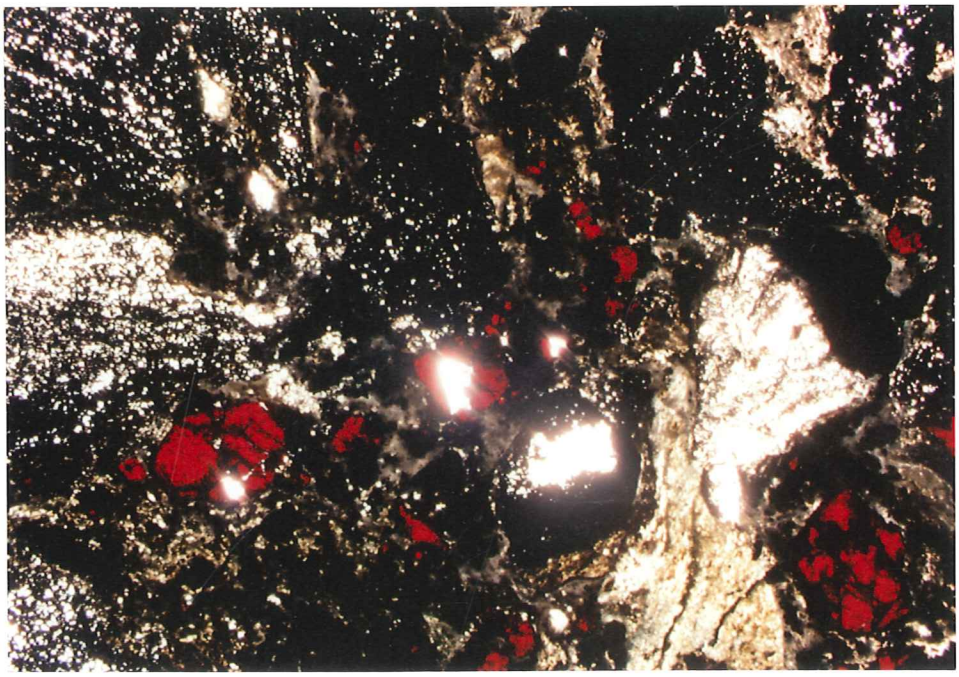

Figure 1b. 13-4904-S4/#1. Pyrargyrite, marcasite, and tuffaceous volcanic rock fragments in fine black matrix. Same view and scale as Figure 1a. TLP; 1cm on the photo= 0.532mm.

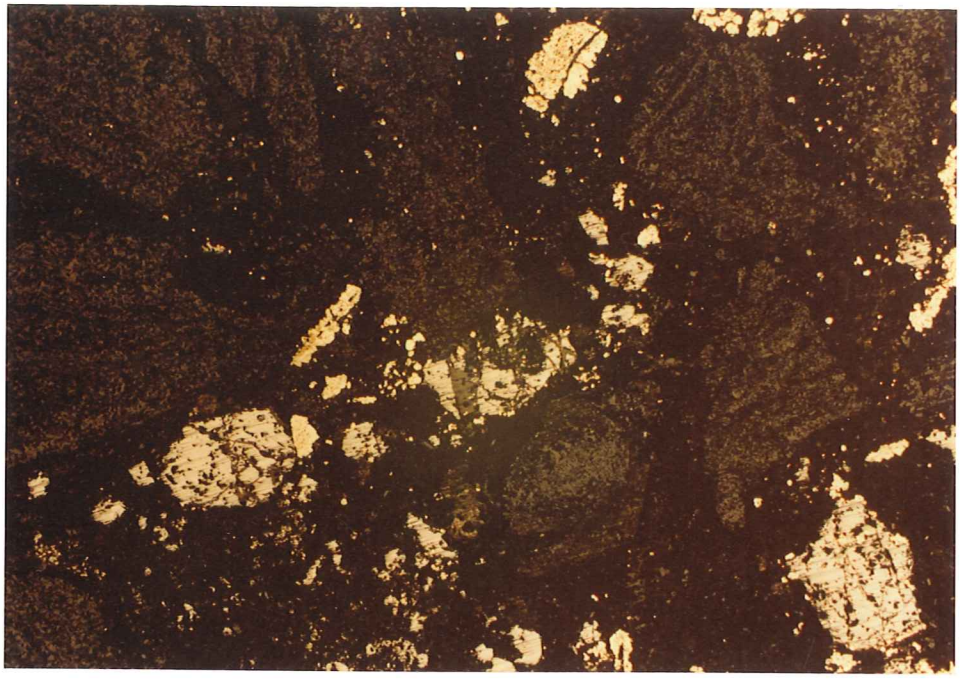

Figure 1c. 13-4904-S4/#1. Pyrargyrite, marcasite, and tuffaceous volcanic rock fragments in fine black matrix. Same view and scale as Figures 1a and b. Marcasite has a yellowish white color and a higher reflectance than the pyrargyrite. Very fine-grained stannite III in the black matrix polishes only sporadically, but is visible in the lower left corner of the photo. RL; 1cm on the photo= 0.532mm

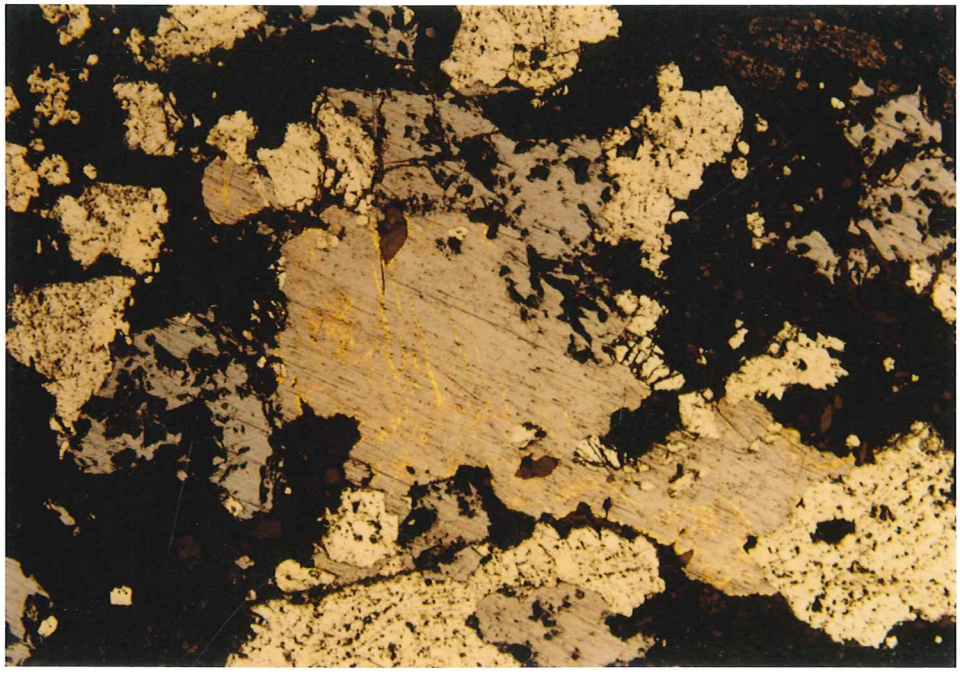

Figure 2. 13-4904-S4/#1. Pyrargyrite, marcasite, and tuffaceous volcanic rock fragments in fine black matrix. Marcasite (yellowish-white, high R) in edge contact with pyrargyrite (gray; near upper and left edges of photo) and pearceite/polybasite group phase (photo center, slightly brownish gray against pyrargyrite). The pearceite/polybasite phase has internal filaments and narrow, discontinuous margins of native gold. RL; 1cm on the photo= 0.106mm.

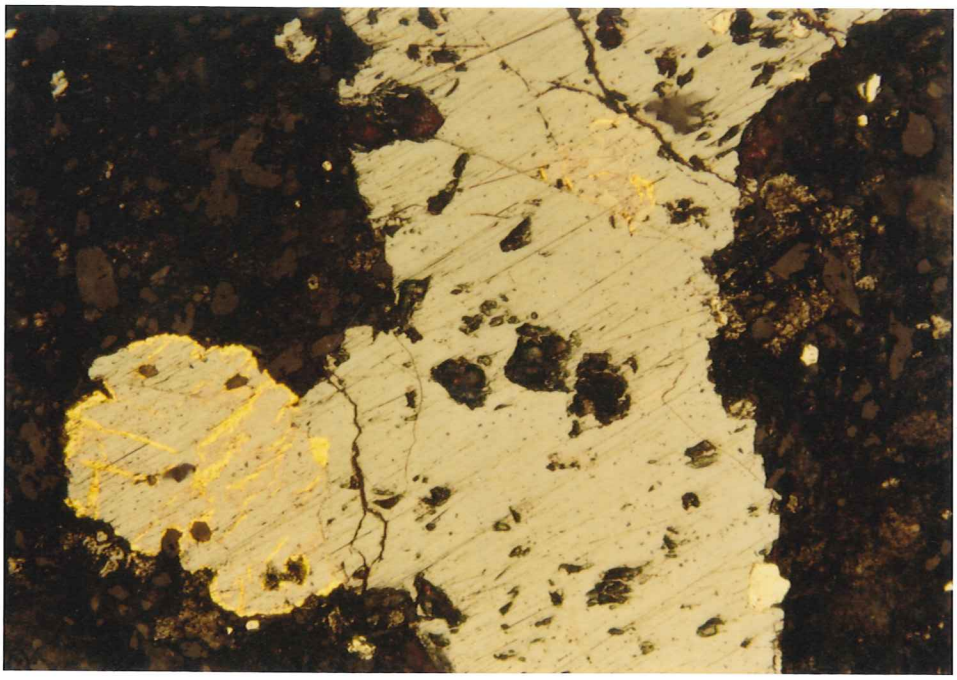

Figure 3a. 13-4904-S4/#1. Pyrargyrite, marcasite, and tuffaceous volcanic rock fragments in fine black matrix. Pearceite/polybasite phase with internal filaments and partial rims of native gold in edge contact with and as internal bleb in pyrargyrite. Note restriction of native gold to the pearceite/polybasite group mineral. Minor polished stannite III at right edge of pyrargyrite and adjacent to pearceite/polybasite at lower left corner of photo. RL; 1cm on photo= 0.053mm.

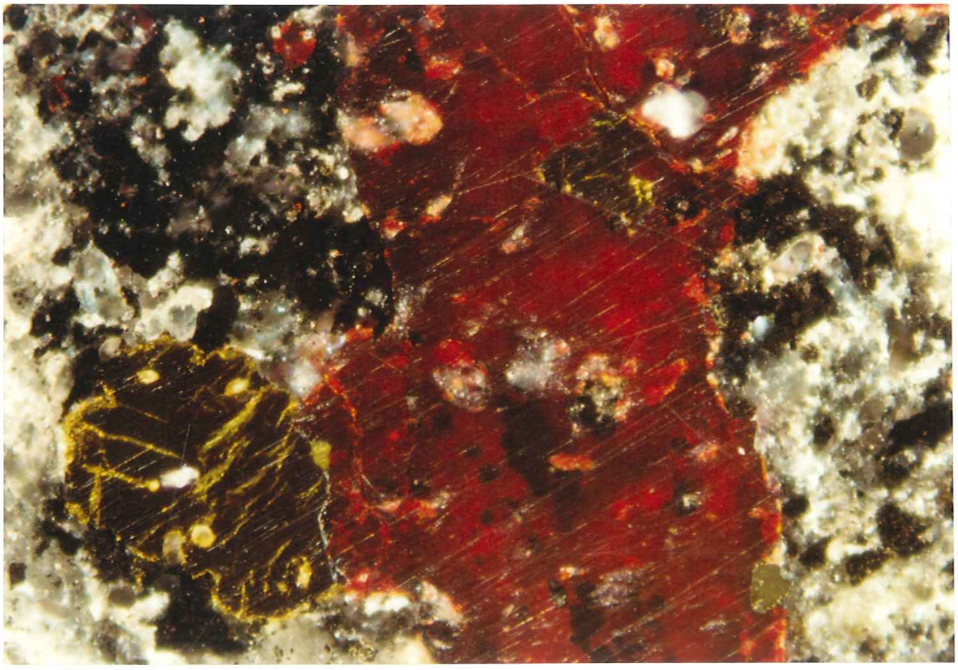

Figure 3b. 13-4904-S4/#1. Pyrargyrite, marcasite, and tuffaceous volcanic rock fragments in fine black matrix. Same view and scale as Figure 3a. Note strong red internal reflections in pyrargyrite. Internal reflections are lacking in the pearceite/polybasite group mineral.

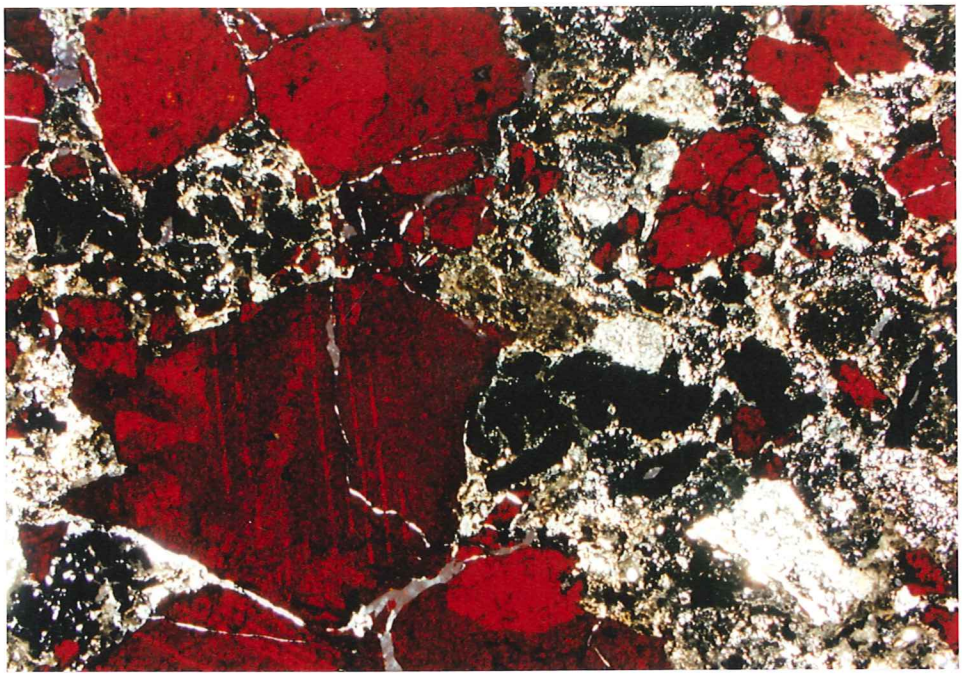

Figure 4a. 13-4904-S4/#2. Pyrargyrite, marcasite, and tuffaceous volcanic rock fragments in fine black matrix. Coarse to fine pyrargyrite crystals (red internal reflections) and opaque marcasite distributed in fine black matrix of stannite III, quartz, and minor clay-sericite. TLX; 1cm on the photo= 0.532mm.

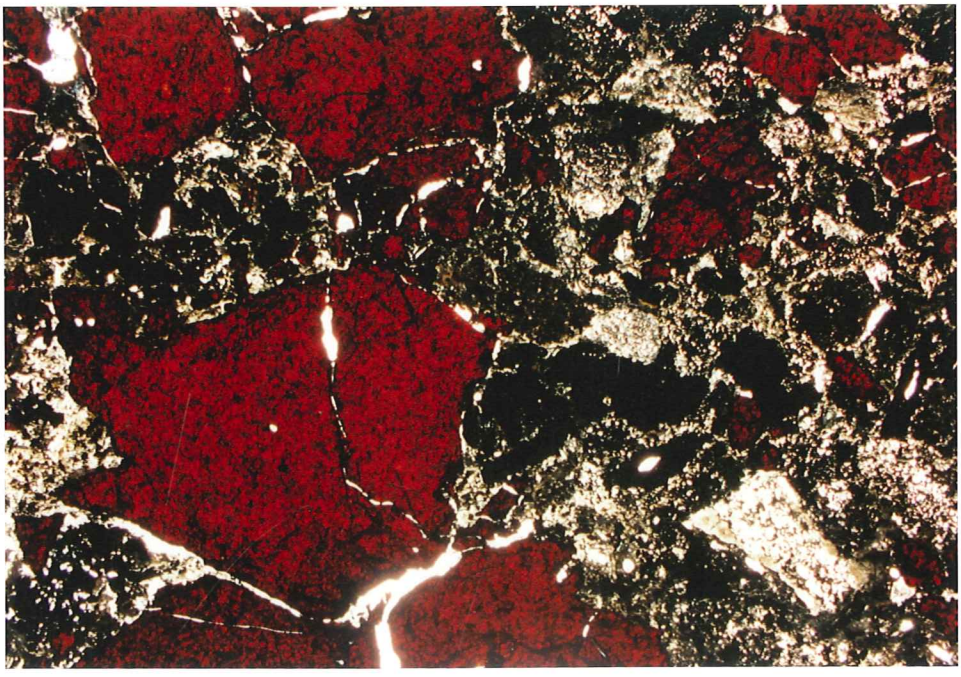

Figure 4b. 13-4904-S4/#2. Pyrargyrite, marcasite, and tuffaceous volcanic rock fragments in fine black matrix. Same view and scale as figure 4a; 1cm on the photo= 0.532mm.

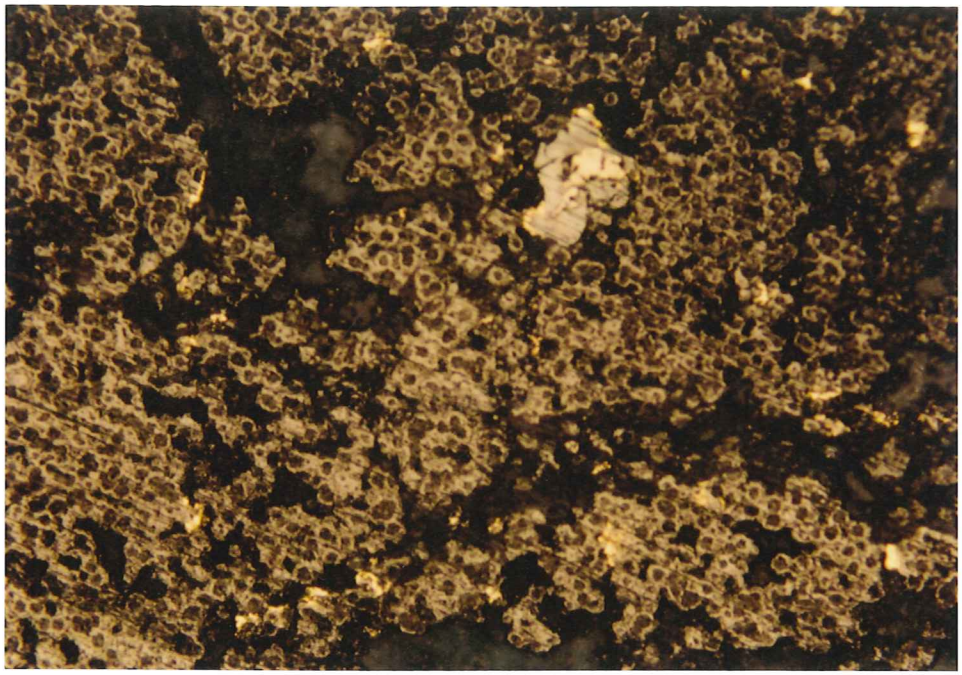

Figure 5. 13-4904-S4/#2. Pyrargyrite, marcasite, and tuffaceous volcanic rock fragments in fine black matrix. Black matrix with porous stannite III network (grayish brown, low reflectance) and coarser pearceite/polybasite group mineral intergrown with marcasite. Native gold (high R; yellow to nearly white in this photo) forms partial rims on the pearceite/polybasite group mineral (upper and lower left edges), and on some of the stannite III crystals (upper right corner of photo and near lower edge of photo). RL; 1cm on the photo= 0.053mm.

Figure 6. 13-4904-S4/#2. Pyrargyrite, marcasite, and tuffaceous volcanic rock fragments in fine black matrix. Porous, subhedral prismatic marcasites formed from crystal aggregates. The porous central zone with a light brown color may be pyrrhotite (?), although the sample does not respond to a hand magnet. RL; 1cm on the photo= 0.106mm.

13-4904-S4/#5 - #7 (black matrix with hydrothermal breccia fragments)

This sample type consists of pieces of a polyphase hydrothermal breccia that has been disrupted and dispersed in an unusual, very fine-grained, laminated black matrix similar to that described in the previous sample type. The hydrothermal breccia fragments enveloped by the black matrix are subround to angular and reach 4cm in length. The larger pieces consist of pink, white and light green fragments to more than 3cm in length distributed in a very fine-grained, light gray quartz matrix. The pink fragments are themselves brecciated.

Under transmitted light through the petrographic microscope the larger breccia pieces are polyphase. One breccia phase contains angular to subround fragments to 4.5mm diameter in a matrix of fine sericite-clay and a few narrow quartz veinlets. The lithic fragments are interpreted to be very fine-grained devitrified and silicified tuffaceous volcanic rocks. They are light to dark brown and composed of very fine saccharoidal quartz, residual brown glass, and minor clay-sericite ± minor disseminated opaques. Average crystal size is on the order of 0.015mm diameter. Crudely rectangular zones of coarser polycrystalline quartz may represent former pyrogenic feldspar fragment sites. Opaques with generally cubic morphology are sparsely disseminated in both fragments and matrix. The breccia is essentially matrix-supported, but the fragments are closely packed in the matrix.

The second breccia type contains fragments of partly devitrified welded lapilli tuff and of the sericite-clay matrix breccia in a very fine-grained matrix dominated by polycrystalline quartz and carrying minor sericite-clay and disseminated opaques. The lithic lapilli tuff fragments are angular to subround and reach 9mm in length, although most fragments are considerably smaller. The lithic fragments contain a significant amount of relict dark brown glass. Some of the fragments are partly to completely altered to fine sericite-clay. Some of the sericite-clay fragments may be derived from the sericite-clay matrix network in the earlier breccia type. One small fragment, approximately 1mm diameter, is composed of an xenomorphic-granular mix of quartz and K feldspar (section 13-4904-S4/#6). Average crystal size in this fragment is about 0.15mm diameter. The fragment is either a piece of hypabyssal intrusive rock or represents granophyric devitrification of glassy volcanic material. Some of the fragments have partial to complete rims of fine sericite-clay. This hydrothermal breccia type is matrix-supported. The polycrystalline quartz matrix has a xenomorphic-granular texture with an average crystal size of about 0.04mm. Slightly coarser quartz (±0.1mm length) partly rims the contact between the two breccia types, and the quartz matrix breccia is interpreted to be later than the sericite-clay matrix breccia, although both have probably a close temporal relationship. Similar quartz also partly rims some of the lithic fragments. Some of the lithic fragments contain relatively abundant disseminated opaques with pyritohedron and cubic morphology. Disseminated opaques occur also in both the quartz and sericite-clay breccia matrix types.

The larger pieces of polyphase breccia are enveloped by an unusual, concentrically laminated matrix composed of very fine-grained opaques, quartz, and minor clay-sericite. The black matrix is very similar in texture and composition to that described above for the other sample type, but the concentric, laminated nature is more prominent. The laminated part of the black matrix forms a concentric zone up to several millimeters thick that wraps concentrically around the pieces of silicate matrix hydrothermal breccia. Beyond the narrow concentric zone, the laminated character diffuses rapidly and is noted only locally. The matrix texture consists of a network of very fine opaques that has crystallized along the grain boundaries of very fine,

xenomorphic-granular quartz. Average opaque crystal size is on the order of 0.006mm diameter, while the average quartz crystal size is about 0.02mm diameter. Fine sericite-clay occurs as tiny patches and along quartz crystal boundaries. Quartz appears to make up no more than about 15-20% of the black matrix, while sericite-clay is relatively minor, perhaps no more than 1-2 percent.

RL: Based on detailed examination under reflected light of the three polished thin sections from this sample type, the opaque phases present and estimated abundance ranges are as follows:

Black matrix	10 - 50%
Marcasite-pyrite	4 - 7%
Ag sulphosalt minerals	2 - >8%
pearceite/polybasite group (±stephanite)	1.5 - 6.5%
pyrargyrite	0.5 - 1.5%
Native gold	<0.05%

The black matrix has essentially the same composition and texture in this sample type as in the pyrargyrite-marcasite-black matrix sample type. It is composed of stannite III, quartz, and trace to minor sericite-clay. The stannite III forms a very fine-grained, spongy, porous network with very fine, xenomorphic quartz in the interstices, with sericite-clay in bits and tiny patches along quartz crystal boundaries. Once again the stannite III is characterized by its porous texture and poor polishing characteristics that result in large areas of very low reflectance where the stannite III has not polished or has been plucked. The poor polishing habit and/or plucking is particularly apparent in the concentric laminated zones adjacent to the hydrothermal breccia fragments. Native gold is associated locally with the stannite III as narrow, discontinuous rims and as internal thin filaments.

Marcasite and pyrite are generally the most abundant opaque phases in this sample type, except in section 13-4904-S4/#7, where they are collectively subordinate to the silver sulphosalt phases. The marcasite and pyrite are disseminated to varying abundance levels in both the fine-grained, polycrystalline quartz breccia matrix and in the breccia fragments. The crystals are generally subhedral to anhedral, and morphologies include cubic, trapezoidal, and prismatic. Maximum crystal size is 2.2mm in length, with a maximum aspect ratio in the prismatic crystals of about 5.5. Many of the crystals are porous. Some consist of aggregates of subhedral to anhedral crystals that are conformable to a subhedral to anhedral crystal form. Many of the pyrite crystals have minor included marcasite. Pyrite is the more abundant of the two within the silicate hydrothermal breccia pieces, while marcasite dominates in the black matrix. In the black matrix marcasite occurs in edge contact with silver sulphosalt minerals, and also as inclusions within those phases. It can occur also as discrete subhedral to anhedral crystals in the black matrix, but this occurrence mode is not common.

The silver minerals are present only in the black matrix and were not observed wholly contained within the quartz or sericite-clay matrix hydrothermal breccia pieces. There are at least three silver sulphosalt minerals present in the black matrix. They occur as irregular

crystals to nearly 0.5mm in length/diameter, generally dispersed in the porous, sponge-like network of stannite III. The larger grains display an intergrowth of two silver sulphosalt phases, both gray with low to moderate reflectance and weak, though distinct, anisotropism. One of the phases is gray with a faint greenish tint and is tentatively identified as belonging to the pearceite/polybasite group minerals. The other phase is gray with a slight pinkish brown tint and is identified tentatively as stephanite. The pearceite-polybasite group phase was noted in one instance to fill small, discontinuous fractures in the fine quartz breccia matrix. The pearceite/polybasite group mineral only rarely shows red internal reflections, perhaps owing to significant substitutional copper. Polishing hardness for both phases is considerably less than that of pyrite. Locally the crystals are associated closely with native gold as narrow, discontinuous to, rarely, complete rims and as thin, irregular, internal filaments. Marcasite occurs also as tiny inclusions in some crystals. Pyrargyrite is present also, but is much less abundant than the silver sulphosalt intergrowths described above. It occurs as irregular discrete crystals to 0.04mm diameter and as irregular crystals in edge contact with the pearceite-stephanite intergrowths.

Native gold occurs sporadically associated with stannite III in the black matrix and with the pearceite-stephanite intergrowths. The native gold is present as partial to complete narrow rims and as thin internal filaments, some of which may fill microfractures.

CL: The fine quartz breccia matrix has a very dull blue CL that is enhanced by the long exposure photography over what was observed through the microscope. A pyrogenic quartz fragment in one of the tuffaceous breccia fragments has dull blue CL slightly stronger than that of the quartz breccia matrix. This quartz is interpreted to be magmatic in origin. Most of the quartz has no observable CL and is probably hydrothermal fine-grained polycrystalline quartz. Calcite with reddish orange CL was observed in several of the breccia fragments.

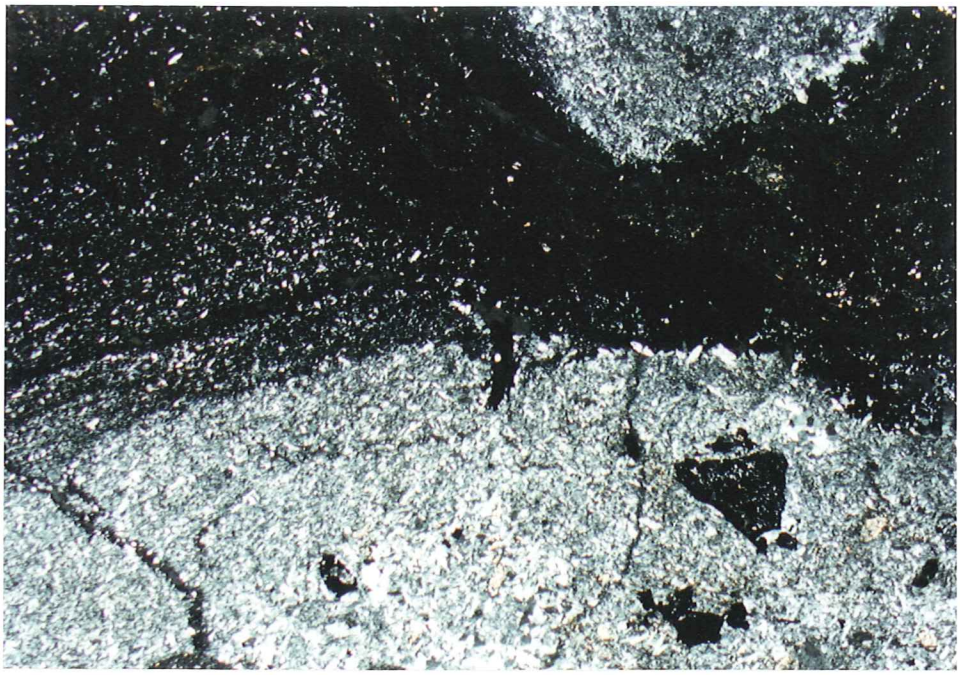

Figure 7a. 13-4904-S4/#5. Polyphase hydrothermal breccia fragments in fine-grained black matrix. Rounded fragments of quartz matrix hydrothermal breccia in very fine-grained, laminated black matrix composed of stannite III, quartz, and minor sericite-clay. TLX; 1cm on the photo= 0.532mm.

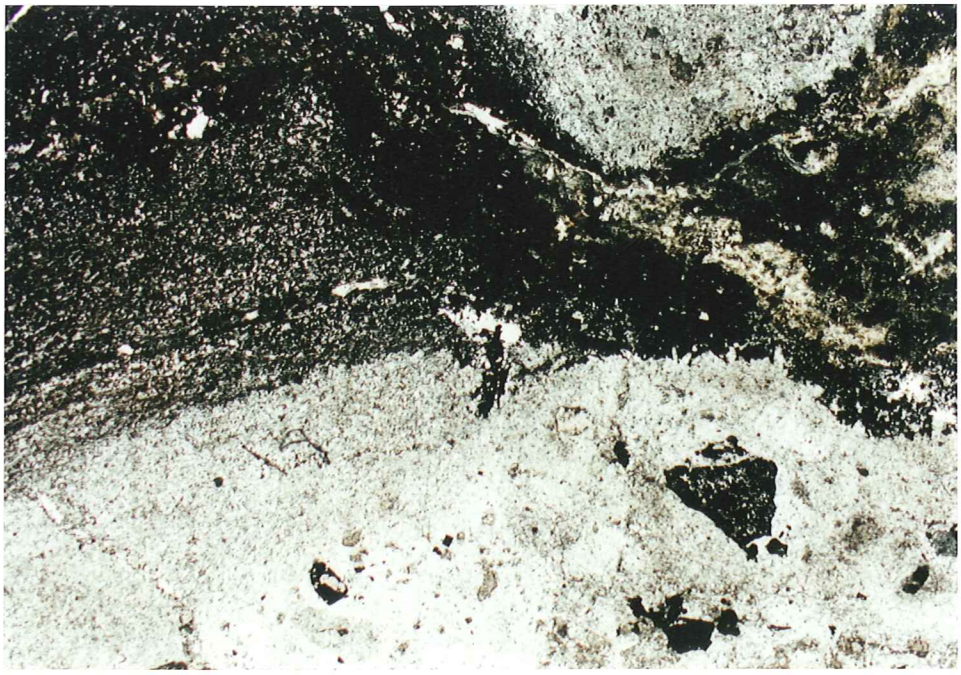

Figure 7b. 13-4904-S4/#5. Polyphase hydrothermal breccia fragments in fine-grained black matrix. Same view and scale as Figure 7a. TLP; 1cm on the photo= 0.532mm.

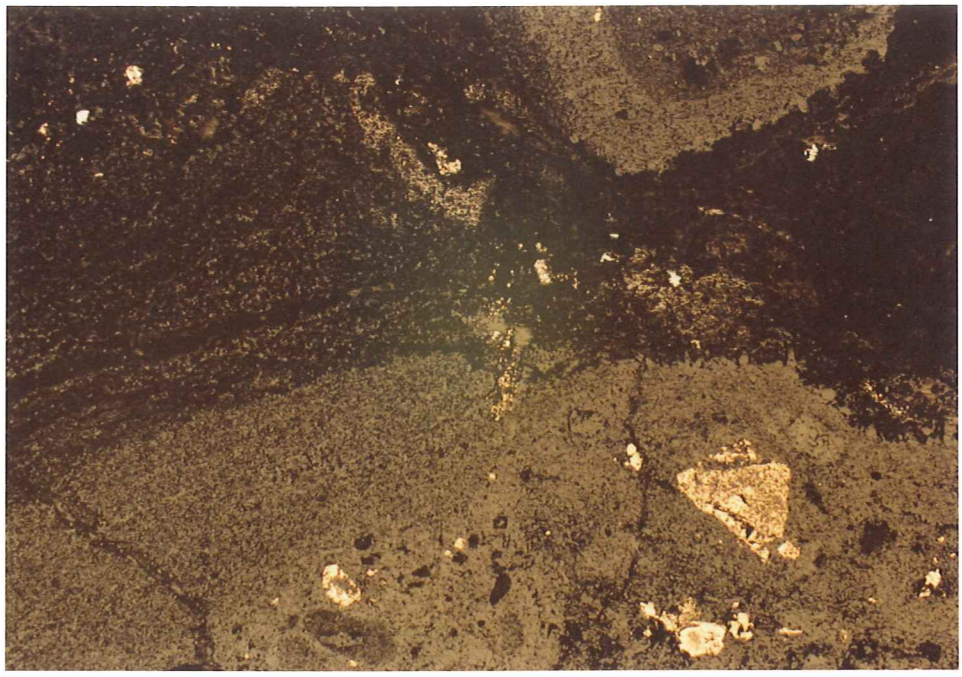

Figure 7c. 13-4904-S4/#5. Polyphase hydrothermal breccia fragments in fine-grained black matrix. Same view and scale as Figures 7a and b. Pyrite and marcasite are disseminated within the quartz matrix hydrothermal breccia. The gray to white minerals in the black matrix are a pearceite/polybasite group mineral. Small zones of stannite III that has taken a polish are present in the area between the two fragments (grayish brown color). RL; 1cm on the photo= 0.532mm.

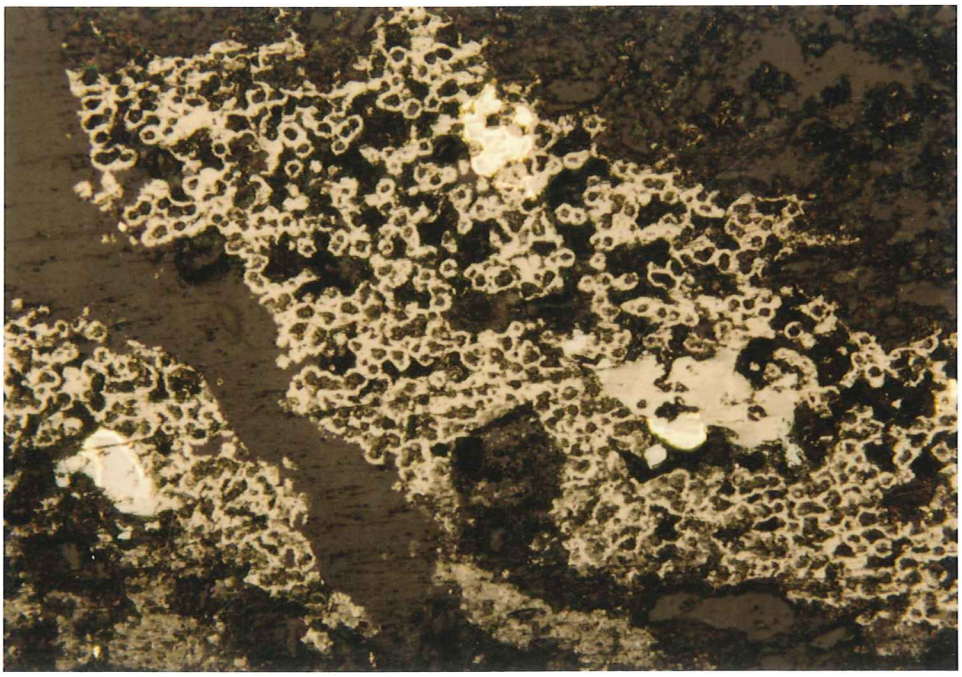

Figure 8. 13-4904-S4/#5. Polyphase hydrothermal breccia fragments in fine-grained black matrix. Porous-textured stannite III of the black matrix has a grayish brown color and relatively low reflectance. Coarser pearceite/polybasite is distributed in the black matrix and is rimmed and veined by native gold (high R; washed out whitish yellow in this photo). RL; 1cm on the photo= 0.053mm.

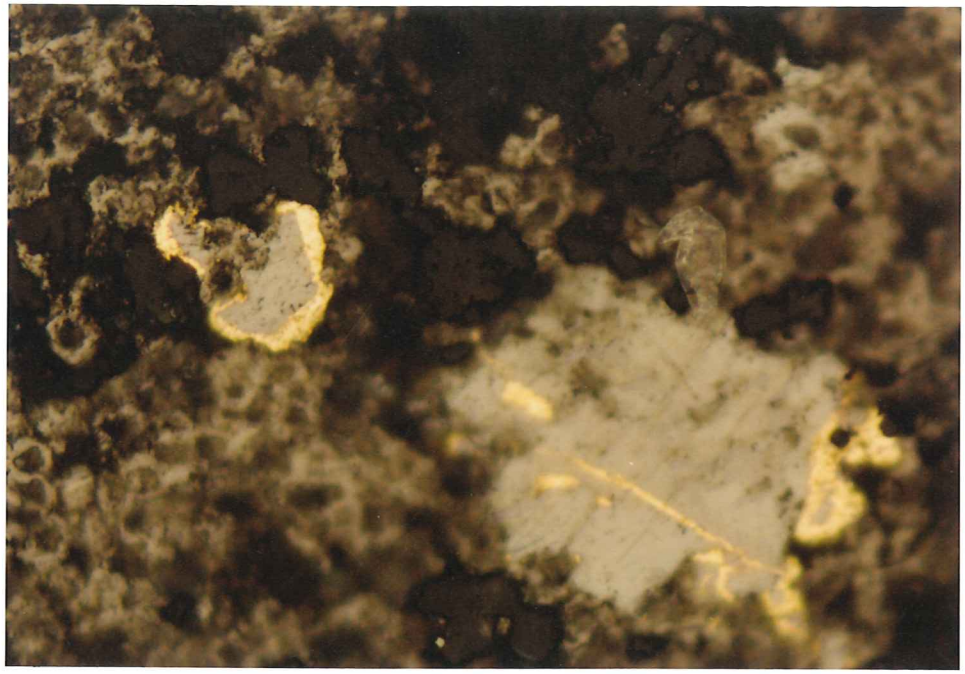

Figure 9. 13-4904-S4/#5. Polyphase hydrothermal breccia fragments in fine-grained black matrix. Native gold (high R; pale yellow) forms partial rims and narrow filaments in pearceite/polybasite group minerals dispersed in the porous stannite III of the black matrix. RL; 1cm on the photo= 0.021mm.

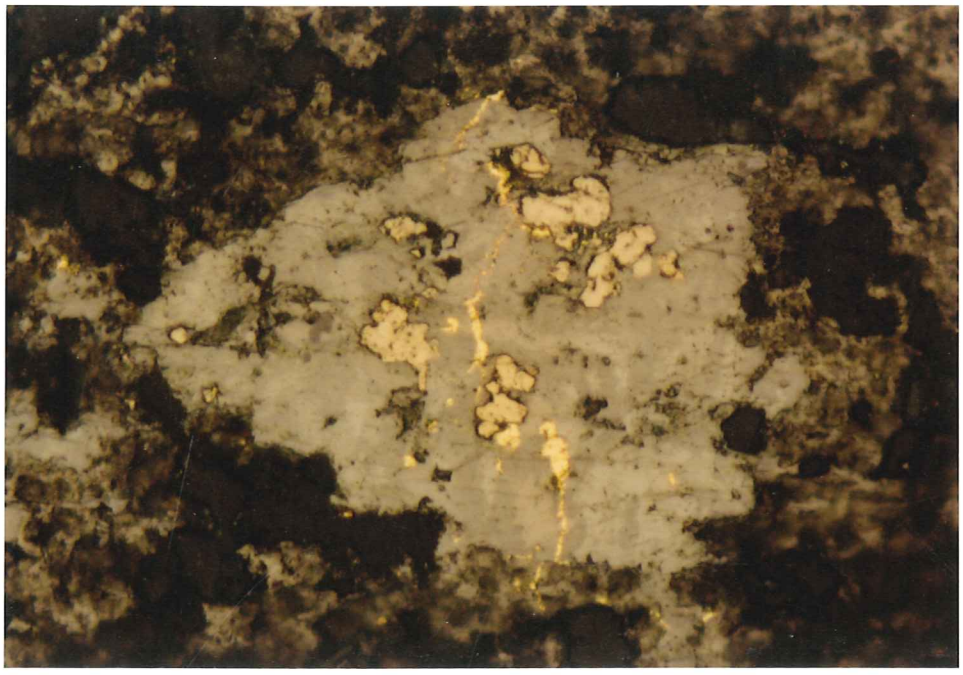

Figure 10. 13-4904-S4/#5. Polyphase hydrothermal breccia fragments in fine-grained black matrix. Intergrown pearceite/polybasite (lighter gray) and stephanite (gray with pinkish brown tint) with inclusions of marcasite and thin filaments of native gold (pale yellow; high R). The porous stannite III of the black matrix has lower R and a grayish brown color. RL; 1cm on the photo= 0.021mm.

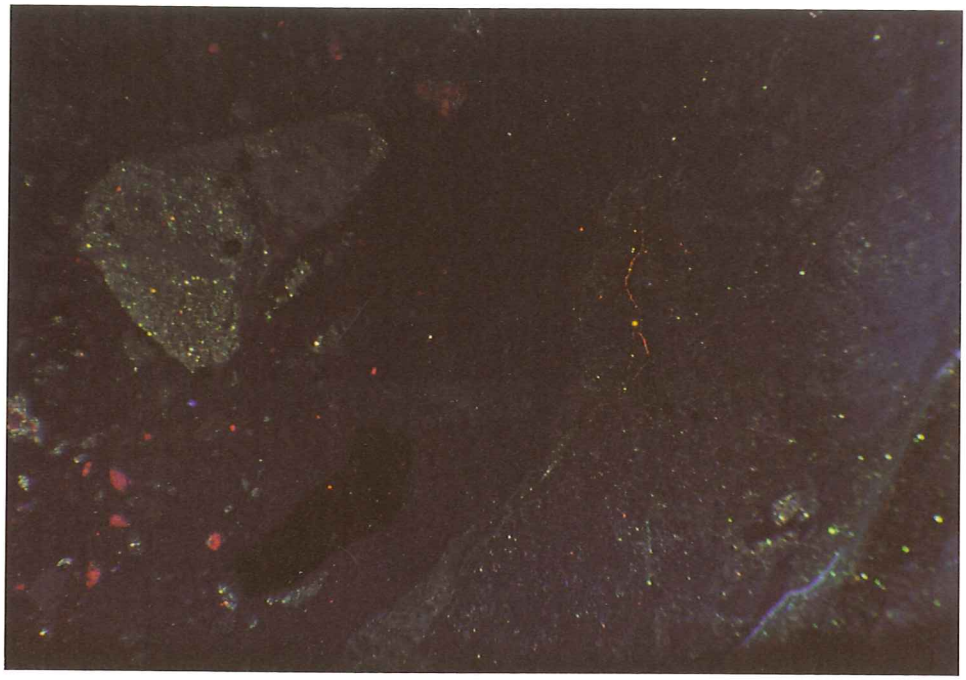

Figure 11a. 13-4904-S4/#6. Polyphase hydrothermal breccia fragments in fine-grained black matrix. Hydrothermal quartz in the breccia fragment matrix is essentially non-luminescent. Calcite (reddish orange CL) is present in the quartz matrix and as a narrow, discontinuous veinlet in the sericite-clay matrix breccia. CL; 1cm on the photo= 0.72mm.

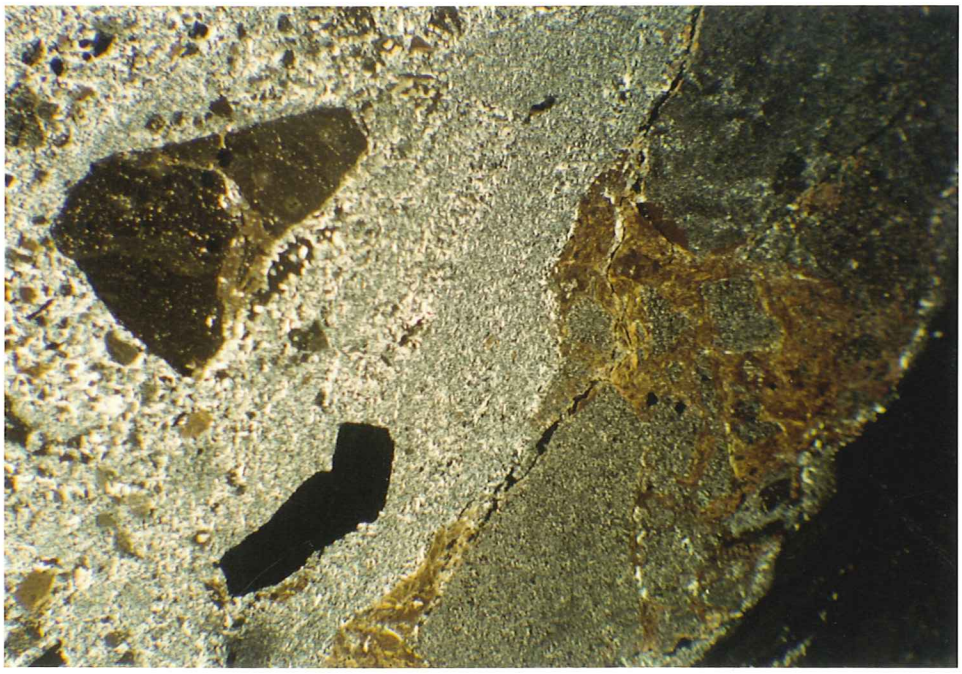

Figure 11b. 13-4904-S4/#5. Polyphase hydrothermal breccia fragments in fine-grained black matrix. Same view and scale as Figure 11a. A single fragment enclosed by black matrix has sericite-clay matrix breccia in contact with quartz matrix breccia. TLX; 1cm on the photo= 0.72mm.

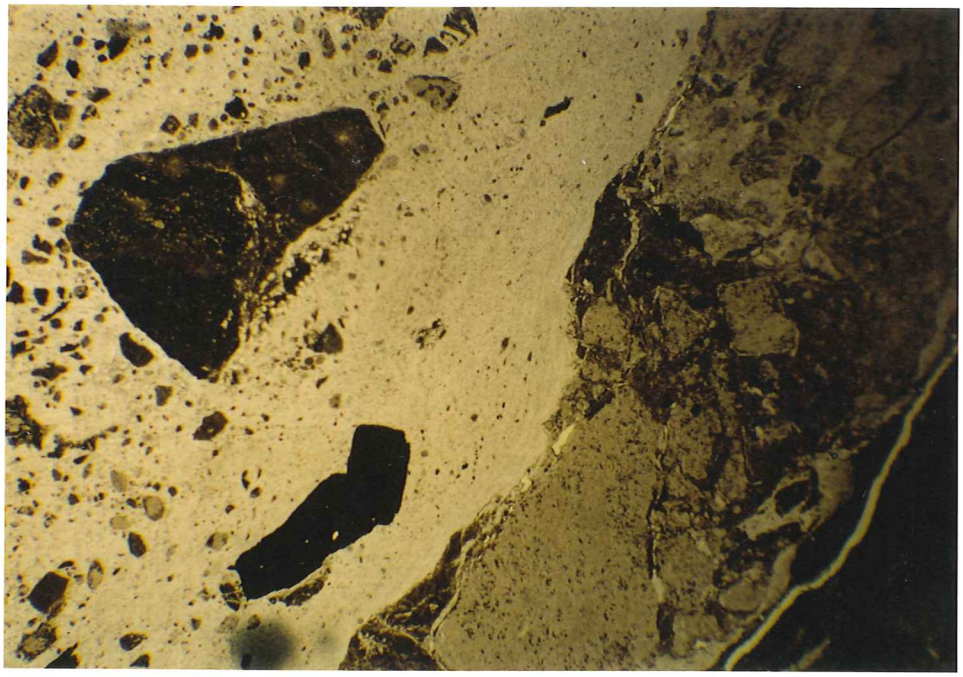

Figure 11c. 13-4904-S4/#5. Polyphase hydrothermal breccia fragments in fine-grained black matrix. Same view and scale as Figures 11a and b. TLP; 1cm on the photo= 0.72mm.

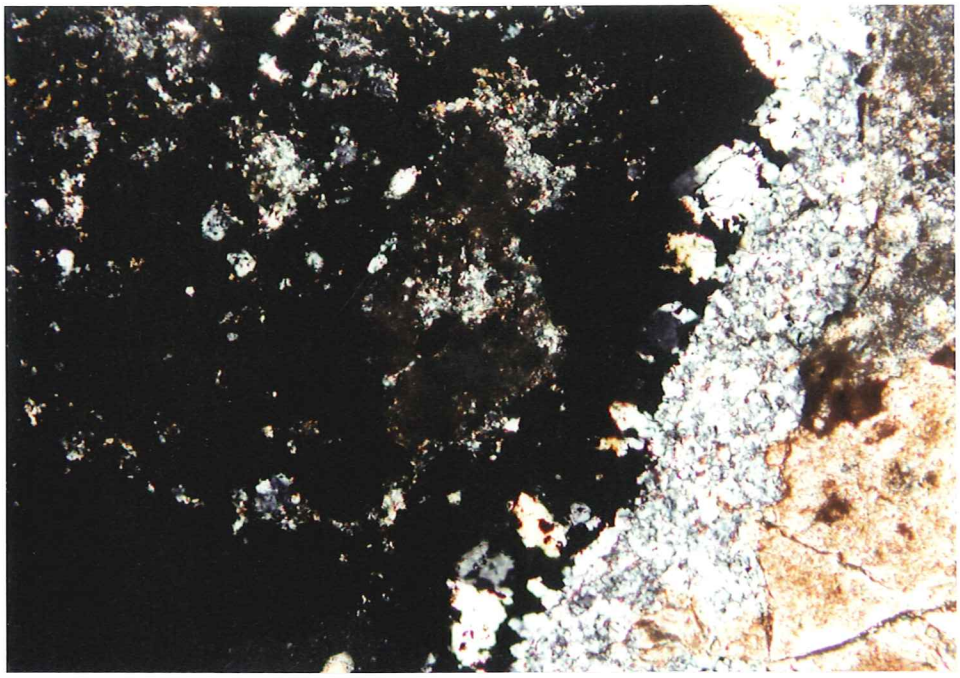

Figure 12a. 13-4904-S4/#7. Polyphase hydrothermal breccia fragments in fine-grained black matrix. Quartz matrix hydrothermal breccia encloses fragment of earlier sericite-clay matrix breccia (right third of photo). The polyphase breccia fragment is enclosed by fine black matrix (stannite III-Q-sericite/clay). TLX; 1cm on the photo= 0.106mm.

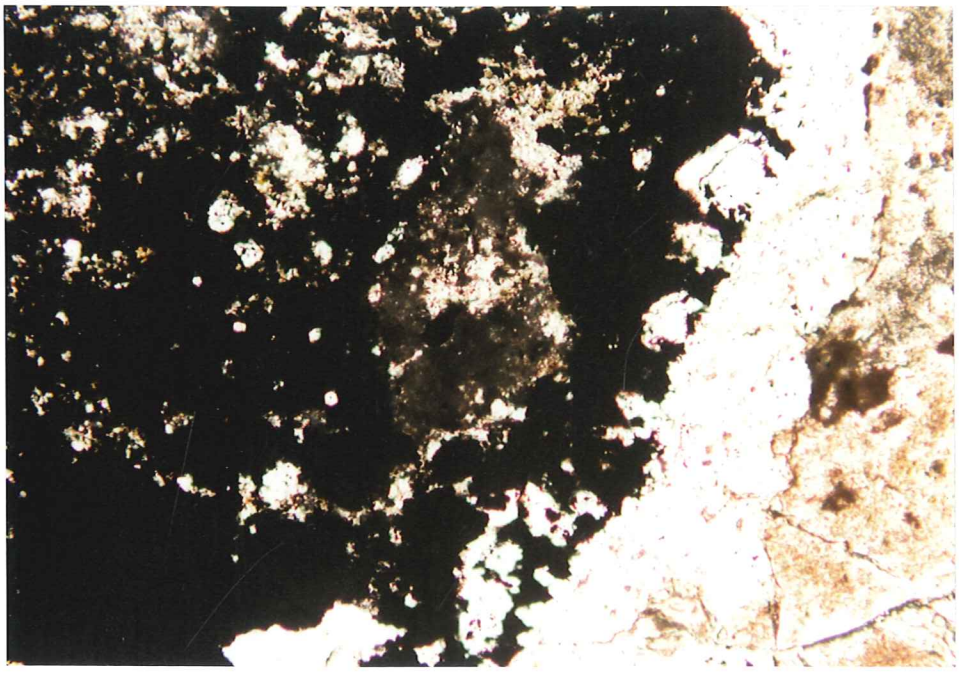

Figure 12b. 13-4904-S4/#7. Polyphase hydrothermal breccia fragments in fine-grained black matrix. Same view and scale as Figure 12a. TLP; 1cm on the photo= 0.106mm.

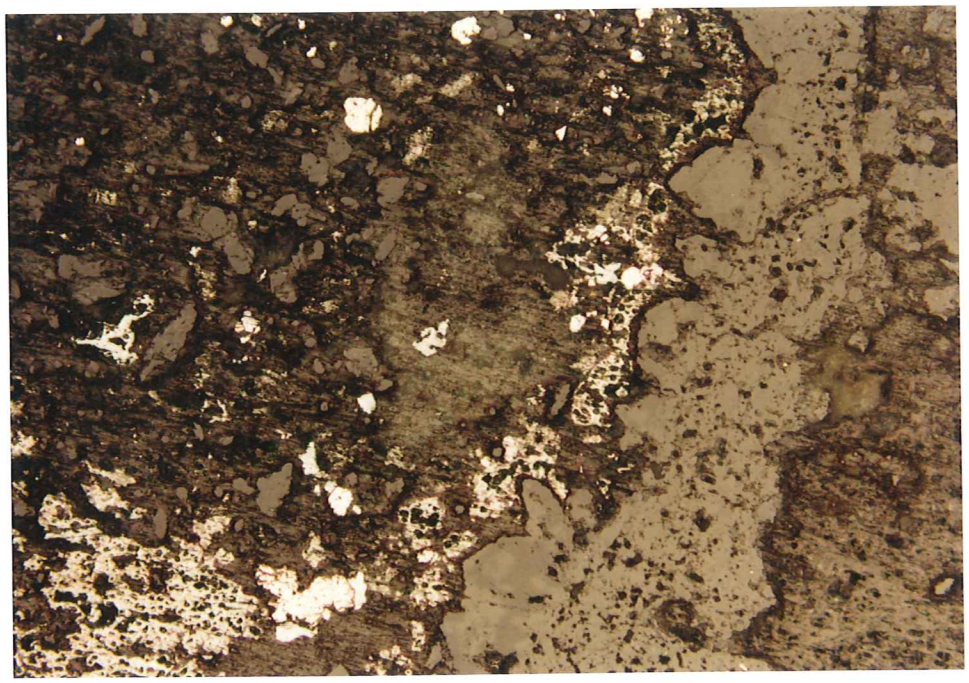

Figure 12c. 13-4904-S4/#7. Polyphase hydrothermal breccia fragments in fine-grained black matrix. Same view and scale as Figures 12a and b. Sporadic polished areas of porous stannite III in black matrix near contact with polyphase breccia fragment. Coarser pearceite/polybasite group mineral distributed in the black matrix (white, irregularly-shaped crystals in this photo). RL; 1cm on the photo= 0.106mm.

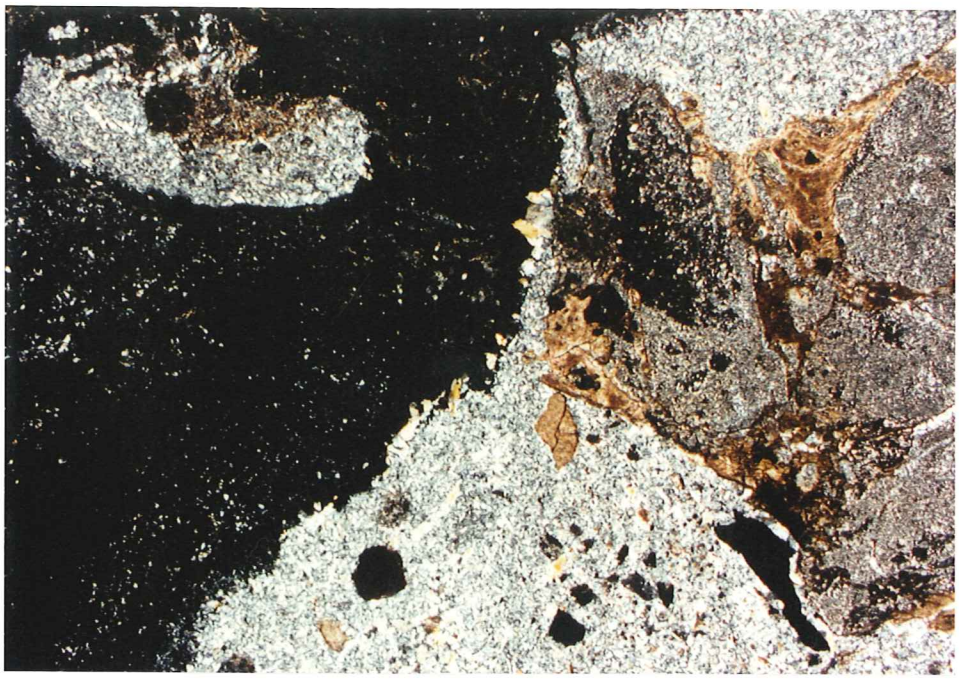

Figure 13a. 13-4904-S4/#7. Polyphase hydrothermal breccia fragments in fine-grained black matrix. Quartz matrix hydrothermal breccia encloses fragment of earlier sericite-clay matrix breccia (right half of photo). The polyphase breccia fragments are enclosed by fine black matrix (stannite Ill-Q-sericite/clay). TLX; 1cm on the photo= 0.532mm.

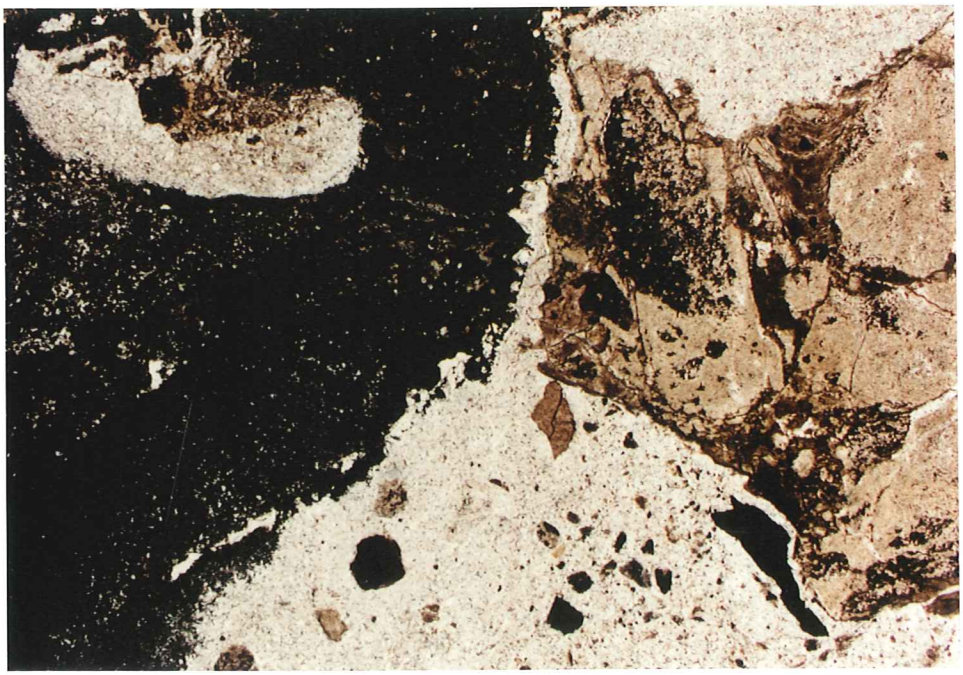

Figure 13b. 13-4904-S4/#7. Polyphase hydrothermal breccia fragments in fine-grained black matrix. Same view and scale as Figure 13a. TLP; 1cm on the photo= 0.532mm.

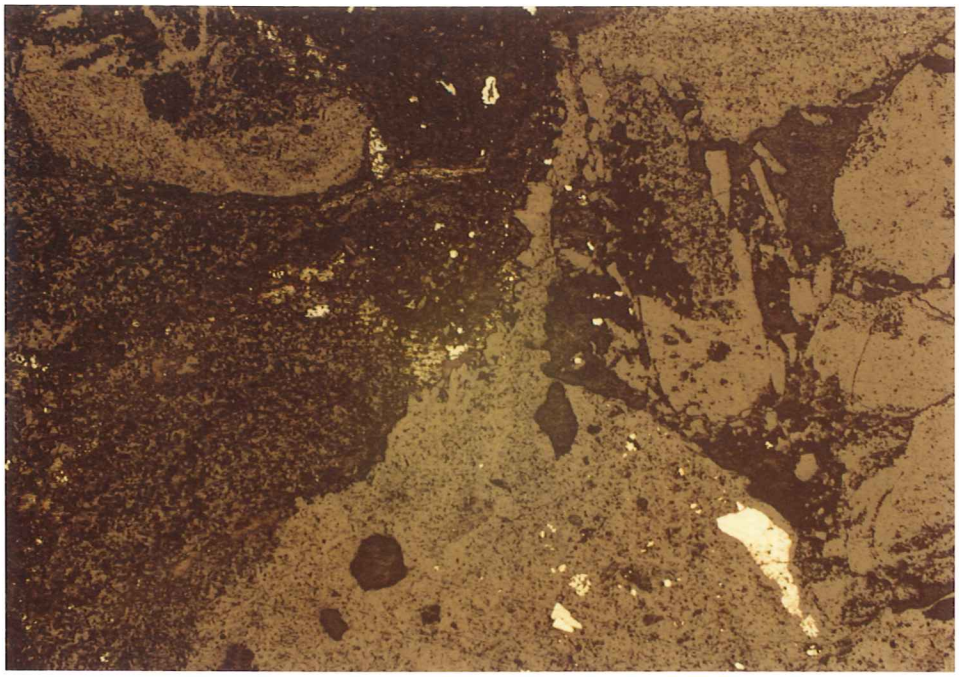

Figure 13c. 13-4904-S4/#7. Polyphase hydrothermal breccia fragments in fine-grained black matrix. Same view and scale as Figures 13a and b. Sporadic polished areas of porous stannite III in black matrix near contact with polyphase breccia fragments. Pyrite is disseminated in the polyphase hydrothermal breccia, while marcasite and a pearceite/polybasite group mineral distributed in the black matrix. RL; 1cm on the photo= 0.532mm.

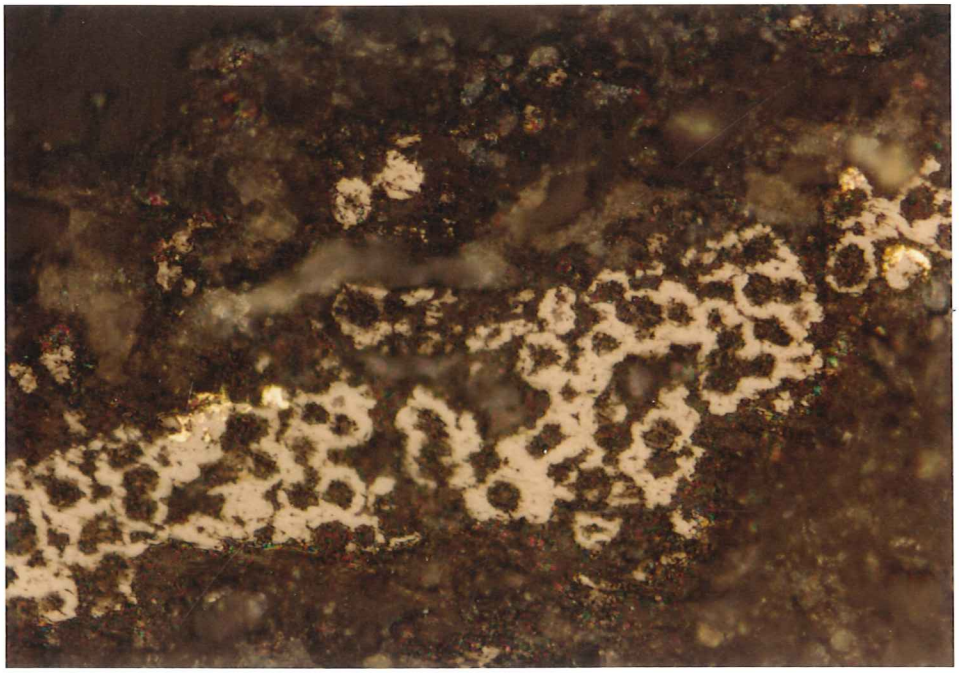

Figure 14. 13-4904-S4/#7. Polyphase hydrothermal breccia fragments in fine-grained black matrix. Porous-textured stannite III (grayish brown; moderately low R) with minor blebs and partial rims of native gold (pale yellow; high R). RL; 1cm on the photo= 0.021mm.

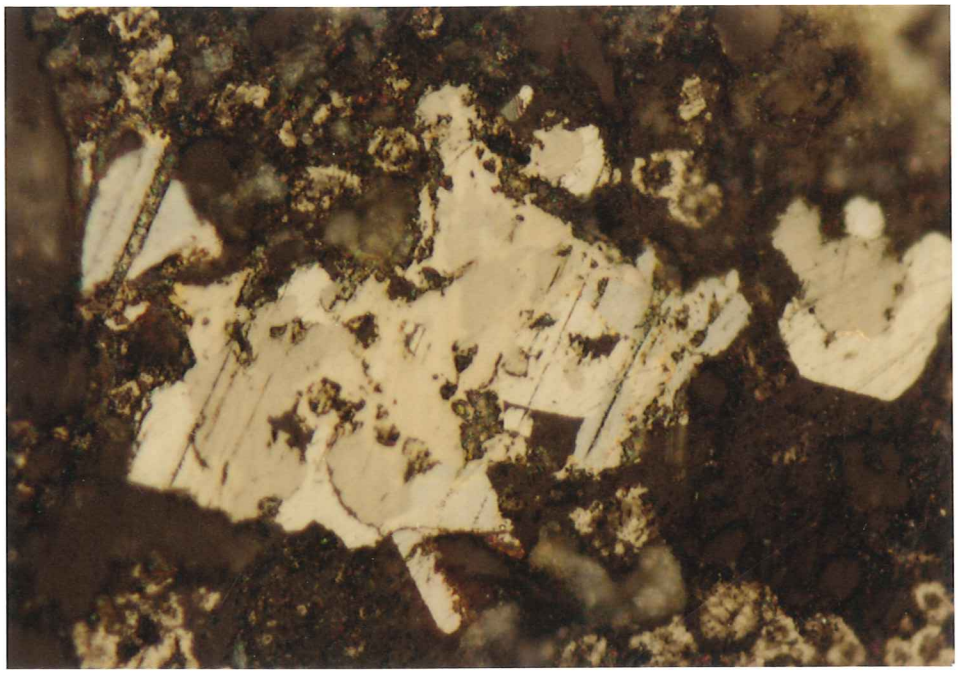

Figure 15. 13-4904-S4/#7. Polyphase hydrothermal breccia fragments in fine-grained black matrix. Pyrargyrite (gray with faint bluish tint) rims pearceite/polybasite-stephanite (gray with brownish tint against pearceite/polybasite phase) intergrowth. Trace of native gold (pale yellow; high R) near right edge of photo at contact between pearceite/polybasite and pyrargyrite. RL; 1cm on the photo= 0.021mm.

APPENDIX 1/Individual Section Descriptions

13-4904-S4/#1 pyrargyrite-marcasite in black matrix

This section consists dominantly of the same black matrix that encloses pieces of polyphase hydrothermal breccia in the other sample type (sections #5, #6, and #7). The black matrix itself is very fine-grained, but contains abundant coarse opaques, primarily pyrargyrite and pyrite-marcasite, based on hand specimen examination. Megascopic examination of the sample with a hand lens shows it to consist of perhaps 30 - 40% of a generally coarse to fine silver sulphosalt phase that appears to be pyrargyrite and 7 - 10% coarse to fine pyrite-marcasite packed randomly in fine black matrix material.

RL: Identities and estimated abundances of opaque phases is as follows:

black matrix (stannite III-quartz-sericite/clay)	± 50%
pyrargyrite	30 - 40%
marcasite-pyrite	7 - 10%
pearceite/polybasite group	5%
native gold	± 0.1 - 0.2%

Coarse, subhedral to anhedral crystals and crystal aggregates of pyrargyrite, pearceite/polybasite, and composite marcasite-pyrite are packed in a fine matrix of porous, spongy stannite III, scattered, wispy polycrystalline quartz, and minor fine sericite-clay. An amorphous gray brown material appears to be the impregnation media. The black matrix is highly unusual and appears to be composed primarily of a fine network of a porous, sponge-textured phase identified tentatively as stannite III. In addition to its texture the phase is characterized by a grayish brown to brownish gray color, low to moderate reflectance (R<28), weak anisotropism, and poor polishing characteristics. Where the matrix has not taken the polishing reflectance is extremely low. Locally the stannite III is associated with native gold, which forms partial thin rims and narrow internal filaments, perhaps filling microfractures.

Pyrargyrite is present as coarse to fine, irregular to rounded to crudely rectangular crystals to 13mm in length/diameter. The larger crystals exhibit significant fracturing. The pyrargyrite is characterized by a light gray color with a weak bluish tint and strong red internal reflections. Some of the pyrargyrite crystals contain blebs of a second silver sulphosalt that is a similar gray, but with a slight brownish tint and slightly higher reflectance. This phase is identified tentatively as belonging to the pearceite/polybasite group. It displays weak anisotropism and weak to non-existent red internal reflections. This phase is noted also in edge contact with the pyrargyrite, where it forms generally anhedral, irregular crystals to 0.9mm in length. This second silver sulphosalt phase is notable because it commonly carries very fine blebs and narrow filaments of native gold. Fine blebs of native gold are found only rarely within the pyrargyrite.

Marcasite is the second most abundant phase dispersed in the black matrix. The marcasite forms subhedral to anhedral crystals and crystal aggregates to 4mm length. The crystals are commonly somewhat porous and locally contain small inclusions of pyrite. Marcasite is commonly,

although not universally, in edge contact with pyrargyrite or the pearceite/polybasite group mineral. Marcasite may have crystallized later than the silver minerals; it locally forms discontinuous, irregular rims on some pyrargyrite crystals. In many instances, however, the marcasite and silver minerals are intergrown, and the relative parageneses are not clear. Minor pyrite is present, as well. The pyrite occasionally forms small inclusions within marcasite crystals and occurs also as small subhedral crystals dispersed in the black matrix.

Native gold forms partial thin rims and narrow internal filaments on stannite III in the fine black matrix and is common in the same occurrence modes in the pearceite/polybasite group mineral. It occurs only rarely as tiny blebs in pyrargyrite.

13-4904-S4/#2

This sample is a black matrix hydrothermal breccia. It contains scattered angular to rounded fragments of polyphase quartz matrix and sericite-clay matrix hydrothermal breccias to 2mm in diameter dispersed in a fine-grained black matrix of opaques, quartz, and minor sericite-clay. Average matrix grain size is approximately 0.02mm diameter. Dispersed in the fine black matrix in addition to the silicate-bearing hydrothermal breccia fragments are abundant coarse to fine sulphides and sulphosalt minerals, including significant pyrargyrite. The pyrargyrite forms subhedral to anhedral hexagonal crystals to 5mm in diameter.

RL: Total opaque phases are on the order of 80-85 percent. Phases identified and estimated abundances are:

Fine black matrix (stannite III-quartz-sericite/clay)	45-55%
pyrargyrite	30-35%
marcasite	10 -15%
pearceite/polybasite group phase	<1%
native gold	<0.1%

This section contains more of the black matrix residual from the preparation process. Texture and mineralogy of the black matrix are similar to those in the other sections.

The pyrargyrite forms subhedral to anhedral hexagonal crystals to 5mm in diameter. Some crystals have tiny inclusions of marcasite ±pyrite, and small marcasite crystals partly rim pyrargyrite crystals locally. The pyrargyrite crystals contain broadly scattered blebs of a pearceite/polybasite mineral, commonly carrying narrow filaments of native gold. Pyrargyrite is often in edge contact or intergrowth with marcasite. The pyrargyrite contains rare very fine blebs of native gold. Most of the native gold contained within pyrargyrite occurs in the pearceite/polybasite group phase.

The pearceite/polybasite phase is less abundant in this section than in sample 13-4904-S4/#1. It occurs as the aforementioned scattered blebs in pyrargyrite, most often in association with internal native gold filaments, and as small, discrete, irregular grains to 0.5mm length. Most of the pearceite/polybasite crystals have at least a trace of associated native gold. Locally the pearceite/polybasite crystals are in edge contact with pyrargyrite, and, locally the pyrargyrite appears to form partial rims on the pearceite/polybasite phase.

Marcasite occurs generally as elongate, crudely prismatic crystal aggregates to 2.2mm in length and with aspect ratios to about 6. These composite marcasite crystals are characterized by typical yellowish white color and strong anisotropism. They commonly have a porous core and rims composed of more solid marcasite crystals. Several of the marcasite crystals have porous cores of a light pinkish brown phase with reflectance slightly less than the marcasite. This phase may be pyrrhotite (?), although the sample itself does not respond to a hand magnet. The marcasite occurs as dispersed crystal aggregates and in edge contact or relatively simple intergrowth with pyrargyrite.

Sample 13-4904-S4/#3

Sample 13-4904-S4/#3 is prepared as a thick section, owing to the difficulties of sample preparation with this particular sample. Based on examination of the thick section under the hand lens the sample contains about 30% pyrargyrite and 20% marcasite dispersed in a sooty black matrix (stannite III-quartz-minor clay).

RL: Opaque phases identified in the sample and their estimated abundances are:

pyrargyrite	± 30%
pearceite/polybasite group mineral	<1%
marcasite	20%
native gold	<0.1%
black matrix (stannite III-Q-clay)	±50%

The pyrargyrite occurs as coarse to fine, subhedral-anhedral to irregular crystals to nearly 15mm in diameter. Some of the crystals have recognizeable hexagonal outlines. Most of the pyrargyrite crystals are fractured and pitted. Scattered rarely through the pyrargyrite crystals are blebs of a silver sulphosalt mineral that probably belongs to the pearceite/polybasite group. The pearceite/polybasite group mineral commonly contains microfilaments of native gold.

The pearceite/polybasite group mineral was not observed in this section outside of pyrargyrite crystals.

Marcasite forms eleongate, skeletal crystal aggregates to 5mm in length. Aspect ratios reach nearly ten. The marcasites are dispersed as aggregates in the black matrix and occur also in edge contact or in simple intergrowth with pyrargyrite. Marcasite occurs also as small inclusions in some pyrargyrite crystals. Pyrite occurs only rarely as small, generally euhedral crystals to 0.05mm diameter.

Native gold occurs as partial thin rims and narrow internal filaments in the pearceite/polybasite blebs in some pyrargyrite crystals, and in the same occurrence modes in the fine, porous textured stannite III (?) of the black matrix.

The fine black matrix makes up about half of the section. It did not fare well during section preparation, and limited information could be derived from the thick section. Where it took the polish the stannite III appears to form a porous, spongy network with fine polycrystalline quartz and minor clay-sericite. Quartz and clay make up probably no more than about 20% of the black matrix. Sparsely scattered throughout the fine black matrix is very fine native gold as narrow rims and thin filaments in the stannite III crystals.

Sample 13-4904-S4/#4

Black matrix hydrothermal breccia. There are no substantial differences between Sample 13-4904-S4/#3 and Sample 13-4904-S4/#4.

13-4904-S4/#5

The sample appears to be a polyphase hydrothermal breccia that has been disrupted, with clasts of breccia enveloped by an unusual, crudely concentric, fine-grained matrix of opaques, quartz, and minor clay, and a polyminerallic sulfide-sulphosalt assemblage.

One breccia phase contains angular to subround fragments to 4.5mm diameter in a matrix of fine sericite, clay, and a few fine quartz veinlets. The lithic fragments are interpreted to be very fine-grained devitrified and silicified tuffaceous rocks. Average crystal size is on the order of 0.015mm diameter. Crudely rectangular zones of coarser polycrystalline quartz may represent former pyrogenic feldspar fragment sites. The breccia contains minor disseminated pyrite with generally cubic morphology. The second breccia type contains fragments of partly devitrified welded lapilli tuff in a very fine-grained matrix dominated by polycrystalline quartz and carrying minor sericite-clay and disseminated pyrite. The lithic lapilli tuff fragments are angular to subround and reach 9mm in length, although most fragments are considerably smaller. The lithic fragments contain a significant amount of relict dark brown glass. This hydrothermal breccia type is matrix-supported. The polycrystalline quartz matrix has a xenomorphic-granular texture with an average crystal size of about 0.04mm. Slightly coarser quartz (±0.1mm length) partly rims the contact between the two breccia types, and the quartz matrix breccia is interpreted to be later than the sericite-clay matrix breccia, although both have probably a close temporal relationship. Similar quartz also partly rims some of the lithic fragments. Wisps of sericite-clay partly rim some lithic fragments, as well. Some of the lithic fragments contain relatively abundant disseminated pyrite with pyritohedron and cubic morphology. Disseminated pyrite occurs also in both the quartz and sericite-clay breccia matrix types.

The larger pieces of breccia are enveloped by a concentrically laminated matrix composed of a network of very fine-grained opaque phases that appear to crystallize along the margins of the fine, xenomorphic quartz crystals. Quartz makes up no more than 15-20% of the black matrix. Minor fine sericite-clay is also distributed along quartz crystal margins. Irregularly-shaped fine to medium-grained silver sulphosalt minerals are also distributed in the black matrix.

RL: Opaque phases present and estimated abundances are listed below:

Black matrix (stannite III-quartz-sericite/clay)	10 - 15%
Marcasite-pyrite	± 5%
Ag sulphosalts	± 2%
pearceite/polybasite (±stephanite)	±2%
pyrargyrite	<0.2%
Native gold	<0.05%

The black matrix has essentially the same composition and texture in this sample type as in the pyrargyrite-marcasite-black matrix sample type. It is composed of stannite III, quartz, and trace to minor sericite-clay. The stannite III forms a very fine-grained, spongy, porous

network with very fine, xenomorphic quartz in the interstices, with sericite-clay in bits and tiny patches along quartz crystal boundaries. Once again the stannite III is characterized by its porous texture and poor polishing characteristics that result in large areas of very low reflectance where the stannite III has not polished or has been plucked. The poor polishing habit and/or plucking is particularly apparent in the concentric laminated zones adjacent to the hydrothermal breccia fragments. Native gold is associated locally with the stannite III as narrow, discontinuous rims and as internal thin filaments.

Marcasite and pyrite are both present in the section. Pyrite is more abundant in the silicate-bearing breccia pieces, while marcasite predominates in the laminated black matrix. The pyrite is disseminated in both the fine-grained, polycrystalline quartz breccia matrix and in the breccia fragments. Pyrite crystals are generally subhedral to anhedral, and morphologies include cubic, trapezoidal, and prismatic. Maximum crystal size is 2.2mm length. Maximum aspect ratio in the prismatic crystals is about 5.5. Many of the crystals are porous. Some consist of aggregates of subhedral to anhedral crystals that are conformable to a subhedral to anhedral crystal form. Some of the pyrite crystals have internal zones of marcasite. In the black matrix marcasite is found in edge contact with silver sulphosalt minerals, as well as inclusions within those minerals.

There are at least three silver sulphosalt minerals present in the section. They occur as irregular crystals to nearly 0.5mm in length/diameter, generally dispersed in the porous, sponge-like network of stannite III-quartz-minor clay. The larger grains display an intergrowth of two silver sulphosalt phases, both gray with low to moderate reflectance and weak, though distinct, anisotropism. One of the phases is gray with a faint greenish tint and is tentatively identified as belonging to the pearceite/polybasite group minerals. The other phase is gray with a slight pinkish brown tint and is identified tentatively as stephanite. The pearceite/polybasite group mineral only rarely shows internal reflections, perhaps owing to a significant abundance of substitutional copper. The polishing hardness of these phases is considerably less than that of pyrite. Locally the crystals carry thin, irregular, internal filaments of native gold. Native gold also forms partial to complete narrow rims on some of the crystals. Marcasite occurs locally as small inclusions in the silver sulphosalt intergrowth. Pyrargyrite is present also, but is much less abundant than the silver sulphosalt intergrowths described above. It occurs as irregular crystals to 0.04mm diameter. The silver and gold-bearing phases are most commonly associated with the dark areas of the slide that concentrically envelope the zones of quartz hydrothermal breccia. The pearceite-polybasite group phase occurs also filling small, discontinuous fractures at the edge of quartz matrix breccia pieces.

CL: Noted fragment of quartz in one of the breccia fragments. The quartz has dull blue CL and is interpreted to be of magmatic origin. Most of the quartz has no observable CL and is probably hydrothermal fine-grained polycrystalline quartz. A trace of calcite with reddish orange CL was observed in one of the larget breccia fragments.

13-4904-S4/#6

As expected, Sample 8 is very similar to Sample 7. Sample 8 is again a polyphase hydrothermal breccia. One microbreccia phase consists of partly to completely devitrified and silicified tuffaceous volcanic fragments dispersed in a matted fine sericite-clay network. The fragments are angular to subround and range to 6mm in length/diameter. They are light to very dark brown and contain minor to moderate residual brown glass in addition to very fine xenomorphic-granular polycrystalline quartz. One of the fragments appears to have a crude stratification. Average silicified fragment quartz crystal size is on the order of 0.02mm diameter. Fragments and matrix contain minor disseminated pyrite with dominant cubic morphology. The second breccia phase appears to be later paragenetically, though probably closely related in time. This breccia has a fine polycrystalline quartz matrix that encompasses angular to subround, partly to completely devitrified and silicified tuffaceous volcanic fragments. Some of the fragments are partly to completely altered to fine sericite-clay. Some of the sericite-clay fragments may be derived from the sericite-clay matrix network in the earlier breccia type. One small fragment, approximately 1mm diameter, is composed of an xenomorphic-granular mix of quartz and K feldspar. Average crystal size of this fragment is about 0.15mm diameter. The fragment is either a piece of hypabyssal intrusive rock or represents granophyric devitrification of glassy volcanic material. Some of the fragments have partial to complete rims of fine sericite-clay. The breccia matrix is composed dominantly of fine polycrystalline quartz and minor dispersed sericite-clay. Most of the matrix quartz has an average crystal size of about 0.02mm diameter, but there are pockets and zones of slightly coarser quartz with crystal sizes on the order of 0.1 to 0.2mm in length/diameter. The contact zone between the two breccia variants is partly rimmed by this coarser quartz, most of which has the long axis perpendicular to the contact. Minor disseminated pyrite occurs in both matrix and some fragments. Although most of this pyrite is very fine-grained (0.05 - 0.3mm diameter), the larger crystals reach 3mm in length. Morphologies include rectangular, cubic, and pyritohedron.

The breccia pieces are enveloped by a very fine-grained black matrix that consists of a network of opaque phases that tends to crystallize along the margins of the xenomorphic quartz crystals. Minor fine sericite-clay is also distributed along quartz crystal margins. The black matrix is concentrically laminated along a zone several millimeters thick adjacent to the breccia fragments, but the laminated nature diffuses rapidly outside that zone. Quartz makes up no more than 15-20% of the black matrix. Irregularly-shaped fine to medium-grained silver sulphosalt minerals and subhedral to anhedral marcasite are also distributed in the black matrix.

RL: Opaque phases present and estimated abundances are listed below:

Black matrix (stannite III-quartz-sericite/clay)	10 - 15%
Marcasite-pyrite	± 4%
Ag sulphosalts	± 3%
pearceite/polybasite (±stephanite)	±2.5%

pyrargyrite	<0.5%
Native gold	<0.1%

The black matrix is a porous, spongy network of a phase identified tentatively as stannite III (CuSnS2-AgSnS2 series mineral). The is characterized by a brownish gray color, relatively low reflectance, and weak anisotropism. Not uncommonly the spongy crystals are partly to completely rimmed by native gold. Native gold also occurs as narrow internal filaments in the stannite III.

The abundance of pyrite exceeds that of marcasite in the polyphase breccia pieces. Pyrite occurs primarily as disseminations in fragments and matrix of the polyphase breccias. It forms euhedral to anhedral crystals to 3mm in length/diameter, although most of the pyrites are much smaller than the maximum size and range between 0.05 and 0.3mm diameter. The larger crystals have a subhedral, generally rectangular morphology and are composed of aggregates of smaller sub- to anhedral pyrite and marcasite crystals. Many of the pyrite crystals demonstrate some degree of anisotropism. Marcasite and lesser pyrite are dispersed in the dark matrix areas, where they occurs as isolated fine crystals and crystal aggregates. Marcasite is present also as inclusions in sulphosalt phases.

Amongst the spongy network of stannite III are scattered, sometimes larger (to 0.4mm length/diameter) crystals of a silver sulphosalt phase that probably belongs to the pearceite-polybasite group. The phase is characterized by a light gray color with a faint greenish tint and low to moderate reflectance. Red internal reflections are rare, perhaps owing to a high abundance of substitutional copper. Locally there appears to be an intergrowth of the pearceite/polybasite group mineral with a second silver sulphosalt mineral. The second phase is also light gray, but has a brownish to purplish tint against the pearceite/polybasite. It is identified tentatively as stephanite. Native gold commonly occurs in association with the pearceite/polybasite (± stephanite) as thin internal filaments and narrow partial to complete rims.

CL: Minor carbonate in breccia clasts has reddish orange CL. One fragment has weak yellow-green CL (fine plagioclase?). Hydrothermal quartz has no visible CL.

13-4904-S4/#7

Hydrothermal breccia. Several pieces of the polyphase hydrothermal breccia are enclosed in a very fine-grained black matrix. A fragment of the sericite-clay matrix breccia is encompassed by the quartz matrix breccia in one piece of the polyphase breccia. The rounded piece of polyphase breccia is about 12mm in diameter. The black matrix is concentrically laminated in a several millimeter thick zone adjacent to the included polyphase breccia fragments. The dark, laminated matrix is composed of abundant, fine-grained opaques that crystallize along the margins of fine, xenomorphic quartz crystals. Quartz probably makes up about 15-20% of the black matrix. Minor sericite-clay occurs also along quartz crystal boundaries. Silver sulphosalt minerals and marcasite are also distributed throughout the black matrix.

RL: Opaque phases present and estimated abundances are listed below:

Black matrix (stannite III-quartz-sericite/clay)	±50%
Marcasite-pyrite	± 7%
Ag sulphosalts	± 8%
pearceite/polybasite (±stephanite)	±7%
pyrargyrite	<1%
Native gold	<0.1%

A significant, but unusual opaque phase is present in the dark matrix only. The phase is characterized by a grayish brown to brownish gray color, a porous, spongy network texture, generally low reflectance (R < 28), weak anisotropism, and very poor polishing characteristics. This phase is identified tentatively as stannite III (CuSnS2-AgSnS2 series). Other possibilities may be tetrahedrite and the argyrodite-canfieldite series minerals. The porous texture and poor polishing characteristics are highly characteristic of stannite III, however. The abundance of this phase is difficult to determine owing to the low reflectance, texture, and poor polishing characteristics, and to the possibility that much of the material may have been plucked during preparation. Areas of matrix that have not polished well have very low reflectance. Native gold is sparsely present as partial narrow rims and inclusions or thin filaments within the stannite III.

Pyrite and minor marcasite are the only opaque phases noted in the polyphase hydrothermal breccia, where they constitute about 3% by volume of the breccia. Marcasite is present well in excess of pyrite in the black matrix, where they are collectively less abundant than the silver ore phases. Within the polyphase hydrothermal breccia pieces, pyrite occurs as anhedral to subhedral crystals and crystal aggregates to 0.8mm diameter. It is present predominantly dispersed in the polycrystalline quartz matrix, but is also disseminated in some of the devitrified tuffaceous volcanic fragments. In the dark laminated matrix marcasite occurs intergrown with and as inclusions in a pearceite/polybasite group mineral.

At least three silver sulphosalt phases are present dispersed in the black matrix. The most abundant phase appears to belong to the pearceite-polybasite group of minerals. They are characterized by a light gray color with faint greenish tint, low to moderate reflectance (R= ± 30), weak anisotropism, and occasional weak red internal reflections. The absence of significant internal reflections may be due to an anomalously high copper content. The pearceite-polybasite group phase commonly shows an intergrowth with a second phase that has similar reflectance, but a brownish tint compared to the host phase. This second phase may be stephanite (5Ag2S.Sb2S3). The pearceite/polybasite occurs as irregular crystals to 2.2mm in length or 1.1mm in diameter. Inclusions of anhedral marcasite are locally abundant, and some crystals appear to have grown partly in poikilitic intergrowth with the marcasite. In this particular slide the abundance of pearceite/polybasite exceeds that of marcasite. Fine native gold is found as internal filaments and narrow partial rims in the pearceite/polybasite ± stephanite minerals. Pyrargyrite is subordinate in abundance to the pearceite/polybasite ± stephanite phases. It is characterized by a light gray color with a weak bluish tint, low to moderate reflectance (±30), and strong red internal reflections. In this slide the pyrargyrite crystals are widely dispersed as irregular crystals to 0.2mm diameter. Locally they have tiny inclusions of native gold. Rarely native gold occurs as narrow rims on parts of the pyrargyrite crystal margins.

Very fine native gold is dispersed throughout the slide. Its occurrence mode is similar within all of the host phases. The native gold occurs as thin filaments and microfracture fills, and as narrow, irregular and discontinuous rims in stannite III, and the silver sulphosalt minerals. It is much less common in association with pyrargyrite than in the pearceite/polybasite ± stephanite minerals.

CL: Minor carbonate with weak reddish orange CL is present in breccia clasts. Hydrothermal quartz has no CL. A pyrogenic mineral fragment in the polyphase breccia has light blue to reddish blue CL (Kspar?).