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MINERALOGY
AND
PREDICTIVE METALLURGY
OF THE
SAMATOSUM DEPOSIT

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SUMMARY

This study has been undertaken in order to establish the mineralogy, textures and middling ratings of the various parts of the Samatosum deposit. These data are used to determine if differing ore-types are present, to predict their metallurgical response, and to choose representative samples for metallurgical testwork.

The important ore minerals of the Samatosum deposit are tetrahedrite, sphalerite, galena, chalcopyrite, and electrum; gangue minerals are pyrite, quartz, ferroan dolomite and muscovite.

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The key sulphides, tetrahedrite (main silver-copper carrier) and sphalerite (main zinc carrier) are medium-coarse, possessing average middling ratings (tt,sp/py,gn) of 2.5 and will therefore require only a relatively coarse grind of about 50% -200 mesh for liberation. Chalcopyrite, which contributes less copper than tetrahedrite, is also medium coarse (2.7); galena (lead carrier) is finer-grained (3.7).

Because the ore has a relatively low pyrite content (<10%) and contains considerable quantities of soft minerals including tetrahedrite, sphalerite, carbonate, and muscovite, the work index will be low.

The orebody has been divided into three zones, I, II, and III on the basie of mineralogy/predictive metallurgy/mining sequence. Zone I contains massive high-grade ore in the upper part of the proposed open-pit; Zone II contains mainly-disseminated ore in the lower part of the open-pit, and Zone III contains mainly-disseminated ore (similar to the ore of Zone II) that will be mined by underground methods. Sub-zone I_O contains the ore to be mined initially, from the surface to ten meters depth.

Except for some covellite and other secondary minerals occurring in surface Trench-3, (in Zone I_O), metallurgically-deleterious minerals such as pyrrhotite and porous pyrite/marcasite were not observed. Most of the ore contains +20% dolomite and should be relatively stable and non-acid generating.

Assuming that treatment of Samatosum ores is by flotation, with Pb-Cu-Ag/Zn separation, recoveries of +90% are anticipated for silver and copper, which occur mainly in tetrahedrite (36.1%Cu, 3.8% Ag), with subordinate amounts of copper in chalcopyrite; somewhat elevated middling ratings for galena may indicate reduced lead recoveries.

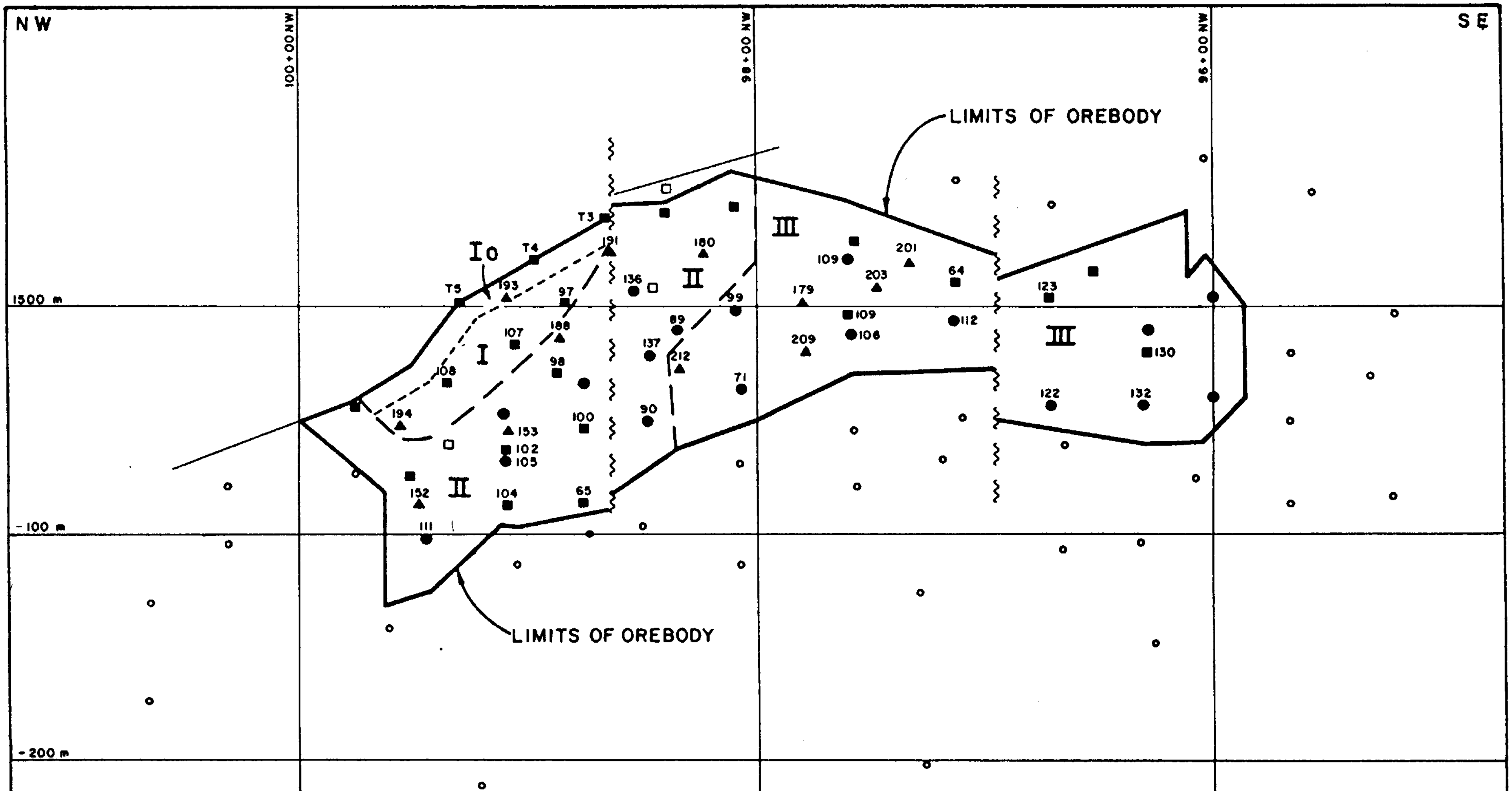
Zinc recoveries of 70-80% are anticipated, with lowered recoveries due to poor Pb-Cu-Ag/Zn separation caused by fine "chalcopyrite disease" in about 50% of the sphalerite, especially in Zone I, and due to significant amounts of zinc being carried by tetrahedrite to the Pb-Cu-Ag-Au concentrates of Zones II and III (tetrahedrite averages 4.9% Zn). Zinc separation may be particularly difficult in Sub-zone I_O where activation of sphalerite due to the presence of covellite is anticipated.

Because of a very strong association of the electrum with tetrahedrite rather than pyrite or arsenopyrite, gold recoveries to the Pb-Cu-Ag-Au concentrate are estimated to be about 90%.

Tetrahedrite, with its silver content and its association with gold, is by far the most important mineral at Samatosum. If the production of a lead-copper-silver-gold concentrate containing 50% tetrahedrite (average content=36.1% Cu, 23.3% Sb, 3.8% Ag, 3.4% As) is achieved, calculations indicate that it will contain approximately 19% Cu, 600 opt Ag, 1 opt Au, 11.6% Sb, 1.7% As, <<100ppm to a maximum of ±400ppm Hg (high mainly in Zone I), and depending on ore source and grind, an estimated 10% Pb and 10-30% Zn.

Because the Samatosum sphalerite has a high zinc content (65.4% Zn) and the ore is low in pyrite, it should be possible to produce a zinc concentrate grading ±55% Zn from the bulk Pb-Cu-Ag-Au flotation tailings; electron microprobe analyses of sphalerite grains indicate that the mercury content of the zinc concentrate will vary from <<100ppm to a maximum of approximately ±400ppm, depending on the source of the ore.

It is recommended that samples that contain the ore intersection and appropriate dilution from each of several drill holes throughout the deposit should be tested individually, and then combined to form composites for Zones I, II, and III for more detailed testwork. An additional composite made up of samples from deep trenches and shallow drill-holes, should be obtained from Subzone I_O in order to test the initially-mined, partly oxidized ore.



METALLURGICAL ZONES

- — — — ZONE LIMITS
- I — UPPER OPEN-PIT ORE
- Io — INITIAL OPEN-PIT ORE
- II — LOWER OPEN-PIT ORE
- III — UNDERGROUND ORE

DRILL HOLES

- ■64 ●90 NUMBERED HOLES SAMPLED FOR THIS STUDY
- ▲191 METALLURGICAL HOLES
- ∘ HOLES OUTSIDE OREBODY
- ■ MINNOVA BLOCK A > 250 g/t Ag
- □ MINNOVA BLOCK A < 250 g/t Ag
- ● MINNOVA BLOCK B > 250 g/t Ag
- ○ MINNOVA BLOCK B < 250 g/t Ag

SAMATOSUM DEPOSIT LONGITUDINAL SECTION

0 50 100m

FIGURE 1

PURPOSE AND SCOPE

The Samatosum volcanic exhalative deposit is 25 km east of Barriere, B.C. and contains approximately 800,000 tonnes of ore averaging 1.1% Cu, 1.5% Pb, 3.0% Zn, 32 opt Ag, and 0.05 opt Au.

The Samatosum deposit and the available drill-core in Barriere were examined by the writer on July 14, 15, 1987. A total of 96 polished thin sections of samples collected from 24 drill holes and Trench #3, were made by Geoplastech Limited of Toronto and were examined under the microscope by the writer. Electron microprobe analyses were done on selected mineral grains by J.E. Clemson at the University of Toronto, and J.Stirling of the New Brunswick Research and Productivity Council.

The main purposes of this study are to establish the overall mineralogy and to determine the grain sizes and textures of the silver, gold, zinc, lead, copper, antimony, arsenic and non-sulphide gangue minerals in all parts of the deposit. These mineralogical data are used to predict variations in the metallurgical response from place-to-place in the orebody and to allow for the selection of representative samples for metallurgical testwork.

MINERALOGY

Pertinent data on the mineralogy of the 96 samples studied are presented on the attached MINERAL SHEETS, which also give the MIDDLING RATINGS (see below). The attached PHOTOMICROGRAPHS (PM-1 to PM-34) provide a visual record of the minerals and textures observed.

The important minerals in the Samatosum deposit are tetrahedrite (tt), sphalerite (sp), galena (ga), chalcopyrite (cp), pyrite (py), quartz (qz), carbonate (cb), muscovite (ms) and electrum (au). Minor amounts of gersdorffite (ge) and arsenopyrite (as) and very minor bournonite ($PbCuSbS_3$) are also present.

The orebody can be divided into Zones I, II and III (Figure 1) on the basis of mineralogy/predictive metallurgy (see also PREDICTIVE METALLURGY) and the proposed mining sequence. Zone I contains upper-open-pit massive sulphide ore; Zone II has lower-open-pit mainly-disseminated ore; Zone III contains underground mainly-disseminated ore (no distinction has been made here between Minnova's zones A and B because, except for the upper part of A, which is massive sulphide, these two zones are mineralogically similar). Sub-zone I_o is the uppermost part of Zone I; this sub-zone contains the initially-mined ore, at least some of which (in surface trenches) is known to be partly oxidized; because the extensiveness of the oxidation is not known, the depth of Sub-zone I_o has been arbitrarily chosen to be 10 meters.

Table 1 gives the average (estimated) mineral percentages of the 96 samples studied, as well as a breakdown of the mineral percentages in Zones I, II and III. The estimated percentages of galena, chalcopyrite, sphalerite, and tetrahedrite in Table 1 are 2-3 times higher than the true over-all percentages of ore within the zones because the polished sections studied were made from core with higher-than-average sulphide content (in order to obtain sufficient gold-grain data), and also include some samples from Zone I that were anomalously high in (particularly) chalcopyrite and galena.

TABLE 1 - AVERAGE MINERALOGICAL COMPOSITION OF THE SAMPLES STUDIED, SAMATOSUM

ZONE (no. samples)	py	sp	ga	cp	tt	ge	as	gn		
								qz	cb	ms
Zone I(9)	12.2	24.8	13.2	26.3	12.1	0.0	0.07	6.3	4.8	0.1
Zone II(53)	11.3	10.8	3.2	1.3	9.6	0.1	0.02	32.0	22.8	9.0
Zone III(34)	10.7	9.4	2.6	2.0	8.9	0.1	0.02	37.6	18.1	11.7
OREBODY (96)	11.2	11.6	3.9	3.9	9.6	0.1	0.02	31.6	19.4	9.1

Numbers are estimated volume %

Despite its limitations, Table 1 can be used to illustrate the following mineralogical characteristics of the Samatósum orebody:

1) Pyrite content is relatively low throughout (compared to most volcanogenic deposits), probably averaging less than 10%. Small, pyritic lenses that do occur, will be highly diluted with low-pyrite ore during mining.

2) Tetrahedrite content is unusually consistent in all zones, probably ranging from 3-6%, depending on the amount of dilution.

3) High quantities of sphalerite, galena, and chalcopyrite (rather than high pyrite) make the Zone I ore massive sulphide.

4) Zones II and III are mineralogically similar to one another and consist of about 20% disseminated sulphides (mainly pyrite, sphalerite, and tetrahedrite) in 80% quartz carbonate-muscovite gangue (gn).

Characteristics of the various minerals at Samatosum are shown in the attached photomicrographs. Some pertinent features of the minerals are as follows:

Pyrite-FeS_2: medium grained, mainly disseminated; non-porous (stable); 0.3% Ni content (microprobe) makes it anomalously anisotropic.

As?
Tetrahedrite-$(Cu,Fe,Zn,Ag)_{12}(Ag,Sb)_4S_{13}$: medium-coarse; mainly inclusion-free; commonly intergrown with chalcopyrite; fairly consistent in composition throughout the orebody (Table 2), averaging 36.1% Cu, 3.4% As, 23.3% Sb, 24.7% S, 2.1% Fe, 4.9% Zn, 3.8% Ag (highest silver in 67 analyses is 8.3% Ag in one grain in sample TR-3a); Hg content highest in Zone I, varies from not-detected (400ppm is the detection limit) to an average of 634ppm in TR-3a (highest value obtained is 1240ppm-one grain in RG-97-17.4).

Sphalerite-ZnS: medium to coarse; 50% of Zone I sphalerites have "chalcopyrite disease" (cp/sp=5-6, see MIDDLING RATINGS); 65.4% Zn, low-iron (0.4-1.0% Fe, see Table 3); Ag not detected to 295ppm; Hg not detected to 784 ppm (Table 3).

Galena-PbS: very fine to coarse (coarse in Zone I); commonly intergrown with pyrite,tetrahedrite and sphalerite; Ag content 1.1%-one analysis in sample TR-3a, not detected and 0.7% in RG-136-56.5 (detection limits approximately 500 ppm).

Chalcopyrite-$CuFeS_2$: medium grained, partly coarse in Zone I; abundant only in Zone I; one grain in sample TR-3a has 0.6% Ag; not detected (<500 ppm) in other grains.

Gersdorffite-NiAsS: very minor, commonly rimming tetrahedrite.

Arsenopyrite-FeAsS: very minor.

Quartz-SiO_2: coarse-granular; strained near faults.

Carbonate-$Ca(Fe,Mg)(CO_3)_2$: coarse-granular; ferroan dolomite with about 4% Fe, 0.8% Mn (2 analyses, RG-122-237).

Muscovite-$K(Al,Ti)_2(AlSi_3O_{10})(OH)_2$: medium-grained; 1.2% TiO_2 (1 analysis, RG-122-237).

Covellite-CuS: 0.3% in TR-3a (surface trench).

Chalcocite-Cu_2S: minor amounts observed only in sample RG-121-47.6 which is outside the orebody.

Oxides: minor Fe,Zn,Pb oxides observed in TR-3a (surface trench).

Electrum-(Au,Ag): 842 grains observed (MINERAL SHEETS) are 1-110 microns in diameter (Table 5); 14 grains analysed by electron microprobe contain 21.7-38.0% Ag, averaging 30.4% Ag (Table 4); very strong association of electrum with tetrahedrite, and negligible electrum occurs as inclusions in pyrite (0.12%) or gangue (0.01%); estimated 91.2% gold recovery in Pb-Cu-Ag-Au concentrate (Table 5).

Note: abundant electrum inclusions in pyrite were observed only in sample RG-135-237 which is from a high-pyrite quartz-muscovite vein(?) at depth, below the orebody. In many volcanogenic exhalative deposits, including the original Rea Gold zone, gold and/or electrum grains commonly occur as inclusions in pyrite and/or arsenopyrite; interestingly though, gold in the tetrahedrite-rich low-pyrite parts of the Green's Creek deposit (which is mineralogically somewhat similar to Samatosum) occurs mainly on gangue grain boundaries (au/gn-gn) rather than in pyrite or tetrahedrite.

TABLE 2 - ELECTRON MICROPROBE ANALYSES OF TETRAHEDRITE GRAINS, SAMATOSUM

	ZONE I				ZONES II & III													
SAMPLE	TR-3	97-17	97-17.4	108-35.8	65-76.3	89 48.8	89-50	89-51.2	102-78	106-121.7	106-132.9	109-123.5	112-149	122-237	122-242	132-192	136--56.5	AVG.
No.Anal.	(6)	(6)	(2)	(3)	(3)	(5)	(3)	(4)	(4)	(4)	(3)	(3)	(4)	(5)	(4)	(3)	(5)	(67)
Cu	34.21	36.44	36.79	35.74	36.72	36.05	36.21	36.24	35.35	35.77	38.55	36.65	36.39	35.86	36.45	35.34	35.01	36.10
As	0.99	3.05	4.47	2.73	4.29	4.64	3.48	2.98	3.25	2.79	4.67	3.91	2.39	2.81	3.67	4.61	3.62	3.43
Sb	26.33	22.93	21.78	24.60	22.41	21.21	23.41	23.38	24.08	24.97	22.32	22.15	23.82	23.87	23.27	21.49	24.02	23.30
S	23.80	24.17	24.75	24.40	24.84	25.12	25.04	24.81	24.65	24.51	24.88	24.78	24.54	24.30	24.58	24.71	25.53	24.67
Fe	2.62	1.88	1.81	2.80	1.73	2.31	1.73	2.00	2.17	1.90	2.51	1.89	1.83	1.68	2.50	1.86	2.60	2.11
Zn	4.27	4.87	5.52	3.97	5.36	4.35	5.06	4.59	4.69	5.15	4.57	5.62	4.90	5.01	4.19	6.53	4.95	4.92
Ag	6.98	3.69	3.53	3.44	4.49	4.16	3.50	3.35	3.74	3.94	0.56	3.51	3.31	3.48	3.82	3.69	5.16	3.79
Total	99.19	97.03	98.63	97.68	99.85	97.84	98.43	97.34	97.92	99.02	98.06	98.51	97.18	97.01	98.47	98.22	100.89	98.32

Analyses by J.E. Clemson, except 136-56.5 by J. Stirling, New Brunswick RPC

No. Anal.	(5)	(5)	(5)	(4)	(6)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)	(5)			
Hg-ppm (range)	408 -1061	n.d. -779	n.d. -1240	n.d.	n.d. -434	n.d. -505	n.d. -553	n.d.	n.d.	n.d.	n.d. -511	n.d.	n.d. -884	n.d.	—	—	n.d.

Analyses by J. Stirling, New Brunswick RPC
Detection limit approximately 400 ppm Hg; n.d. = not detected

TABLE 3 - ELECTRON MICROPROBE ANALYSES OF SPHALERITE GRAINS, SAMATOSUM

SAMPLE (ZONE)	NO. ANAL. Zn-Fe	NO. ANAL. Ag-Hg	% Zn	% Fe	ppm Ag	ppm Hg
TR-3a(I)	5	5	65.7	1.03	n.d-295	n.d.-504
RG-65-76.3(II)	-	4	-	-	n.d.-tr	n.d.-tr
RG-97-17.4(I)	2	5	64.6	0.36	n.d.-tr	n.d.
RG-105-87.7(II)	2	5	67.1	0.47	n.d.-tr	tr-784
RG-106-132.9(III)	3	5	65.8	0.85	n.d.-tr	n.d.
RG-108-35.8(I)	-	6	-	-	n.d.-tr	n.d.-tr
RG-109-123.5(III)	2	5	65.1	0.45	n.d.-242	n.d.-tr
RG-112-149(III)	2	5	66.4	0.74	n.d.	n.d.-712
RG-132-192(III)	1	-	64.3	0.94	-	-
RG-136-56.5(II)	1	-	64.4	0.86	-	-
AVERAGE-RANGE	(18)	(40)	65.4	0.71	n.d.-295	n.d.-784

Detection limits approximately 200ppm Ag, 400ppm Hg; n.d.=not detected
Zn and Fe analyses by J.E. Clemson
Ag and Hg analyses by J. Stirling, New Brunswick RPC

TABLE 4 - ELECTRON MICROPROBE ANALYSES OF ELECTRUM GRAINS, SAMATOSUM

SAMPLE	NO. ANAL.	% Au	% Ag	TOTAL
RG-102-81	2	72.52	27.50	100.03
RG-108-35.8	3	75.31	22.96	98.27
RG-111-69	4	65.01	33.19	98.20
RG-122-242	3	65.64	32.80	98.44
RG-137-52.5	2	65.32	35.38	100.70
AVERAGE	(14)	68.76	30.37	99.13

Analyses by J.E. Clemson

TABLE 5 - OCCURRENCE AND ESTIMATED RECOVERY OF GOLD BY FLOTATION, SAMATOSUM

OCCURRENCE	NO. GRAINS	SIZE RANGE	VOLUME u^3	EFF.AVG. DIAMETER	EST.% REC.	CALC. VOL. REC. u^3	CALC. % REC.
au/tt	660	1-110u	1,505,792	16.3u	95%	1,430,502	62.60
au/ga	30	1-20x38u	74,430	16.8u	85%	63,266	2.77
au/cp	12	1-14x36u	17,624	14.1u	95%	16,743	.73
au/sp	9	1-5x50u	10,244	13.0u	20%	2,049	.09
au/py	12	1-9x74u	52,625	20.3u	5%	2,631	.12
au/gn	8	1-14u	4,084	9.9u	5%	204	.01
au/tt-ga	23	1-26x130u	508,566	34.8u	95%	483,138	21.14
au/tt-py	22	3-18u	9,122	9.2u	80%	7,298	.32
au/tt-ge	1	6u	113	6.0u	80%	90	.00
au/tt-gn	12	2-30u	17,081	14.0u	80%	13,655	.60
au/tt-sp-(py, gn,ga)	5	8-18u	7,805	14.4u	80%	6,244	.27
au/ga-py	6	3-12x60u	59,971	26.7u	80%	47,977	2.10
au/ga-gn,cp-gn	5	3-6u	320	5.0u	70%	224	.01
au/ga-sp	3	12-7x24u	6,215	15.8u	70%	4,351	.19
au/sp-py,sp-gn	12	1-14u	4,747	9.1u	50%	2,374	.10
au/py-gn	2	14u	2,874	14.0u	50%	1,437	.06
au/py-py	6	2-4x26u	3,193	10.1u	50%	1,597	.07
au/gn-gn	14	1-5u	293	3.4u	50%	147	.01
TOTALS	842	1-110u	2,285,099	17.3u	-----	2,083,927	91.2

MIDDLING RATINGS

Middling ratings* are semi-quantitative (estimated) classifications of the fineness (grain sizes) of the specific textures or mineral intergrowths that control the degree of liberation of the economic minerals in an orebody. The ratings are from 1 (coarse) to 6 (predominance of -10u inclusions or intergrowths) and can be characterized as follows w/o liberation: 1-excellent, 2-very good, 3-good, 4-fair, 5-poor, 6-extremely poor. For the Samatosum orebody, assuming Cu-Pb-Ag/Zn separation by flotation, the pertinent middling ratings are the following:

(1) sp/py,gn---sphalerite intergrowths with pyrite and gangue

(2) ga/py,gn---galena intergrowths with pyrite and gangue

(3) cp/py,gn---chalcopyrite intergrowths with pyrite and gangue

(4) tt/py,gn---tetrahedrite intergrowths with pyrite and gangue

(5) ga/sp---galena-in-sphalerite

(6) cp/sp---chalcopyrite-in-sphalerite

(7) tt/sp---tetrahedrite-in-sphalerite

Middling ratings (1)-(4) above relate to zinc(1), lead(2), copper(3), and copper-silver(4) recoveries and the purity of the zinc and lead-copper-silver-gold concentrates. Ratings (5),(6), and (7) relate to Pb-Cu-Ag/Zn separation which involves mainly losses of zinc to the lead-copper-silver-gold concentrate.

Middling ratings (1)-(7) were made for the 96 Samatosum samples studied and are given on the attached MINERAL SHEETS. Table 6 summarizes the middling rating data for Zones I, II, III, and for the entire orebody (see Table 7-MINERAL SHEETS LEGEND for explanation).

TABLE 6 - AVERAGE MIDDLING RATINGS OF ZONES I, II, III, SAMATOSUM

	sp/py,gn	ga/py,gn	cp/py,gn	tt/py,gn	ga/sp	cp/sp	tt/sp
Zone I	1.9	2.3	1.6	1.6	3.2	5.3	1.9
Zone II	2.8	3.9	2.7	2.7	2.7	1.9	1.9
Zone III	2.9	4.0	2.9	2.5	2.4	1.8	1.2
OREBODY	2.7	3.7	2.5	2.5	2.7	2.2	1.7

* the Middling Rating method was developed initially for the Grum deposit, the top (stratigraphic) few meters of which have a very serious Pb/Zn separation problem due to the middling rating ga/sp=6("galena disease"); middling ratings for Brunswick ores are (approximately), sp/py=4, ga/py=5-6 and zinc and lead recoveries are about 80% and 60%; Geco middling ratings sp/po,py and cp/po,py probably average about 2.

PREDICTIVE METALLURGY

From Table 6 it is apparent that most of the middling ratings for all three zones of the Samatosum orebody average <3 and that the metallurgical response of most of the ore should therefore by very good. The only major problem encountered is in Zone I where the high average value of cp/sp=5.3 is due to severe "chalcopyrite disease" in more than 50% of the sphalerite, indicating that there will be high losses of zinc to the lead-copper-silver(-gold) concentrate. The only other, less serious problem, is indicated for lead (galena) in Zones II and III where average middling ratings for ga/py,gn=3.9-4.0 indicate reduced lead recoveries and/or reduced concentrate grades due to galena + pyrite and galena + gangue middlings. Significant positive features of the Samatosum ores are the absence of reactive, quickly-oxidizing minerals such as porous pyrite, marcasite, and pyrrhotite, and the presence of acid-neutralizing dolomite.

Unlike many volcanogenic/deposits which are pyritic throughout, the high-pyrite zones at Samatosum are scattered and small and would therefore never comprise a major part of the mill feed. Because of their relatively low average pyrite content and their content of soft sulphides and carbonate-muscovite gangue (Table 1), the Samatosum ores in Zones I, II, and III should possess a low work index. The coarseness of the key sulphides tetrahedrite and sphalerite, as indicated by tt,sp/py,gn middling ratings of about 2.5 (Table 6), should allow for a relatively coarse grind, in the order of 50% -200 mesh. Because tetrahedrite contains nearly all of the silver and most of the gold (as electrum inclusions) and copper, its flotation is of prime importance.

Zone I, the upper open-pit ore (Figure 1) consisting of coarse high-grade massive Pb-Zn-Cu-Ag sulphides, has much sphalerite with "chalcopyrite disease" (cp/sp=5.3, Table 6); even with fine grinding, this texture will cause serious Cu/Zn separation problems, and much of the zinc (as sphalerite+chalcopyrite middlings) will report to the Pb-Cu-Ag-Au concentrate. This problem may be augmented somewhat by the slightly elevated ga/sp average rating of 3.2 for Zones I (Table 6).

Sub-zone I_O, which contains the initially-mined ore, is arbitrarily defined here as the upper 10 meters of Zone I; this sub-zone is separated because near-surface oxidation could affect metallurgical response, but the extent and actual depth of oxidation are not known. Covellite has been observed in sample TR-3a which is from a surface trench in Sub-zone I_O (see MINERAL SHEETS). There are no other samples available from Sub-zone I_O, but if covellite is widespread, then Pb-Cu-Ag/Zn separation, due to zinc activation, may be extremely difficult in the initially-mined ore.

Zones II (lower open-pit) and III (underground) have very similar mineralogy and middling ratings. Middling ratings are low; excellent metallurgical response is therefore anticipated for Zn, Cu, and Ag (also Au-see below).

Deductions regarding the metallurgy of silver, zinc, lead, copper, antimony arsenic, mercury and gold are as follows:

Silver: mainly in clean, medium-coarse tetrahedrite (3.8%Ag); much smaller amounts also in galena, very minor amounts in chalcopyrite and sphalerite; very high (+90%) silver recoveries anticipated in Pb-Cu-Ag-Au concentrate.

Zinc: mainly in low-iron, medium-coarse sphalerite (65.4%Zn), smaller amounts in tetrahedrite (4.9% Zn); fairly high recoveries (+80%) would be anticipated except for zinc activation in Zone I (chalcopyrite disease) and Sub-zone I_O (chalcopyrite disease and covellite), and significant losses in Zones II and III due to zinc in tetrahedrite (4.9% Zn).

Lead: in galena which tends to be finer than the other sulphides; recoveries of about 70-80% anticipated, depending on fineness of grind.

Copper: in tetrahedrite (36.1% Cu), and locally, especially in Zone I, in chalcopyrite (33.3%Cu); high recoveries (90%) anticipated.

Gold: gold occurs exclusively in the mineral electrum which contains about 70% Au; as shown in Table 5, a very large weight percentage of the gold observed and measured occurs in electrum grains that are within tetrahedrite (62.6%) or on tetrahedrite grain boundaries (22.33%); subordinate amounts of gold are within galena and chalcopyrite grains (3.5%) and on galena and chalcopyrite grain boundaries (2.3%); only 0.12% of the measured grains occurs as inclusions in pyrite; gold recovery in a Pb-Cu-Ag-Au flotation concentrate, based on the estimates and calculations outlined in Table 5, is anticipated to be about 90%.

Antimony: antimony occurs almost exclusively in the tetrahedrite (23.3%Sb); +90% of the antimony will report to the Pb-Cu-Ag-Au concentrate.

Arsenic: nearly all of the arsenic occurs in tetrahedrite (3.4%As) and will report to the Pb-Cu-Ag-Au concentrate; only traces of arsenopyrite are present.

Mercury: probe analyses (Tables 2,3) indicate the presence of highly variable amounts of mercury in tetrahedrite and sphalerite, with fairly consistent high values (+500 ppm) in Zone I, and sporadic high values in Zones II and III; calculations suggest that ore from Trench-3 may yield Pb-Cu-Ag-Au and Zn concentrates with as much as 400ppm Hg.

Lead-Copper-Silver-Gold Concentrate: if the Pb-Cu-Ag-Au concentrate has 50% tetrahedrite, it will contain approximately 19% Cu, 11.6% Sb, 1.7% As, <<100ppm to a maximum of ±400ppm Hg (high in Zone I-see Table 2), an estimated 2.0% Ag (600 opt) and 1 opt Au, and possibly 10-30% Zn (depending on the source of the ore).

Zinc Concentrate: Samatosum sphalerite has high zinc (65.4%) and low iron (0.7%); because the ore is also low in pyrite, it should be possible to produce a high-grade (± 55%) zinc concentrate from the inclusion-free sphalerite remaining (in the bulk tailings) after the chalcopyrite+sphalerite and galena+sphalerite middlings have floated to the Pb-Cu-Ag-Au concentrate. Rough estimates and calculations based on Table 3 suggest that the mercury content of the zinc concentrates will range from <<100ppm to a maximum of ±400ppm, with high values for most of Zone I, and sporadic increses to 300-400 ppm for the ores of Zones II and III.

METALLURGICAL TEST SAMPLES

The following recommendations were made during the preparation of this report:

(1) Drill-core samples from each of several drill-holes spaced throughout Zone I, Zone II and Zone III, should be bench-tested individually. Each sample should include the ore interval plus appropriate hangingwall and footwall dilution (30-40%?).

(2) More detailed tests should be carried out on composite samples representing the three zones. The composites should be assembled by combining samples from the individual holes tested (weight of each sample to vary with length of interval), as well as additional material from new drill holes (Metallurgical Holes, Figure 1).

(3) Composites from Zones II and III should give similar results and can be combined, if additional material is required.

(4) The initially-mined ore in Sub-zone I_O should be tested separately. Samples of ore+dilution from several deep trenches and shallow drill-holes could be tested and then combined to give Composite I_O.

TABLE 7 - LEGEND FOR MINERAL SHEETS AND PHOTOMICROGRAPHS

MINERAL	ABBREVIATION	FORMULA	COLOUR (PM'S)
pyrite	py	FeS_2	brassy-white
sphalerite	sp	ZnS	bluish-grey
galena	ga	PbS	silvery-white
chalcopyrite	cp	$CuFeS_2$	yellow
tetrahedrite	tt	$(Cu,Fe,Zn,Ag)_{12}(As,Sb)_4S_{13}$	light grey
gersdorffite	ge	$NiAsS$	off-white
arsenopyrite	as	$FeAsS$	white
quartz	qz	SiO_2	dark grey
carbonate	cb	$Ca(Mg,Fe)(CO_3)_2$	dark grey
muscovite	ms	$K(Al,Ti)_2(Si_3AlO_{10}(OH)_2$	dark grey
covellite	cv	CuS	deep blue
gold	au	(Au,Ag)	gold
gangue	gn	quartz(incl.minor feldspar) +carbonate+muscovite (incl. minor chlorite and chloritoid)	

(mp)tt--- indicates electron microprobe analysis (of tetrahedrite)

2 au/tt=10u,20u---2 electrum grains in tetrahedrite, having diameters of 10 and 20 microns

2 au/tt-gn--- 2 electrum grains on tetrahedrite-gangue grain boundaries

sp/py,gn=3---sphalerite-in-pyrite and -in-gangue has middling rating of 3

Note: sp/py,gn and tt/py,gn rated only if sp and tt are $\geq 2\%$
cp/py,gn and ga/py,gn rated only if cp and ga are $\geq 1\%$
cp/sp and ga/sp rated only if sp$\geq 2\%$
tt/sp rated only if sp and/or tt are $\geq 2\%$
inclusion-free sp has middling ratings of 0

Most photomicrographs are of high-sulphide areas on the polished section; middling ratings given for the PM's are not necessarily the same as the ratings for the entire polished section given in the Mineral Sheets

M = Massive Ore
D = Disseminated Ore

SAMATOSUM

	MINERAL PERCENTAGES							MIDDLING RATINGS							
TRENCH-3	py	sp	ga	cp	tt	ge as	qz cb ms	sp/py gn	ga/py gn	cp/py gn	tt/py gn	ga/sp	cp/sp	tt/sp	Gold : Probe : Misc.
TR-3a M	3	16	68	·5	7	0 ·1	3 2 0	1	1	—	1	4	(6+, 1) 4	1	·3 covellite after sp, ga, cp ·2 oxidation product of ga (cerussite?) and sp (smithsonite?) massive, galena-rich, remobilized ore (mp) tt (7·0% Ag, 408-1061 ppm Hg); sp (1·0% Fe, n.d.-295 ppm Ag, n.d.-504 ppm Hg); ga (1·1% Ag); cp (0·6% Ag)

M = Massive Ore
D = Disseminated Ore

SAMATOSUM

	MINERAL PERCENTAGES							MIDDLING RATINGS							
RG-64	py	sp	ga	cp	tt	ge as	qz cb ms	sp/py gn	ga/py gn	cp/py gn	tt/py gn	ga/sp	cp/sp	tt/sp	Gold : Probe : Misc.
89·5 D	10	20	5	·3	20	0 ·1	25 15 5	3	4	—	2	4	3·5	3·5	
89·9 D	0	15	4	1	10	0 0	60 2 8	3	4	3·5	2·5	3	2	3·5	

M = Massive Ore
D = Disseminated Ore

SAMATOSUM

	MINERAL PERCENTAGES							MIDDLING RATINGS							
RG- 65	py	sp	ga	cp	tt	ge as	qz cb ms	sp/py/gn	ga/py/gn	cp/py/gn	tt/py/gn	ga/sp	cp/sp	tt/sp	Gold : Probe : Misc.
76·3 D	18	25	5	tr	8	0 0	5 0 39	3	4	—	3	3·5	0	2	(mp) tt/tr (4·5% Ag, n.d. - 434 ppm Hg); sp (n.d. Ag,Hg)

M = Massive Ore
D = Disseminated Ore

SAMATOSUM

RG-71	MINERAL PERCENTAGES							MIDDLING RATINGS							Gold : Probe : Misc.
	py	sp	ga	cp	tt	ge as	qz cb ms	sp/py gn	ga/py gn	cp/py gn	tt/py gn	ga/sp	cp/sp	tt/sp	
106·3 D	3	5	tr	tr	6	0 0	76 8 2	3	—	—	3·5	0	0	1	
108·1 D	12	28	5	0	0	·2 0	15 0 40	3	·5	—	—	5	0	0	py strongly anisotropic
120·9 D	10	8	2	tr	8	0 0	66 5 ·5	3	4	—	3·5	3·5	0	2	qz sheared, strained py strongly anisotropic

M = Massive Ore
D = Disseminated Ore

SAMATOSUM

	MINERAL PERCENTAGES							MIDDLING RATINGS							
RG-89	py	sp	ga	cp	tt	ge as	qz cb ms	sp/py gn	ga/py gn	cp/py gn	tt/py gn	ga/sp	cp/sp	tt/sp	Gold : Probe : Misc.
48·2 D	2	·5	·1	1	6	0 tr	70 10 10	—	—	2	2	—	—	2	12 au/tt = 1(2), 2(3), 3, 4, 5(2) 6, 7, 8 u. 1 au/tt-gn = 6u minor graphite
48·8 D	5	3	·1	·2	15	0 ·1	23 50 3	3	—	—	2	0	0	3	4 au/tt = 4, 6, 8, 12 x 30 u (mp) <u>tt</u> (4·2% Ag, n.d.-505 ppm Hg)
49·8 D	·5	5	tr	2	17	0 ·1	20 45 10	3·5	—	3	2	0	3	2·5	3 au/tt = 3, 4, 12 u
50·0 D	·2	·2	·2	tr	4	·1 0	20 65 10	—	—	—	3·5	—	—	0	(mp) <u>tt</u> (3·5% Ag, n.d.-553 ppm Hg); <u>ge</u>; <u>ms</u>; <u>cb</u> = dolomite
50·5 D	·4	·2	·1	tr	3	0 0	75 16 5	—	—	—	3	—	—	0	
51·2 M	20	30	10	·4	20	0 0	5 10 5	3	4	—	3	4	3	3	2 au/tt = 4, 8 u 3 au/tt – ga = 5, 12, 14u (mp) <u>tt</u> (3·4% Ag; Hg n.d.)
51·5 M	20	33	10	tr	7	0 ·2	28 2 0	3	4	—	1	4	0	2	2 au/tt = 5, 6 u much tt is in ga
52·0 M	20	50	8	·1	1	0 0	21 0 ·0	3	4	—	—	4	0	3	minor very fine tt veinlets in sp

M = Massive Ore
D = Disseminated Ore

SAMATOSUM

RG-90	MINERAL PERCENTAGES: py	sp	ga	cp	tt	ge as	qz cb ms	MIDDLING RATINGS: sp/py gn	ga/py gn	cp/py gn	tt/py gn	ga/sp	cp/sp	tt/sp	Gold : Probe : Misc.
98·8 D	8	12	4	·1	1	0 0	35 0 40	3·5	4·5	—	—	4	0	0	
99·4 D	3	2	2	tr	10	·2 0	20 60 3	2	2·5	—	2	1	0	3	1 au/tt = 6u 1 au/tt - gn = 2u 1 au/gn (cb) = 7u
100·0 D	4	5	·1	·1	15	1 0	10 50 15	3	—	—	3	1	1	3·5	
101·8 D	1	4	·2	·1	10	0 0	53 30 2	2	—	—	2	1	1	3	5 au/tt = 1, 5, 10, 12, 14u 1 au/tt - sp - ga = 18u
102·0 D	7	·1	·1	tr	18	·1 0	45 20 10	—	—	—	2	—	—	0	4 au/tt = 6, 8, 12, 22u 1 au/tt - gn = 10u 10 au/gn - gn = 1(2), 2(4), 3(2), 4u(2) 4 au/gn = 4, 6, 7, 12u

M = Massive Ore
D = Disseminated Ore

SAMATOSUM

	MINERAL PERCENTAGES							MIDDLING RATINGS							
RG-97	py	sp	ga	cp	tt	ge as	qz cb ms	sp/py gn	ga/py gn	cp/py gn	tt/py gn	ga/sp	cp/sp	tt/sp	Gold : Probe : Misc.
17·0 M	·4	50	·7	8	30	0 ·5	0 10 0	1	—	1	1	1·5	6	2·5	74 au/tt = 1(2), 2(15), 3(7), 4(4), 5, 6(16), 7(3), 8(11), 10(5), 12(3), 14(2), 16, 18 (2), 20u(2) 1 au/tt - sp - ga - gn = 12 u 3 au/sp - gn = 1, 3, 14 (mp) <u>tt</u> (3·7% Ag, n.d.-779 ppm Hg)
17·4 M	35	·5	6	45	10	0 0	3 0 0	—	3·5	2·5	2·5	—	—	2	(mp) <u>tt</u> (3·5% Ag, n.d.-1240 ppm Hg; <u>sp</u> (0·4% Fe, n.d.-tr Ag, Hg n.d.)
18·0 M	·3	88	tr	7	0	0 0	tr 5 0	1	—	1	—	0	6	0	
19·0 M	35	1	10	53	1	0 0	tr 0 0	—	3	1·5	—	—	—	—	
19·7 M	8	3	6	70	8	0 0	4 1 0	2	4·5	1·5	1	6	4·5	3	13 au/ga = 2, 3(3), 4(2), 6(2), 7, 8, 10, 12u(2) 1 au/py - py = 3 u

M = Massive Ore
D = Disseminated Ore

SAMATOSUM

	MINERAL PERCENTAGES							MIDDLING RATINGS							
RG-98	py	sp	ga	cp	tt	ge as	qz cb ms	sp/py/gn	ga/py/gn	cp/py/gn	tt/py/gn	ga/sp	cp/sp	tt/sp	Gold : Probe : Misc.
47·0 D	7	12	4	7	3	0 0	20 42 5	3	3	3	3	2	3·5	1	graphite = ·2

M = Massive Ore
D = Disseminated Ore

SAMATOSUM

	MINERAL PERCENTAGES							MIDDLING RATINGS							
RG-99	py	sp	ga	cp	tt	ge as	qz cb ms	sp/py/gn	ga/py/gn	cp/py/gn	tt/py/gn	ga/sp	cp/sp	tt/sp	Gold : Probe : Misc.
71·1 D	10	4	·7	3	·3	0 0	62 8 12	2·5	–	3·5	–	1	3	0	
72·0 D	4	tr	tr	·1	16	·2 0	35 25 20	–	–	–	2	–	–	0	11 au/tt = 1(2), 6, 8(2), 10, 12(2), 14, 18, 24u minor spheroidal py
74·0 M	15	27	7	·8	30	·1 ·2	18 2 0	3	4·5	–	3	4·5	4	4	8 au/tt = 2,3,4(3),5(2),3x 44u 1 au/tt - ga = 6u 1 au/tt - py = 6u
75·5 D	20	4	·2	tr	·5	0 0	58 2 15	3·5	–	–	–	0	0	0	
77·6 D	15	7	·7	tr	2	0 0	65 0 10	3	–	–	2	1	0	1	

M = Massive Ore
D = Disseminated Ore

SAMATOSUM

	MINERAL PERCENTAGES							MIDDLING RATINGS							
RG-100	py	sp	ga	cp	tt	ge as	qz cb ms	sp/py gn	ga/py gn	cp/py gn	tt/py gn	ga/sp	cp/sp	tt/sp	Gold : Probe : Misc.
47·3 D	1	tr	tr	·1	15	·2 0	58 18 8	—	—	—	3	—	—	0	21 au/tt = 1(2), 2(5), 3(5), 4(2), 5, 6, 12(2), 14(2) 22u 1 au/tt−ge = 6u
48·0 D	tr	1	·3	·1	18	·2 0	45 30 6	—	—	—	2	—	—	0	34 au/tt = 1(3), 2(8), 3(5), 4(4), 5(3), 6(3) 7, 8(3), 10(2), 22, 110u
49·0 D	10	18	6	·1	10	0 0	44 2 10	3	4·5	—	3	4	1	3·5	
50·0 D	10	20	3	·1	7	0 0	45 7 8	3	4	—	2·5	3	1	2	

M = Massive Ore
D = Disseminated Ore

SAMATOSUM

	MINERAL PERCENTAGES							MIDDLING RATINGS							
RG-102	py	sp	ga	cp	tt	ge as	qz cb ms	sp/py/gn	ga/py/gn	cp/py/gn	tt/py/gn	ga/sp	cp/sp	tt/sp	Gold : Probe : Misc.
75·0 D	4	4	3	8	·3	0 0	41 35 5	3	3	2	–	2	3	0	2 au/tt = 5, 10u 1 au/tt – py = 5u 1 au/sp = 1u; 1au/ga = 1u 2 au/py – py = 2, 4u albite common
76·0 D	18	2	2	1	10	0 ·1	20 40 7	2	4·5	3	2·5	4	2	1	5 au/tt = 2,3,5,10,12u albite common
77·0 D	3	4	4	·2	9	0 0	40 30 10	3	2·5	–	3	1	0	3·5	1 au/tt = 18u 1 au/tt – py = 12u
78·0 D	2	10	1	·3	11	·2 ·1	30 30 15	2	3·5	–	2·5	1	1·5	2·5	2 au/tt = 6, 12u (mp) tt (3·7% Ag, Hg n.d.); ge
79·0 D	1	7	2	·1	7	0 0	68 10 5	1·5	3	–	2·5	2	3·5	3	1 au/tt = 3u
79·8 D	·5	3	·5	·1	16	·4 0	20 55 5	2	–	–	1·5	2	1	2	6 au/tt = 2,3(2),4,8,22 2 au/tt – gn = 3, ·3 x 12u
80·0 D	·2	20	8	·2	30	0 0	5 16 20	2	3	–	1·5	2	2	2·5	13 au/tt = 3,4(4),5,6(2),7,8,10,12,24u 2 au/tt – ga = 8u(2) 2 au/tt – py = 4u (2)
81·0 D	1	·3	·1	·1	15	·1 0	35 40 8	–	–	–	1·5	–	–	1	2 au/tt = 24, 28u (mp) au = electrum (27·5% Ag)

M = Massive Ore
D = Disseminated Ore

SAMATOSUM

RG-104	MINERAL PERCENTAGES							MIDDLING RATINGS							
	py	sp	ga	cp	tt	ge as	qz cb ms	sp/py/gn	ga/py/gn	cp/py/gn	tt/py/gn	ga/sp	cp/sp	tt/sp	Gold : Probe : Misc.
77·0 D	1	3	2	4	10	·3 0	30 45 5	3·5	3	3	2	3	3·5	2	1 au/tt = 10u 1 au/tt - gn = 30u
78·5 D	10	25	5	·2	3	0 0	47 2 8	3·5	4	—	3	3	0	3	some fine py crystals in sp

M = Massive Ore
D = Disseminated Ore

SAMATOSUM

	MINERAL PERCENTAGES							MIDDLING RATINGS							
RG-105	py	sp	ga	cp	tt	ge as	qz cb ms	sp/py/gn	ga/py/gn	cp/py/gn	tt/py/gn	ga/sp	cp/sp	tt/sp	Gold : Probe : Misc.
63·5 D	5	12	3	·1	10	0 0	40 25 5	2·5	4	–	2·5	3·5	0	2	2 au/tt = 3, 7u 1 au/tt - ga-sp-gn = 18u 1 au/sp-gn = 4u fine py crystals in sp
68·5 D	9	·1	·4	·1	5	tr 0	30 50 5	–	–	–	2·5	–	–	0	8 au/tt = 1,3,5,6,7,16,12x66,12x100u
70·0 D	35	15	5	·2	2	0 0	10 0 33	3·5	4·5	–	3	4	1	2	
70·8 M	20	30	10	·2	10	0 0	15 0 15	3·5	4	–	3	4·5	1	2	19 au/tt = 1(3),2(3),3,4(2) 5,6(3),7,8(3), 10,12u
87·7 D	34	10	3	tr	4	0 ·3	30 10 5	3·5	4	–	3	4	0	3	bournonite = ·5 (mp) 3% Mg, Al, silic; sp (0·5% Fe, n.d.-tr Ag, tr-784 ppm Hg); as; bournonite

M = Massive Ore
D = Disseminated Ore

SAMATOSUM

	MINERAL PERCENTAGES							MIDDLING RATINGS							
RG-106	py	sp	ga	cp	tt	ge as	qz cb ms	sp/py gn	ga/py gn	cp/py gn	tt/py gn	ga/sp	cp/sp	tt/sp	Gold : Probe : Misc.
120·5 D	4	·1	tr	·1	8	·1 0	35 35 18	—	—	—	3·5	—	—	0	3 au/tt = 2,4,8u 1 au/gn (cb) = 2 x 28u
121·7 M	15	25	3	2	20	·3 0	7 3 25	2·5	3·5	3	2·5	4	3	3	13 au/tt = 1,2,4(2),5,10,12(2),16(2),18(2),26u 3 au/tt - ga = 6,7,54u 4 au/tt - py = 5,6,8,14u 11 au/ga = 2(2),4,10(2),14,16,18,30, 20x38, 24 x 32u 5 au/ga - py = 3,5,6,14,12 x 60u (mp) tt (3·9% Ag, Hg n.d.)
122·5 D	10	·1	·1	·1	10	tr 0	35 35 10	—	—	—	2·5	—	—	0	12 au/tt = 4,6(4),7,10,12,14,16,18,24u 1 au/tt - ga = 32u 5 au/tt - py = 1,4,6,8,10u 1 au/py-gn = 14u 2 au/py = 6,12u
132·9 M	4	30	6	·2	35	0 ·2	20 1 4	1·5	3	—	1	3	1	3	1 au/tt = 8u (mp) tt (0·6% Ag, n.d. - 511 ppm Hg); sp (0·9% Fe, n.d. - tr Ag, Hg n.d.)

M = Massive Ore
D = Disseminated Ore

SAMATOSUM

	MINERAL PERCENTAGES							MIDDLING RATINGS							
RG-107	py	sp	ga	cp	tt	ge as	qz cb ms	sp/py/gn	ga/py/gn	cp/py/gn	tt/py/gn	ga/sp	cp/sp	tt/sp	Gold : Probe : Misc.
23·2 M	5	30	2	30	·3	0 tr	20 13 0	1	3	1	–	2	6	1	2 au/cp = 3,6u

M = Massive Ore
D = Disseminated Ore

SAMATOSUM

	MINERAL PERCENTAGES							MIDDLING RATINGS							
RG-108	py	sp	ga	cp	tt	ge as	qz cb ms	sp/py gn	ga/py gn	cp/py gn	tt/py gn	ga/sp	cp/sp	tt/sp	Gold : Probe : Misc.
35·8 M	18	5	1	20	46	0 0	8 2 0	3	3·5	1	1	3·5	4·5	3	220 au/tt = 1(35), 2(52), 3(15), 4(20), 5(13), 6(15), 7(5), 8(17), 10(20), 12(13), 14(6), 16, 18(3), 20, 24, 30(2), 2 x 74 u 4 au/tt - ga = 12, 18(2), 14 x 40u 3 au/cp = 6, 12, 16u; 3 au/ga = 2, 3, 6u 2 au/sp = 6, 5 x 50u 3 au/py-py = 6, 12, 4x26 u; 4 au/py = 1, 3, 5, 10u 1 au/gn(qz) = 14u; some euhedral qz crystals (mp) <u>tt</u> (3·4 % Ag); <u>au</u> = electrum (23·0 % Ag); <u>sp</u>
36·9 M	5	30	25	3	7	0 0	19 10 1	3	3·5	3	3	5·5	6	3	1 au/tt = 3u; 6 au/sp = 1(3), 3, 4, 8u 2 au/ga - sp = 16, 7x 24u 3 au/sp - gn = 4(2), 10u

M = Massive Ore
D = Disseminated Ore

SAMATOSUM

	MINERAL PERCENTAGES							MIDDLING RATINGS							
RG-109	py	sp	ga	cp	tt	ge as	qz cb ms	sp/py/gn	ga/py/gn	cp/py/gn	tt/py/gn	ga/sp	cp/sp	tt/sp	Gold : Probe : Misc.
123·5 D	8	tr	·1	·2	15	·1 0	30 45 2	—	—	—	2·5	—	—	0	13 au/tt = 6(2), 7(2), 8, 10(2), 12, 14(2), 18(2), 22u 1 au/tt - ga = 30u 4 au/tt - py = 3, 4, 6, 8u 1 au/py - gn = 14u 3 au/py = 2, 6, 10u
															(mp) tt (Ag = 3·5 %; Hg n.d.); sp (0·5 % Fe, n.d. - 242 ppm Ag, n.d. - tr Hg)
125·5 D	1	·3	·1	·2	3	0 0	40 45 10	—	—	—	3	—	—	0	
141·0 D	20	10	5	·5	·8	0 0	59 0 5	3·5	4	—	—	2	1	0	
142·0 D	15	15	7	·2	1	0 0	52 0 10	3	4·5	—	—	2	2	0	

M = Massive Ore
D = Disseminated Ore

SAMATOSUM

	MINERAL PERCENTAGES							MIDDLING RATINGS							
RG-111	py	sp	ga	cp	tt	ge as	qz cb ms	sp/py gn	ga/py gn	cp/py gn	tt/py gn	ga/sp	cp/sp	tt/sp	Gold · Probe · Misc.
64·0 D	3	·1	tr	4	3	·2 0	44 44 2	–	–	2	2	–	–	0	
66·0 D	3	8	2	2	3	·3 0	40 40 2	2	3	3	3	2	4	3	
69·0 D	·2	20	3	2	8	2 0	10 52 5	3·5	6	3	3·5	1	4	3	31 au/tt = 1(4), 2(5), 3(3), 4(2), 5(3), 6, 8(2), 10(2), 12, 14(2), 16, 18(3), 22, 30u 3 au/tt - ga = 14, 7x24, 26 x 130u 1 au/tt - gn = 3u 6 au/cp = 1, 2(2), 3, 4u(2) 1 au/ga - sp = 12u graphite = ·1 (mp) au = electrum (33·2% Ag)

M = Massive Ore
D = Disseminated Ore

SAMATOSUM

RG-112	MINERAL PERCENTAGES							MIDDLING RATINGS							Gold : Probe : Misc.
	py	sp	ga	cp	tt	ge as	qz cb ms	sp/py/gn	ga/py/gn	cp/py/gn	tt/py/gn	ga/sp	cp/sp	tt/sp	
145·2 D	2	·4	tr	tr	8	·1 0	50 30 10	–	–	–	3	–	–	0	1 au/tt - py = 18u
148·0 D	6	·2	·1	tr	9	·3 0	65 10 10	–	–	–	3	–	–	0	
149·0 D	10	20	tr	tr	15	·1 0	20 25 10	2·5	–	–	2·5	0	0	2·5	1 au/tt = 7u 1 au/tt - py = 3u 1 au/sp - py = 7 u (mp) tt (3·3% Ag, n.d.-884 ppm Hg); sp (0·7% Fe, Ag n.d., n.d.-712 ppm Hg)
150·0 D	5	10	·2	tr	0	0 0	83 0 2	2	–	–	–	0	0	0	
151·0 D	5	·3	3	tr	0	0 0	62 0 30	–	4·5	–	–	–	–	–	

M = Massive Ore
D = Disseminated Ore

SAMATOSUM

RG-122	MINERAL PERCENTAGES							MIDDLING RATINGS							
	py	sp	ga	cp	tt	ge as	qz cb ms	sp/py gn	ga/py gn	cp/py gn	tt/py gn	ga/sp	cp/sp	tt/sp	Gold · Probe · Misc.
237·0 M	50	16	6	3	15	0 0	0 5 5	3	4	3·5	3·5	2·5	3	2·5	1 au/tt = 16 u 1 au/cp = 36 x 14u (mp) tt (3·5% Ag); cb = dolomite; ms
238·0 M	50	3	8	2	12	0 0	0 10 15	3·5	4·5	3	3	2	3	2	5 au/tt = 2,4,5,6,10u 2 au/ga = 6,24 u
239·0 D	8	·1	2	tr	2	0 0	0 80 8	–	5·5	–	4·5	–	–	0	
242·0 D	4	·2	·2	·2	15	0 0	0 80 0	–	–	–	1·5	–	–	0	14 au/tt = 3(2),5,6,8,10(2),12,14,18,24, 36, 6x24, 20x80u (mp) tt (3·8% Ag); au = electrum (32·8% Ag)
246·0 D	15	15	5	1	2	0 0	35 7 20	4	4·5	3	4	4	3	3	

M = Massive Ore
D = Disseminated Ore

SAMATOSUM

	MINERAL PERCENTAGES							MIDDLING RATINGS							
RG-123	py	sp	ga	cp	tt	ge as	qz cb ms	sp/py/gn	ga/py/gn	cp/py/gn	tt/py/gn	ga/sp	cp/sp	tt/sp	Gold : Probe : Misc.
111·5 D	6	7	5	2	7	0 0	34 34 5	3	2	3	1·5	2	3	2	

M = Massive Ore
D = Disseminated Ore

SAMATOSUM

RG-130	MINERAL PERCENTAGES							MIDDLING RATINGS							Gold : Probe : Misc.
	py	sp	ga	cp	tt	ge as	qz cb ms	sp/py/gn	ga/py/gn	cp/py/gn	tt/py/gn	ga/sp	cp/sp	tt/sp	
195·0 D	6	·2	·1	·3	3	·3 0	42 42 6	—	—	—	3·5	—	—	0	
198·5 D	7	12	5	·1	1	0 0	15 15 45	3	4	—	—	3·5	0	2	

M = Massive Ore
D = Disseminated Ore

SAMATOSUM

	MINERAL PERCENTAGES							MIDDLING RATINGS							
RG-132	py	sp	ga	cp	tt	ge as	qz cb ms	sp/py/gn	ga/py/gn	cp/py/gn	tt/py/gn	ga/sp	cp/sp	tt/sp	Gold · Probe · Misc.
192·0 D	9	30	5	·3	15	·1 0	0 20 20	3	3·5	—	3	4	4	3	1 au/tt - py = 14 u 2 au/ga- gn = 3u(2); 1 au/sp-gn = 4 u 3 au/cp- gn = 5,6u(2); 2 au/gn-gn = 4,5u graphite = ·5 (mp) <u>tt</u>(3·7% Ag); <u>sp</u>(0·9% Fe)
195·0 D	3	·1	·2	·4	10	·1 0	74 7 5	—	—	—	1	—	—	0	1 au/tt = 38u
201·5 M	2	6	1	50	3	·2 ·1	8 20 10	2	3	1	2	2	4·5	2	4 au/tt = 1(2), 2, 14u

M = Massive Ore
D = Disseminated Ore

SAMATOSUM

	MINERAL PERCENTAGES							MIDDLING RATINGS							
RG-136	py	sp	ga	cp	tt	ge as	qz cb ms	sp/py gn	ga/py gn	cp/py gn	tt/py gn	ga/sp	cp/sp	tt/sp	Gold : Probe : Misc.
51·6 D	2	1	2	·1	7	0 0	55 30 3	–	3·5	–	3·5	–	–	1	2 au/tt = 3,7u 2 au/tt-gn = 4,7u 2 au/gn-gn = 3,5u; 1 au/sp-gn = 6u 1 au/gn = 2u
53·5 D	6	7	1	·3	·5	0 0	75 2 8	3	3	–	–	3	2	1	
55·5 D	5	6	4	·2	5	0 0	35 5 40	2	4·5	–	3	4·5	2	2	
56·5 D	20	18	8	4	tr	·1 0	10 0 40	3·5	5	5	–	4·5	3	0	py anom. anisotropic (mp) tt (5·2% Ag, Hg n.d.); sp (0·9% Fe); cp (Ag n.d.); ga (50·7% Ag)
58·0 D	1	15	4	3	15	·1 0	30 27 5	1	3	3	1·5	2	4·5	3·5	31 au/tt = 1(2),2(5),3(5),4(5),7(2),8(4),10(5),12(2),24u 3 au/tt-ga = 3,8,16u 1 au/tt-sp-py = 10u; 2 au/tt-gn = 5,10u

M = Massive Ore
D = Disseminated Ore

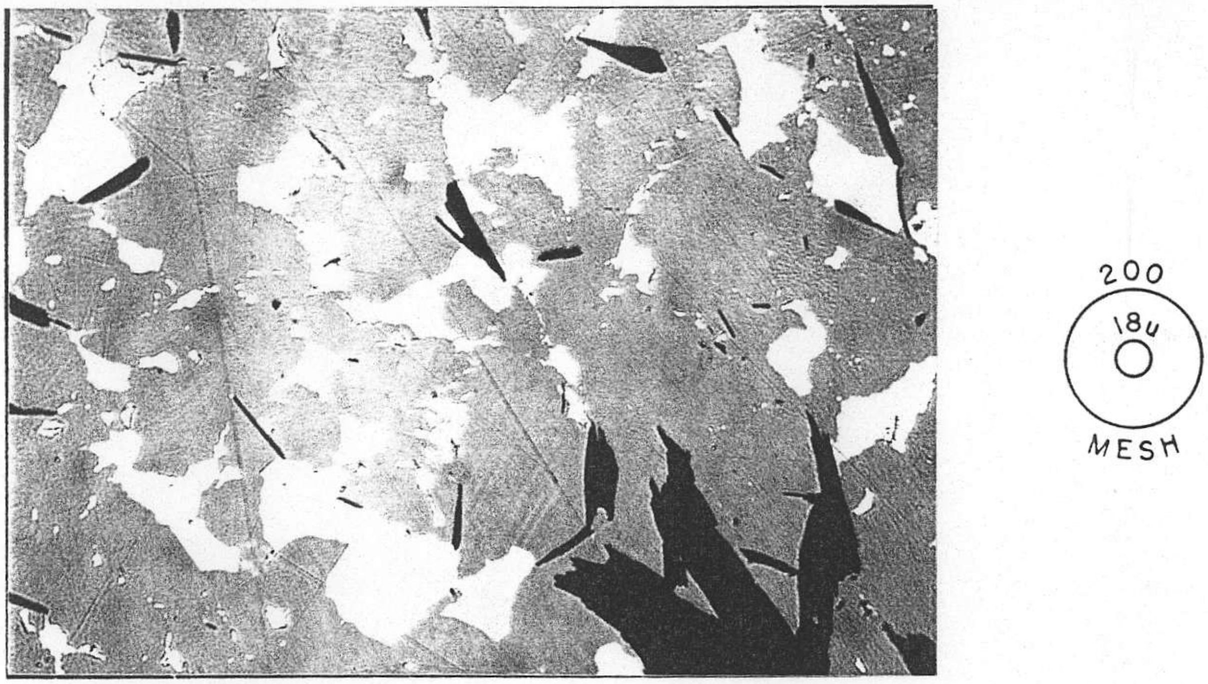
SAMATOSUM

RG-137	MINERAL PERCENTAGES							MIDDLING RATINGS							Gold : Probe : Misc.
	py	sp	ga	cp	tt	ge as	qz cb ms	sp/py gn	ga/py gn	cp/py gn	tt/py gn	ga/sp	cp/sp	tt/sp	
49·5 D	4	5	4	8	7	·2 0	5 62 5	3	2·5	1·5	2·5	1	4·5	2	2 au/tt = 4,6u 1 au/tt - sp = 8u
51·0 D	1	20	·5	4	7	tr 0	20 46 1	3	—	1	3	1	4·5	3	2 au/tt = 8,18u 2 au/tt - py = 5,7u; 1 au/ga - py = 36u 1 au/sp-py = 14u; 1 au/sp-gn = 12u 3 au/py = 7,28, 9 x 74u
52·5 M	1	20	7	7	45	0 0	17 3 0	2·5	3	3	2	4	4·5	3·5	31 au/tt = 3,5,6(3),7(3),8(4),10(4),12(3),14,16,18(2) 20,24(2),28,30,32,36u(2) 2 au/tt - ga = 10,30u; 1 au/tt - gn = 14u (mp) <u>au</u> = electrum (35·4% Ag)
53·8 D	·3	15	7	6	25	0 0	44 0 3	2·5	3·5	3	2	4	3·5	3	5 au/tt = 6,8,14(2),24u
54·0 M	52	3	2	·2	5	0 0	35 0 3	5	6	–	5·5	1	0	1	
54·5 D	7	18	7	·1	17	0 0	30 18 3	3·5	4·5	—	3	4·5	1	3·5	17 au/tt = 2,3,4(3),5,6(2),7,8(2),10(2),12(2), 20u(2) 2 au/tt - ga = 10u(2)
54·7 M	30	20	6	·3	10	0 0	25 0 9	3	5·5	—	4	4·5	4	4·5	2 au/tt = 5,8u graphite = ·2
55·0 M	70	1	2	·1	4	0 0	18 0 5	—	6	—	5	—	—	0	ga,tt/py = 5-6 qz highly strained

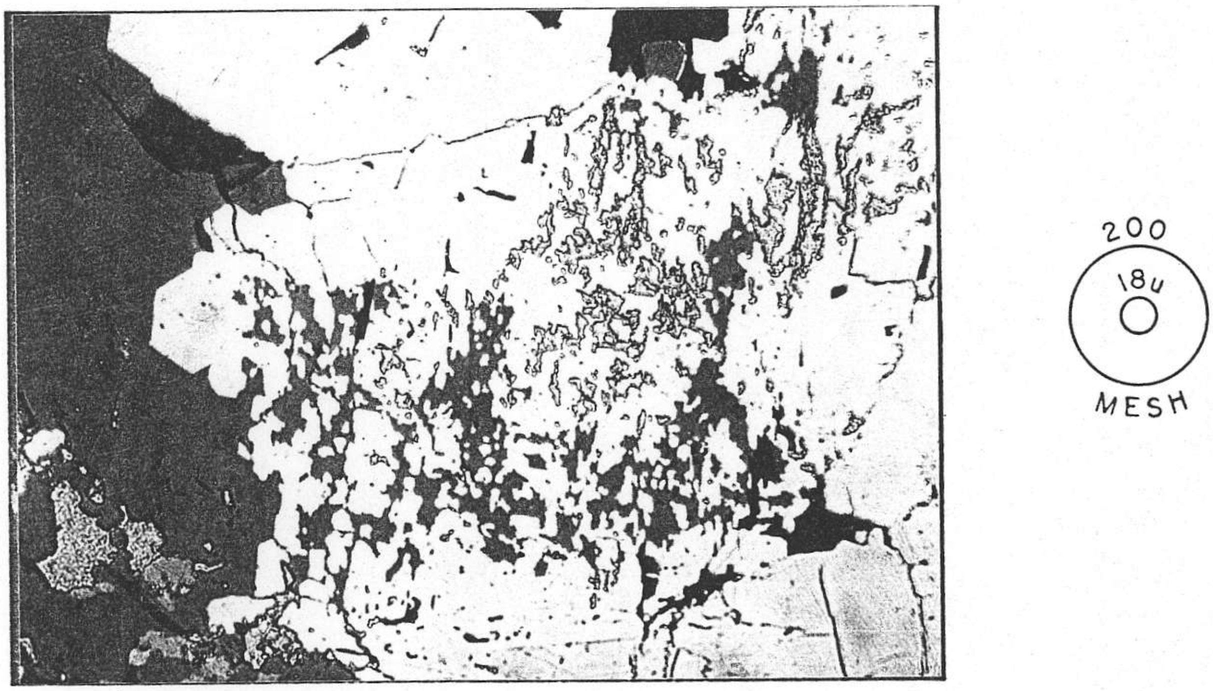
M = Massive Ore
D = Disseminated Ore

SAMATOSUM

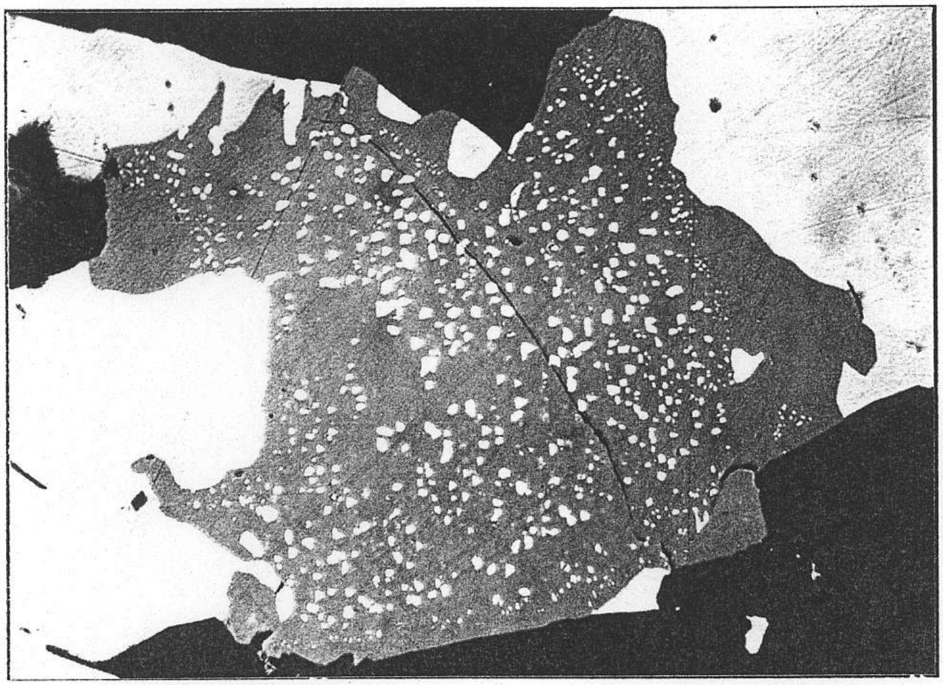
	MINERAL PERCENTAGES							MIDDLING RATINGS							
RG-137 cont'd	py	sp	ga	cp	tt	ge as	qz cb ms	sp/py gn	ga/py gn	cp/py gn	tt/py gn	ga/sp	cp/sp	tt/sp	Gold : Probe : Misc.
56·0 M	70	·2	·6	·4	8	·1 0	18 0 3	—	—	—	3·5	—	—	0	qz highly strained
57·0 D	7	22	7	3	4	0 0	25 32 0	3	4·5	3	2	4·5	3	2	
59·5 D	34	6	2	·3	3	0 0	52 2 1	2	4	—	4·5	2	2	2	

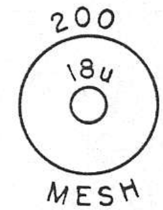


(33) RG-137-54.7 (Zone II): Sphalerite with tetrahedrite (tt/sp=4), galena (ga/sp=5), gangue, and chalcopyrite inclusions. Fortunately, most sphalerite in the Samatosum deposit is free of tetrahedrite inclusions.

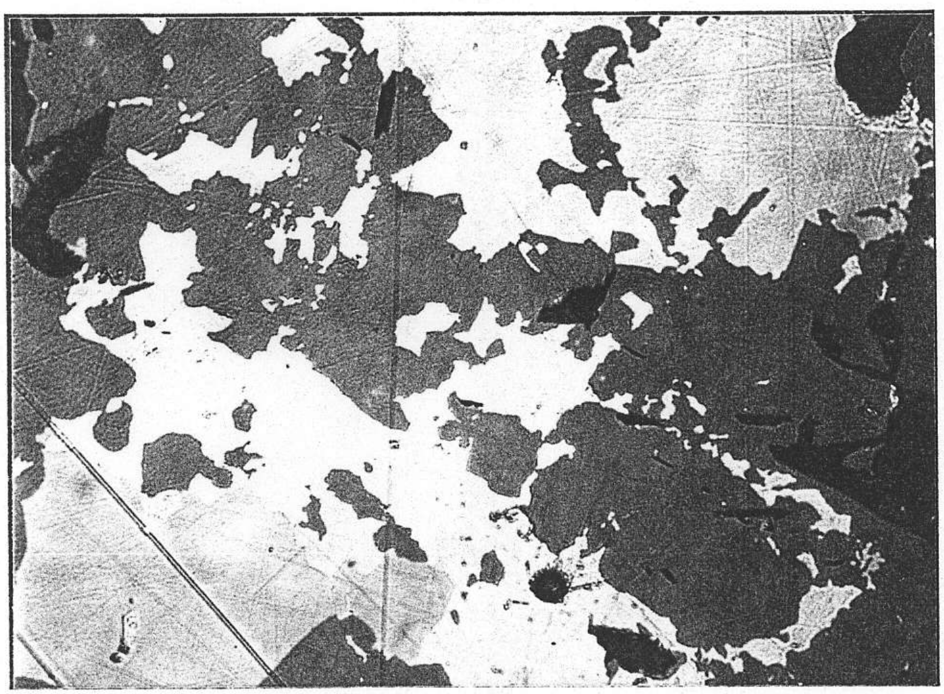


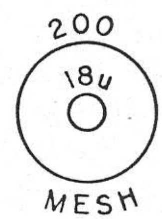
(34) RG-137-54.7 (Zone II): Fine-grained galena and sphalerite (very dark grey in this photomicrograph) in pyrite (for right 2/3 of photomicrograph ga,sp/py=5-6); some coarser sphalerite on left has galena and tetrahedrite inclusions (lower-left). Fine intergrowths of galena and sphalerite in pyrite are not common at Samatosum but this texture is typical of many pyritic massive sulphide deposits such as Brunswick.



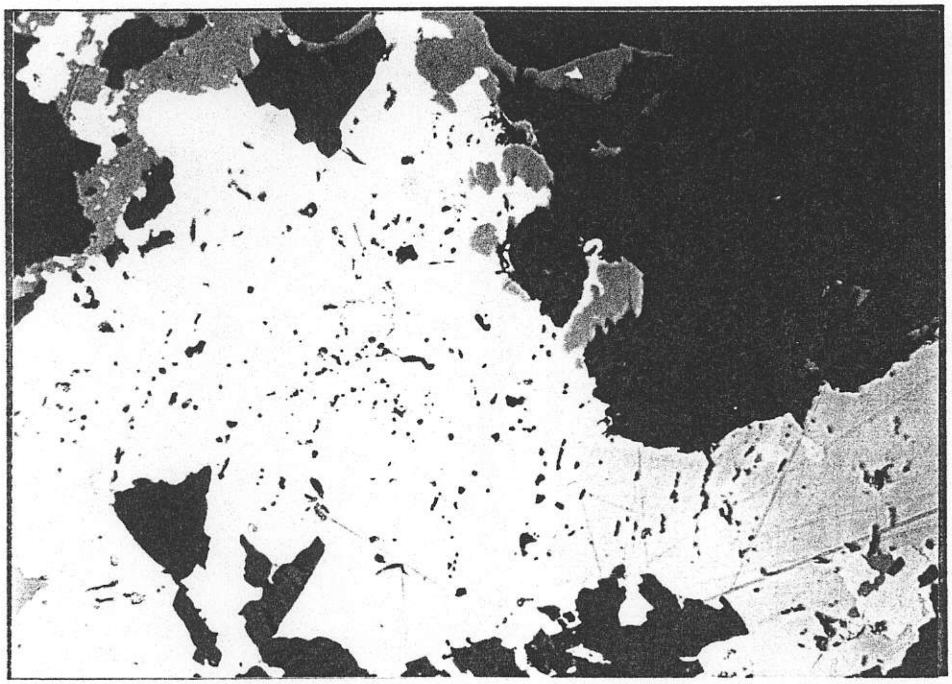


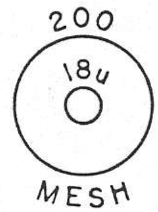
(31) RG-137-51 (Zone II): Sphalerite with "chalcopyrite disease" (cp/sp=5). Tetrahedrite, chalcopyrite, gangue.



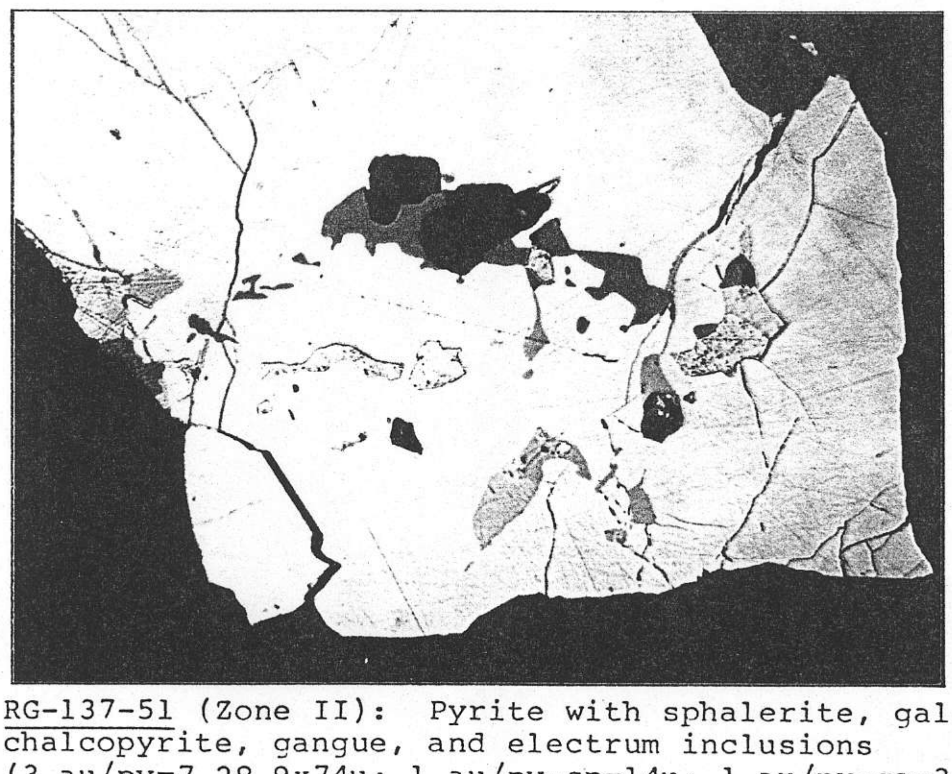


(32) RG-137-52.5 (Zone II): Sphalerite-chalcopyrite-galena intergrowths (cp,ga/sp=3.5-4). Tetrahedrite (lower-left), and minor gangue.

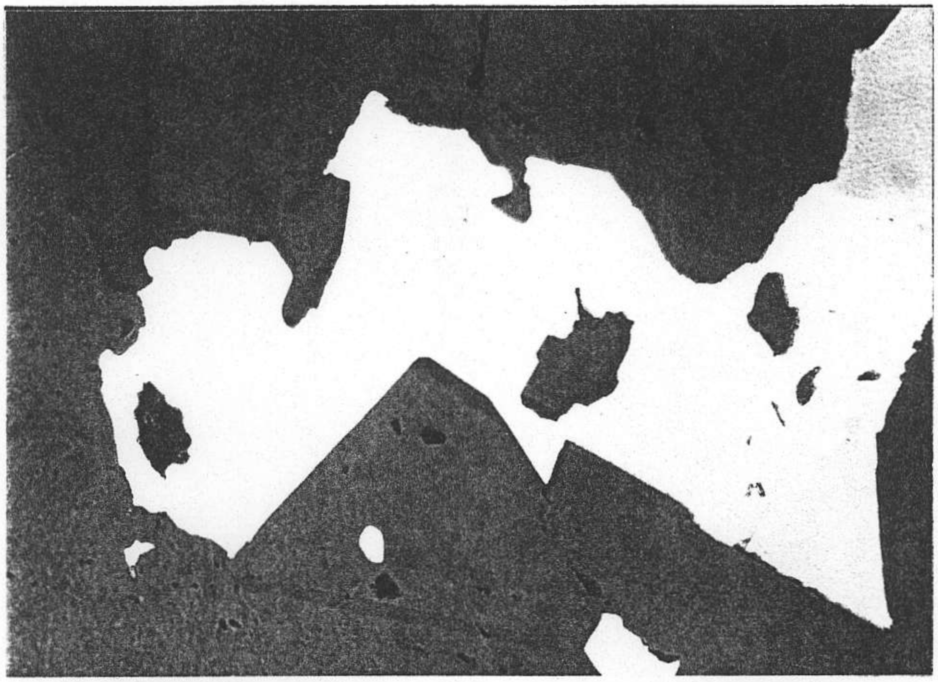


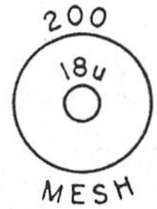


(29) RG-136-58 (Zone II): Coarse tetrahedrite with electrum inclusion (1 au/tt=24u). Grey-black gangue, and minor sphalerite, chalcopyrite, galena.

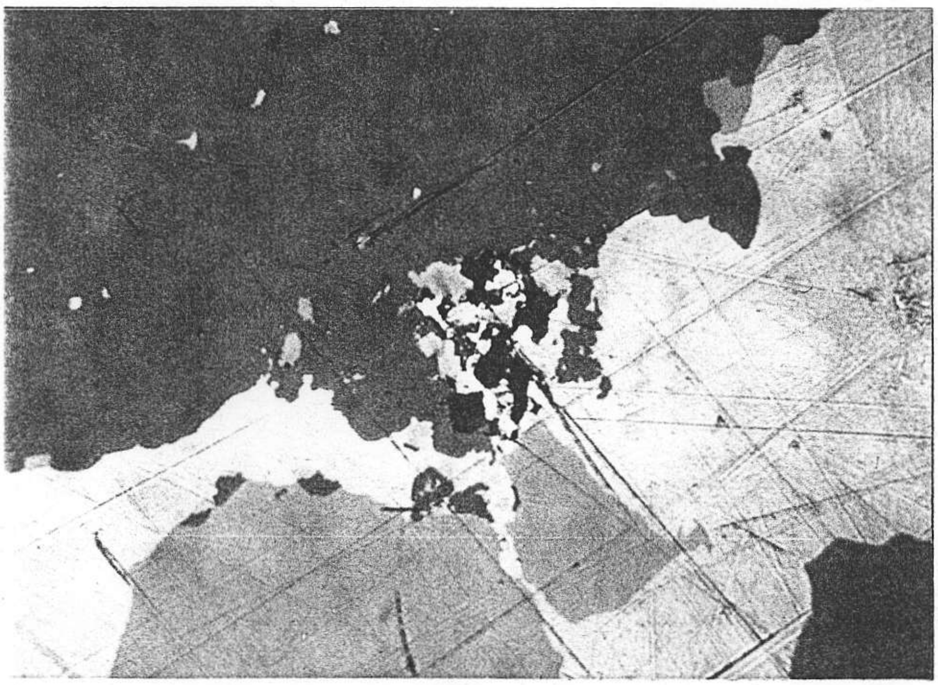


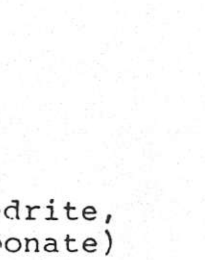
(30) RG-137-51 (Zone II): Pyrite with sphalerite, galena, chalcopyrite, gangue, and electrum inclusions (3 au/py=7,28,9x74u; 1 au/py-sp=14u; 1 au/py-ga=36u; 2 au/tt-py=5,7u).



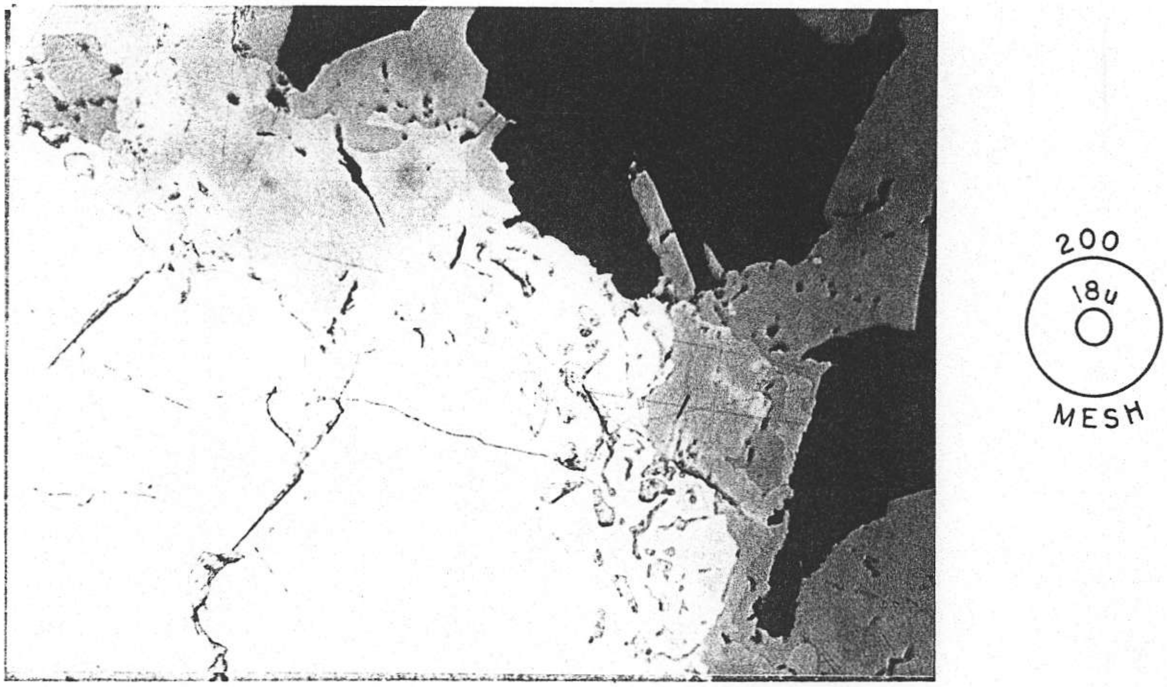


(27) RG-122-242 (Zone III): Gersdorffite rimming tetrahedrite, in gangue (carbonate). Minor galena and chalcopyrite.

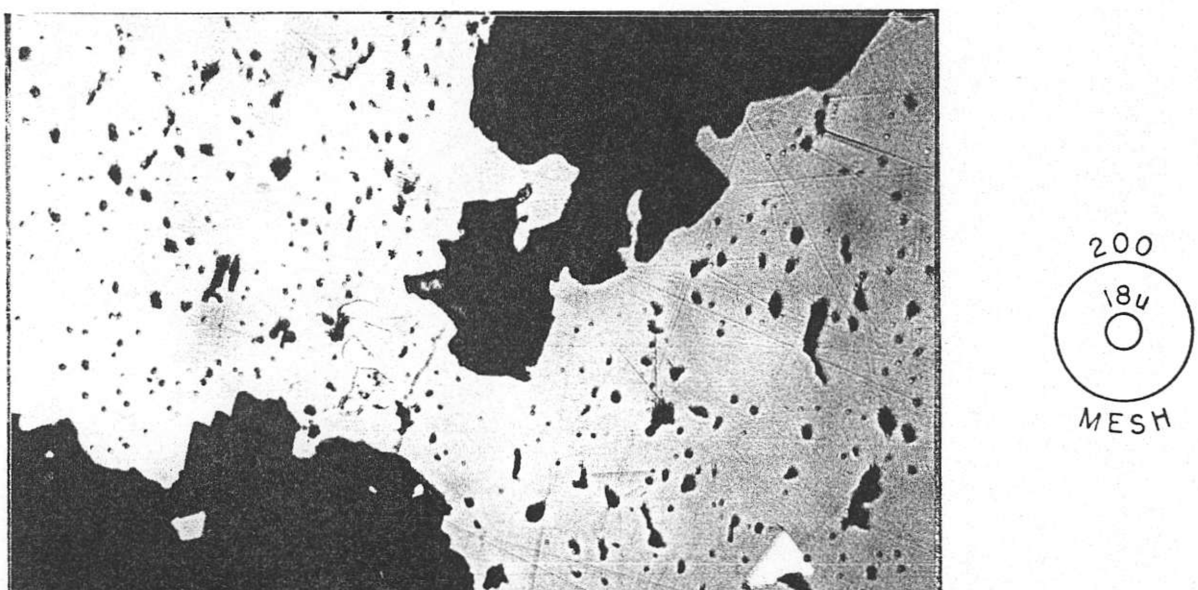




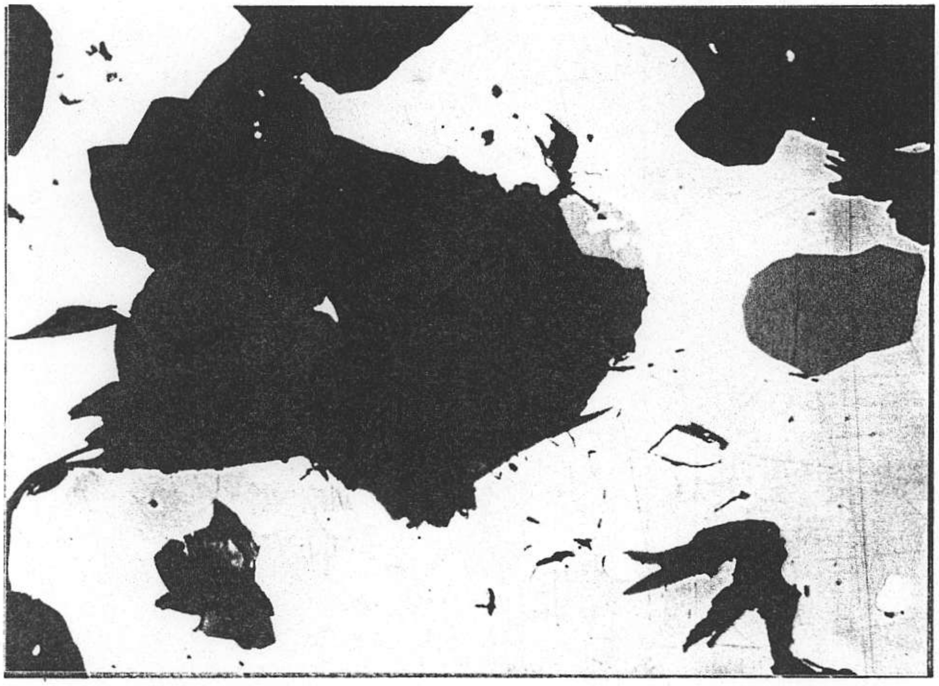
(28) RG-132-192 (Zone III): Sphalerite, galena, tetrahedrite, minor chalcopyrite, and clot of gangue grains (carbonate) with electrum on their boundaries (2 au/ga-gn=3,3u; 1 au/sp-gn=4u; 3 au/cp-gn=5,6,6u; 2 au/gn-gn=4,5u).

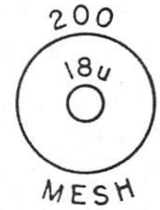


(25) RG-122-237 (Zone III): Pyrite with galena inclusions (ga/py=4.5). Chalcopyrite, tetrahedrite, gangue (cp,tt/py,gn=1-2).

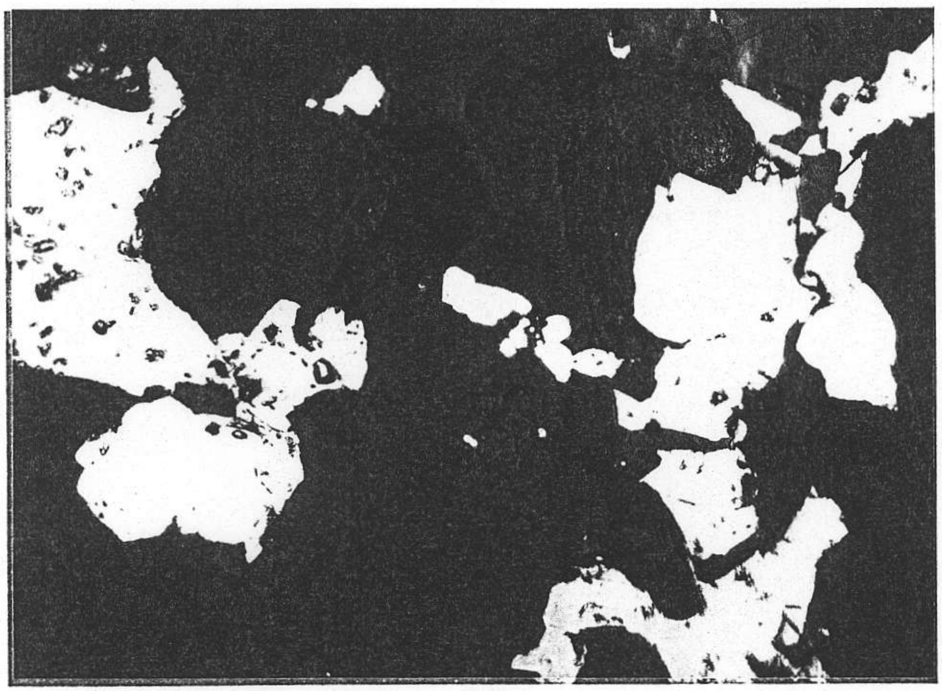


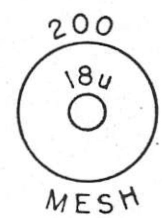
(26) RG-122-242 (Zone III): Coarse tetrahedrite with electrum inclusions (4 au/tt=3,14,18,24u). Gangue (carbonate), and minor galena and pyrite in tetrahedrite.



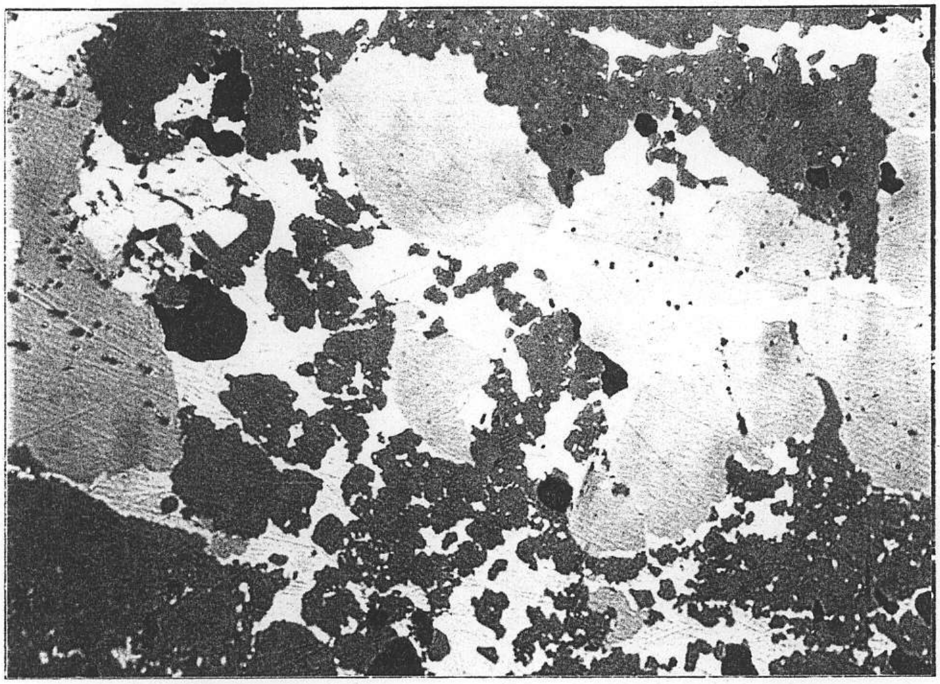


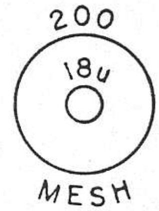
(23) RG-111-69 (Zone II): Gersdorffite crystals rimming chalcopyrite and tetrahedrite in dark grey quartz-carbonate gangue(cp,tt/gn=1-2). Minor sphalerite (right).



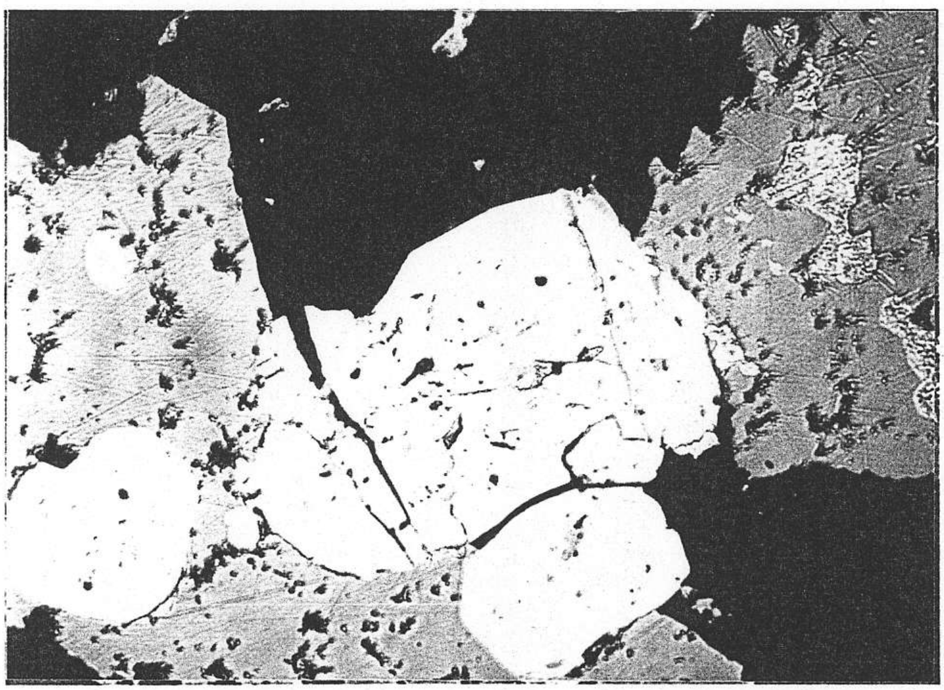


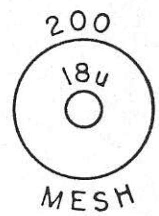
(24) RG-112-148 (Zone III): Tetrahedrite and pyrite disseminated in gangue (tt/py,gn=2-3).



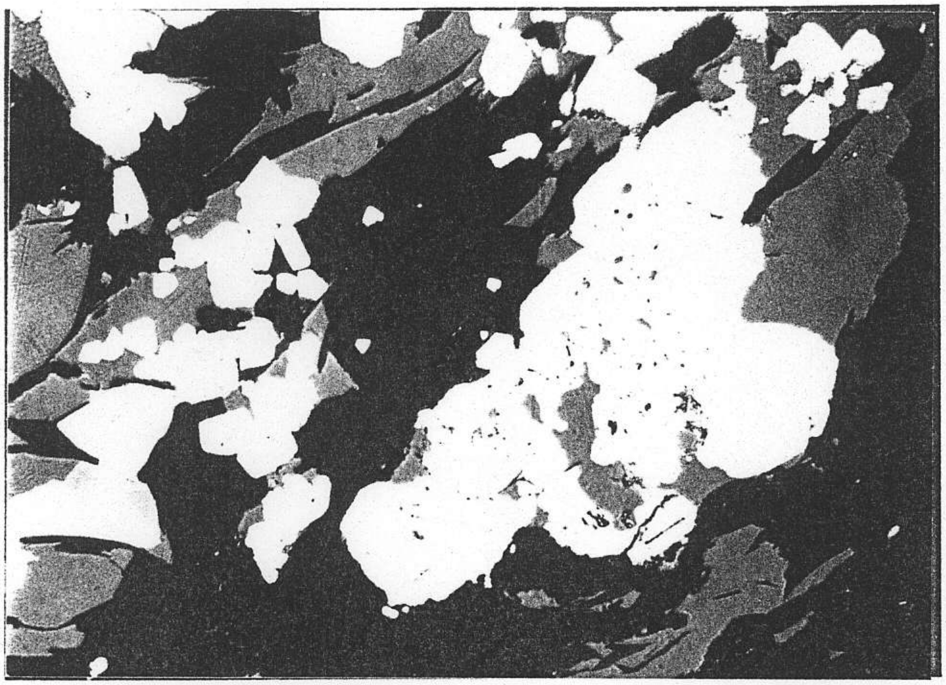


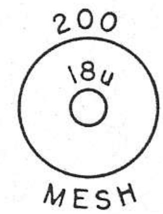
(21) RG-106-132.9 (Zone III): Tetrahedrite-sphalerite-galena intergrowths (ga/sp=4; tt/sp=2). Minor pyrite and gangue.



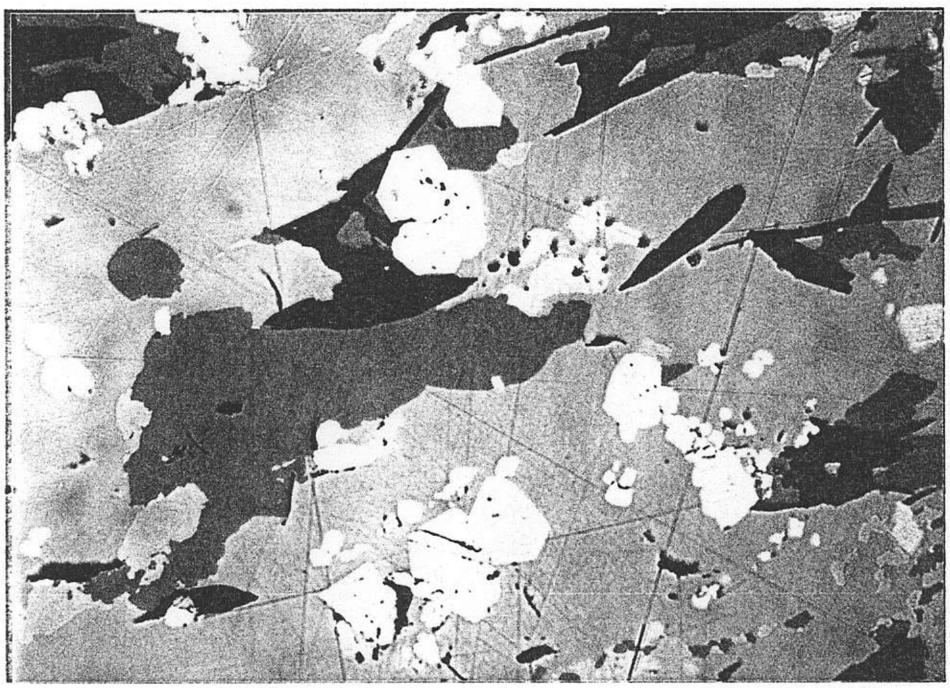


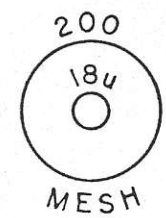
(22) RG-109-123.5 (Zone III): Pyrite-tetrahedrite-gangue, with numerous electrum grains (3 au/tt=6,6,22u; 1 au/tt-ga=30u; 4 au/py-tt=3,4,6,8u; 1 au/py-gn=14u; 3 au/py=2,6,9u). Some fine tetrahedrite inclusions in pyrite. Some galena and fine chalcopyrite inclusions in tetrahedrite (upper-right).



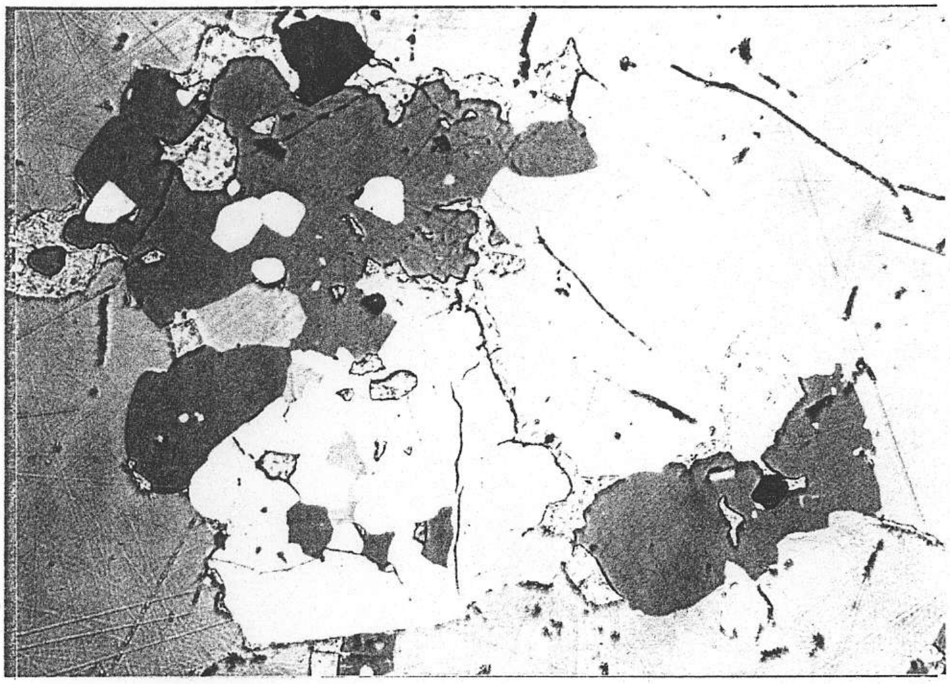


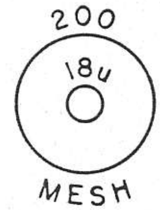
(19) RG-106-121.7 (Zone III): Gersdorffite crystal clot (white) with sphalerite ang galena inclusions, intergrown with gangue (black) and sphalerite. Disseminated pyrite crystals, and tetrahedrite (lower-left).



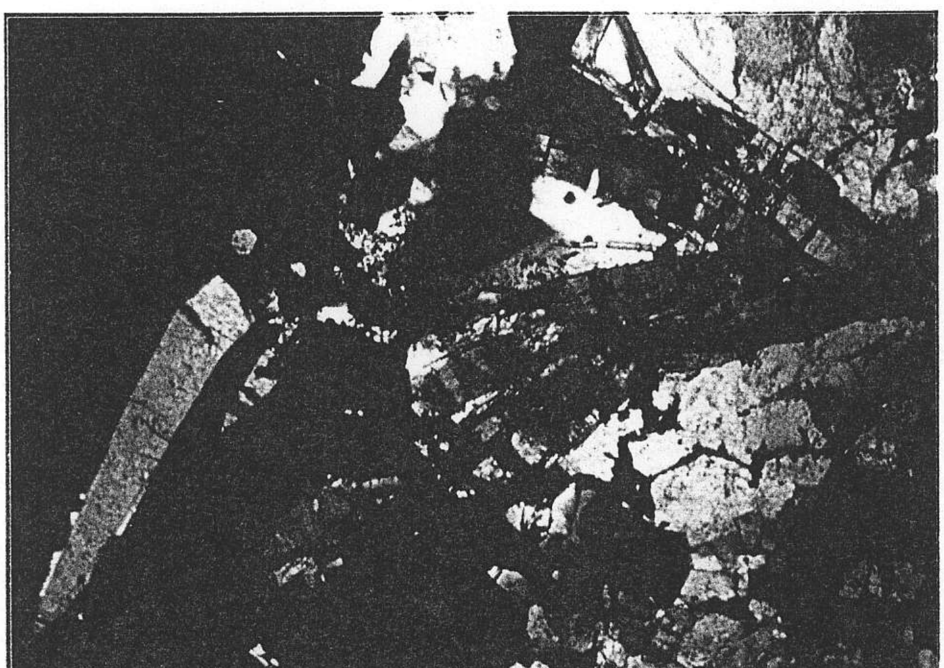


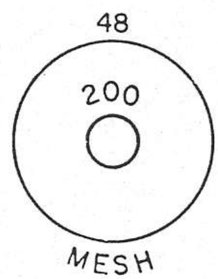
(20) RG-106-121.7 (Zone III): Coarse tetrahedrite with sphalerite, pyrite, galena, chalcopyrite, and gangue inclusions. One grain of electrum (1 au/tt=16u). Note the variation in the colour of pyrite grains (cream to whitish) which is thought to be due to minor nickel content.



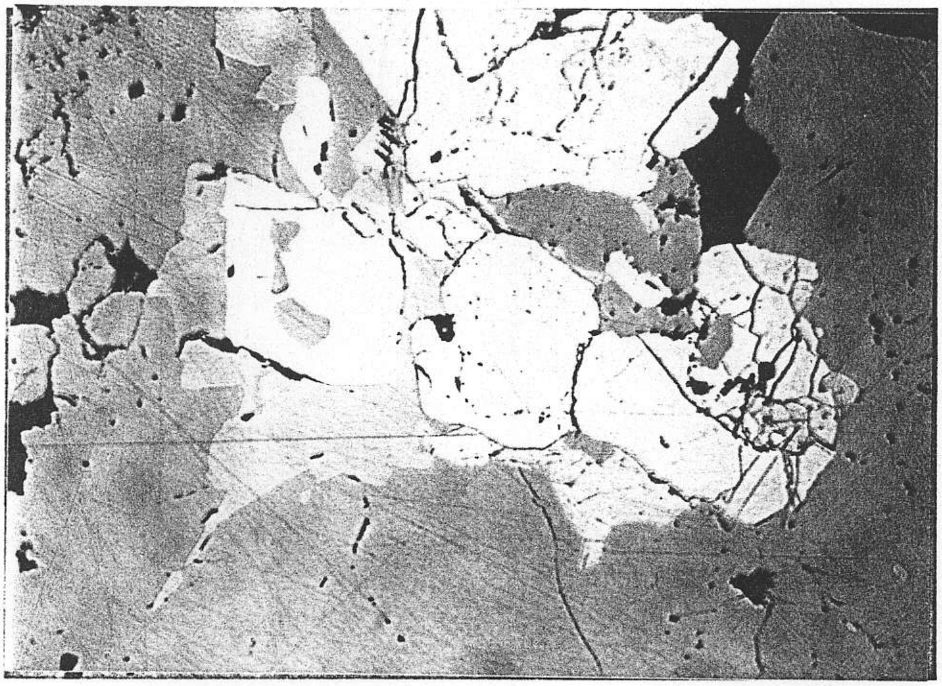


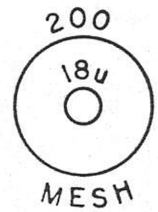
(17) RG-105-70.8 (Zone II): Typical tetrahedrite-sphalerite-pyrite-galena intergrowths.



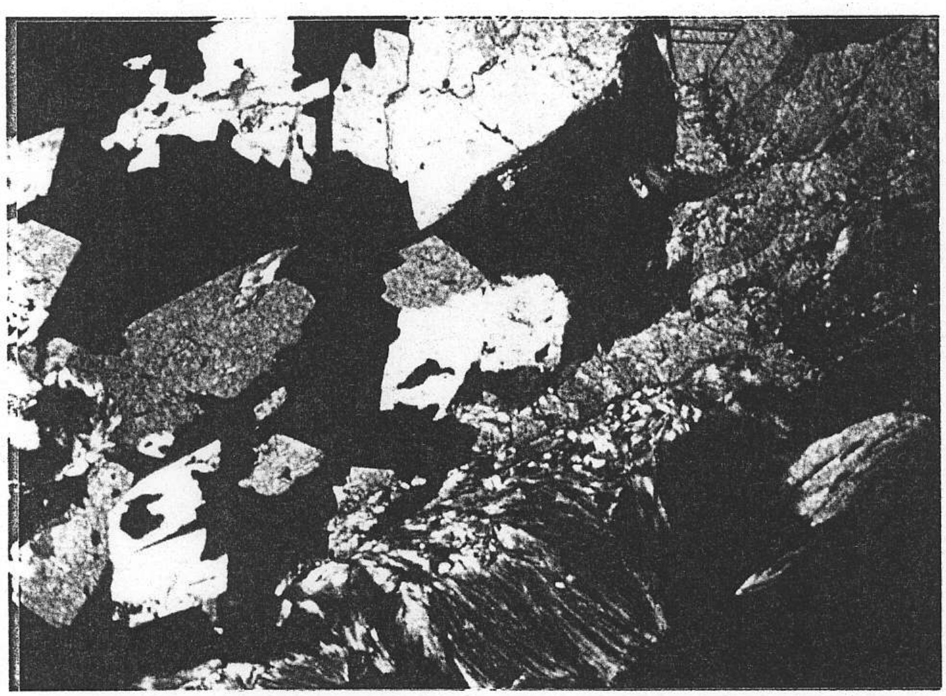


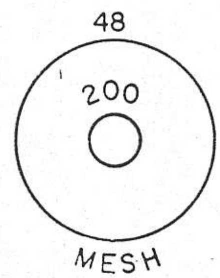
(18) RG-105-87.7 (Zone II): (transmitted light, crossed nicols) Curved Mg, Al silicate intergrown with tetrahedrite (black) and quartz grains.



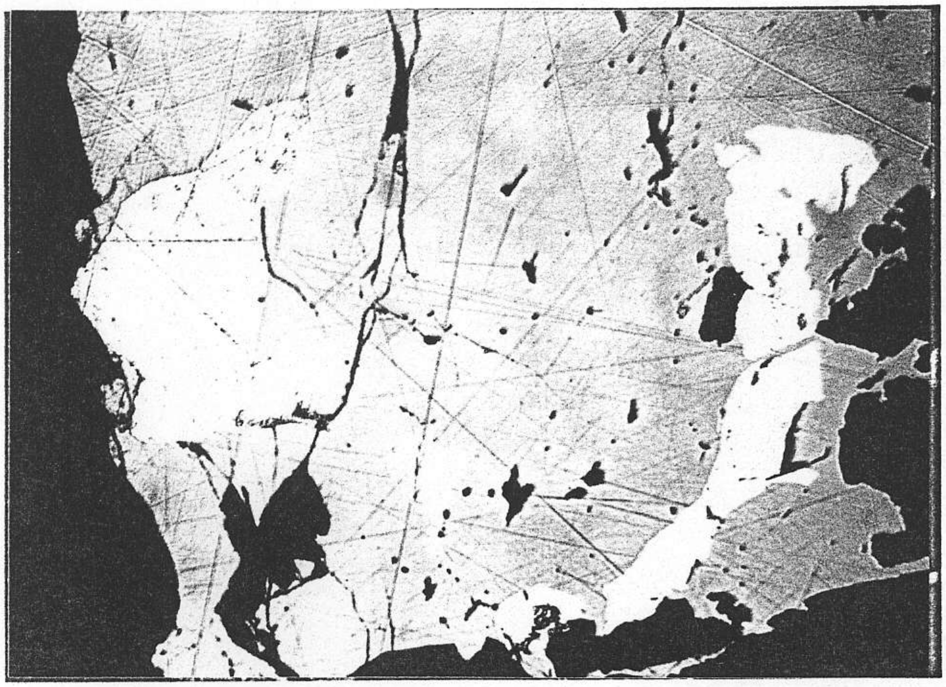


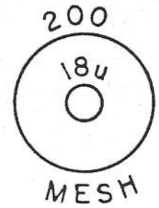
(15) RG-102-76 (Zone II): Coarse tetrahedrite, pyrite grains, chalcopyrite, galena, and diamond-shaped arsenopyrite crystal with tetrahedrite inclusions.



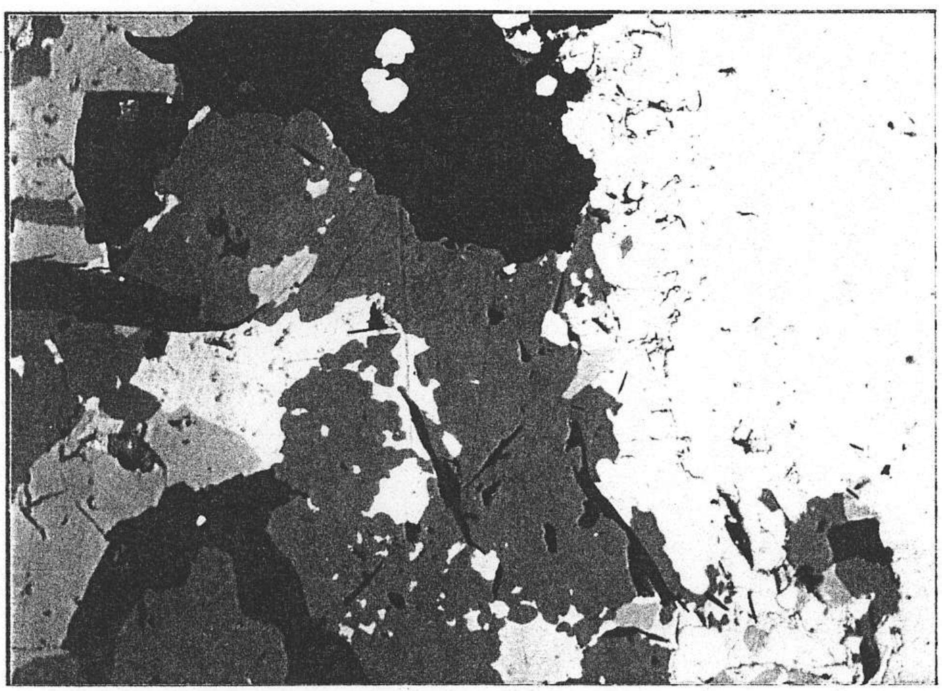


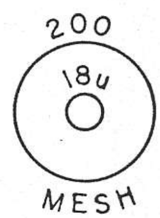
(16) RG-102-79.8 (Zone II): (transmitted light, crossed nicols) Opaque tetrahedrite (black, on left) intergrown with grey to white carbonate, and quartz (top). Coloured muscovite grains.



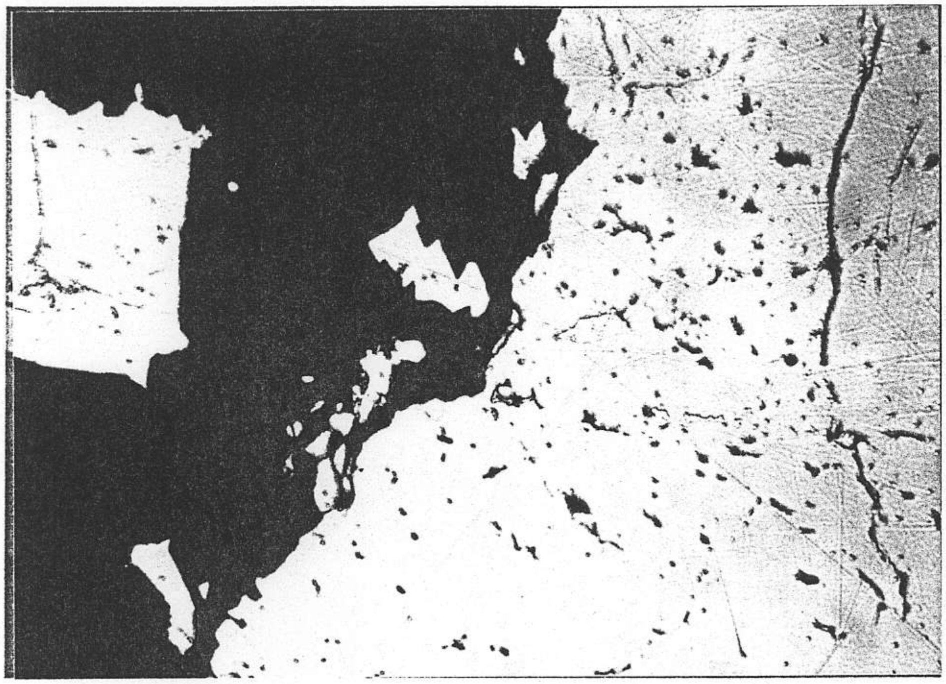


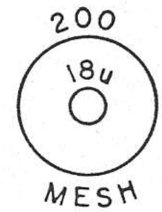
(13) RG-100-48 (Zone II): Coarse tetrahedrite with inclusions of electrum (1 au/tt=110u, largest gold grain observed), gersdorffite (elongate off-white grains on right), and galena. Gangue is black. Detached 10u electrum grain occurs in epoxy on left.



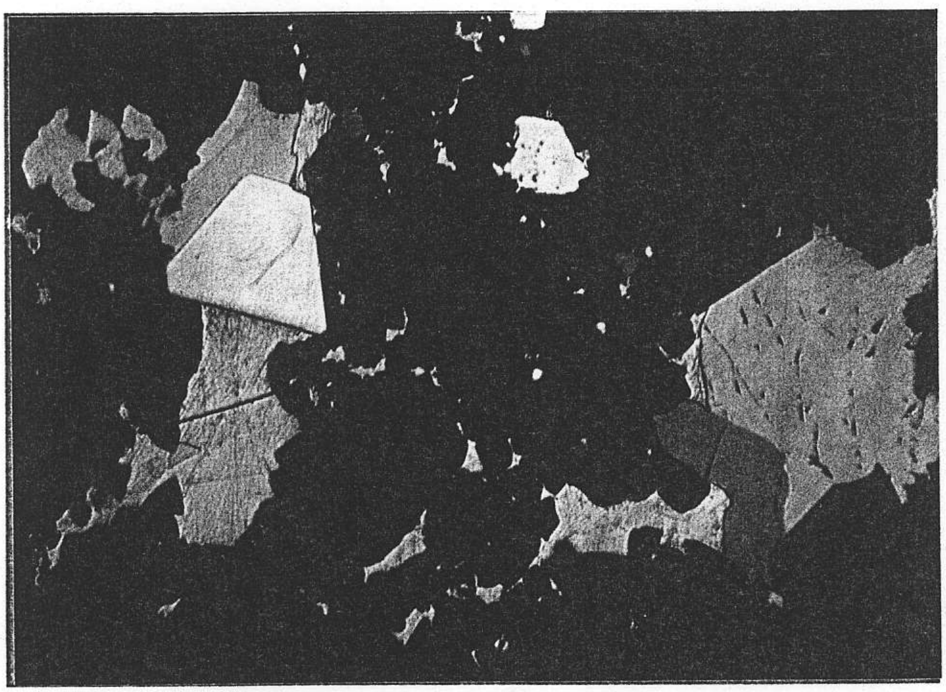


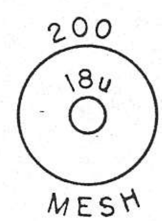
(14) RG-100-49 (Zone II): Pyrite with galena inclusions on right (ga/py=4.5). Sphalerite with galena, tetrahedrite, and gangue inclusions on left.



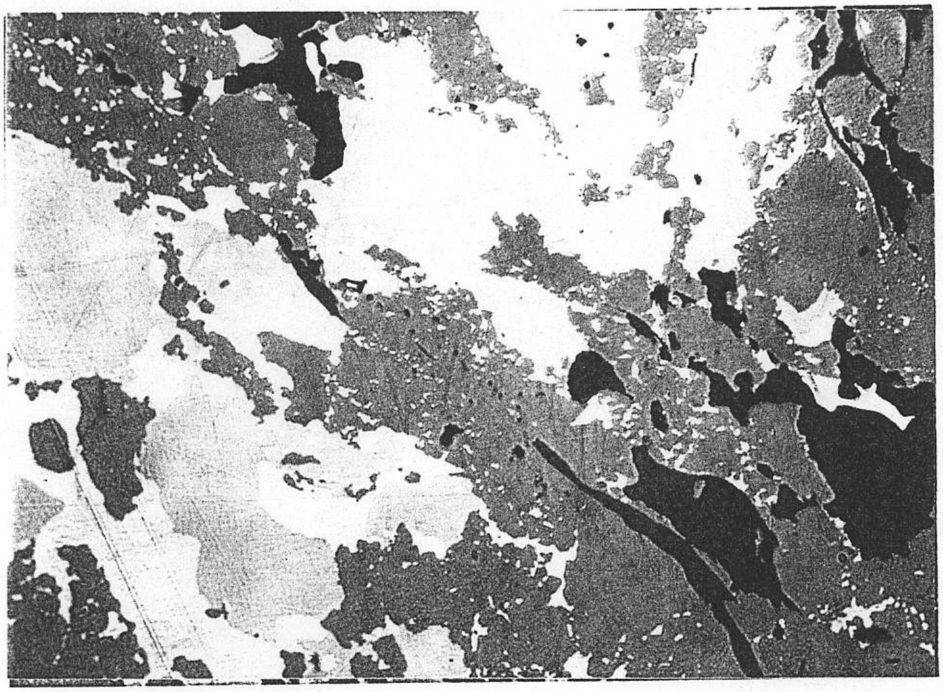


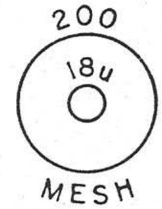
(11) RG-89-48.8 (Zone II): Coarse tetrahedrite with gold inclusions (4 au/tt=4,6,8,12x30u) and gangue.



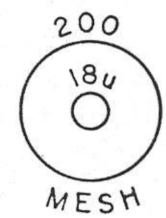


(12) RG-98-47 (Zone II): Tetrahedrite (light grey, right), galena, sphalerite (grey, with tetrahedrite on right), chalcopyrite and pyrite disseminated in (dark grey) carbonate-quartz gangue (tt/gn=1; ga/gn=4).

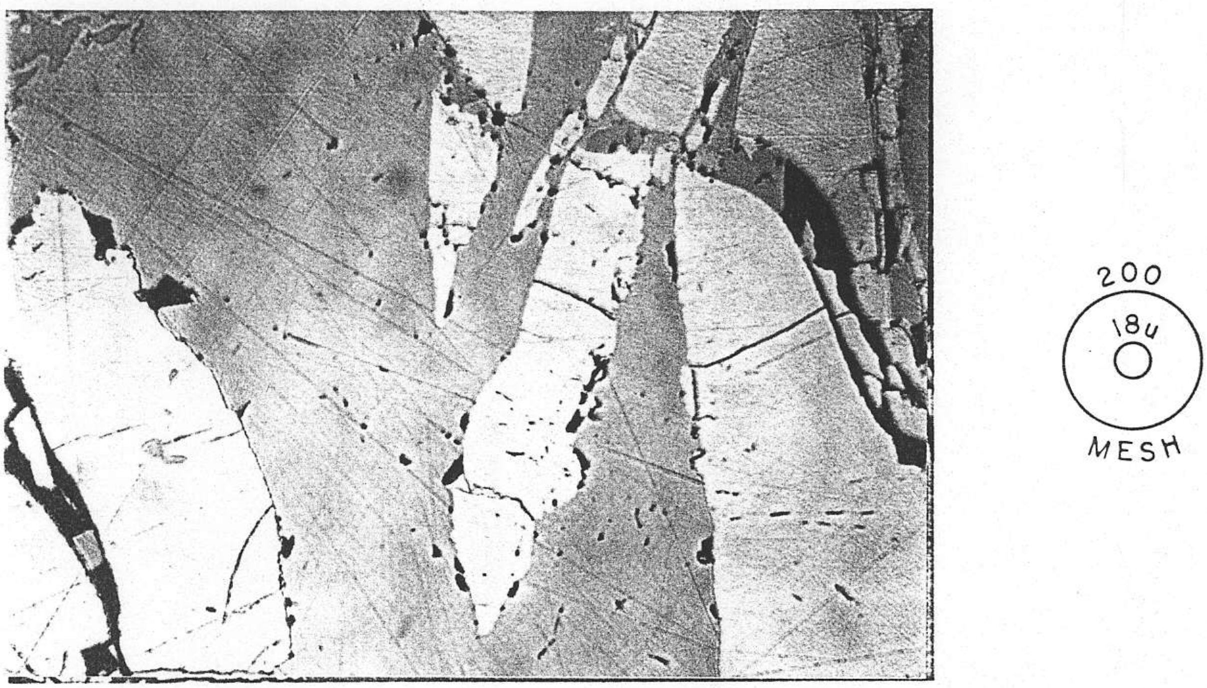




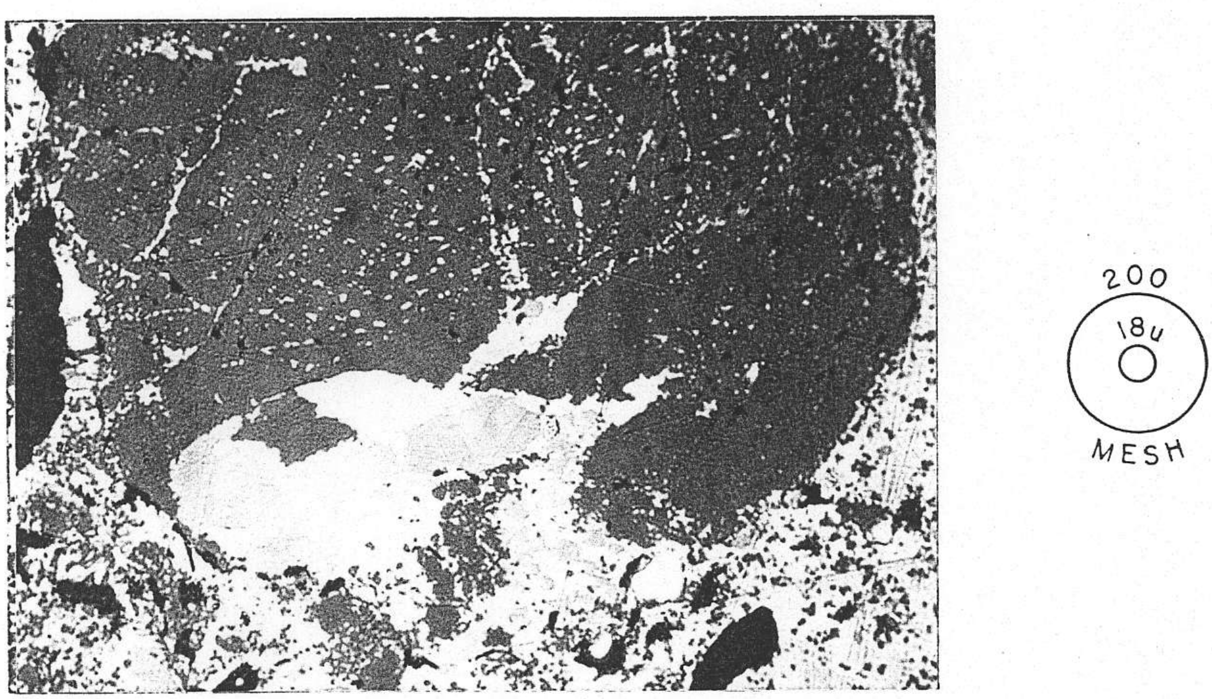
(9) RG-64-89.5 (Zone III): Sphalerite-tetrahedrite-galena-chalcopyrite-gangue intergrowths (tt/sp=2; ga/sp=3.5; cp/sp=4.5).



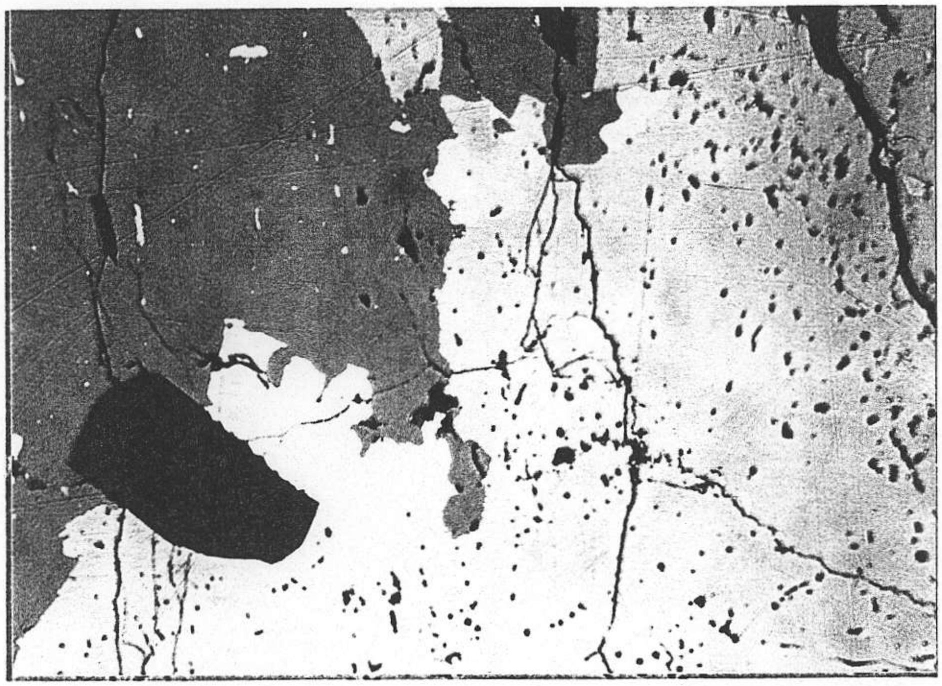
(10) RG-65-76.3 (Zone II): Tetrahedrite-sphalerite-galena-pyrite-gangue intergrowths (sp/py,gn=1; tt/py,gn=1; ga/sp=2).

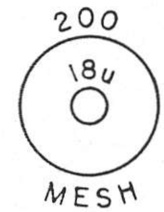


(7) RG-108-35.8 (Zone I): Chalcopyrite, pyrite, minor tetrahedrite, and one electrum grain (1 au/py-py=4x26u).

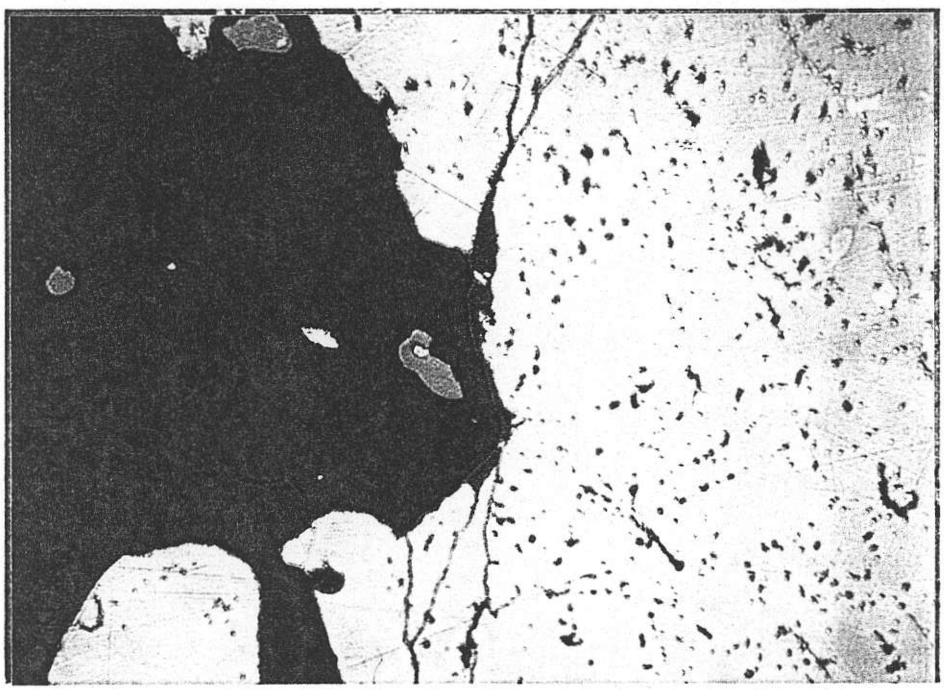


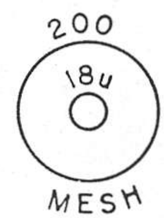
(8) RG-108-36.9 (Zone I): Sphalerite with chalcopyrite inclusions (cp/sp=6), and some galena inclusions. Galena-tetrahedrite intergrowths (common). Minor pyrite crystals (lower-right) and gangue (dark grey).



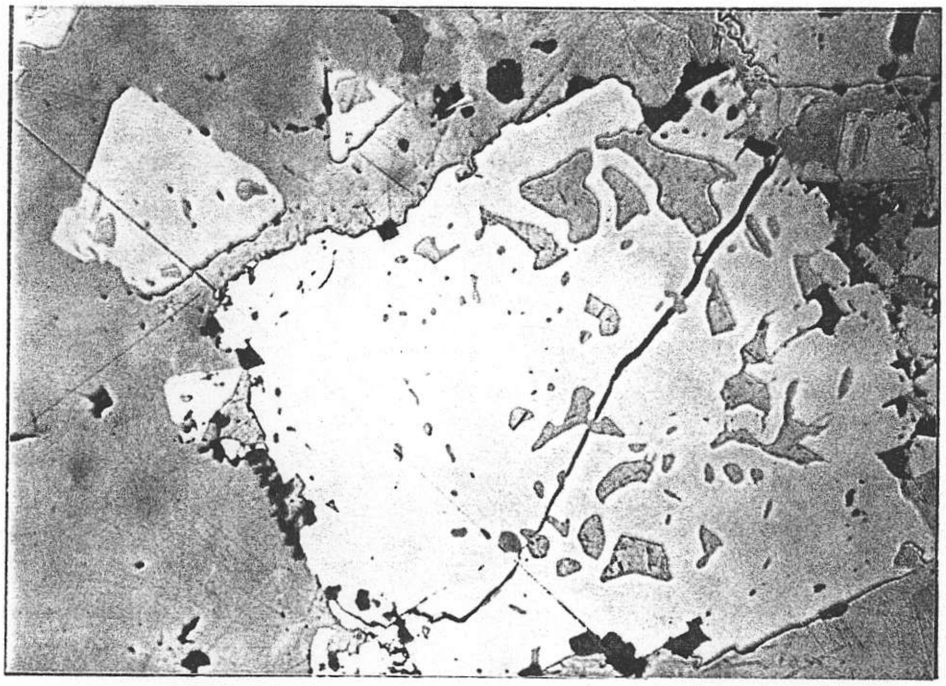


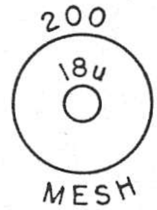
(5) RG-108-35.8 (Zone I): Coarse sphalerite (left) with some chalcopyrite inclusions. Coarse tetrahedrite (right) with chalcopyrite and electrum inclusions (2 au/tt=3,18u). Dark grey quartz crystal.



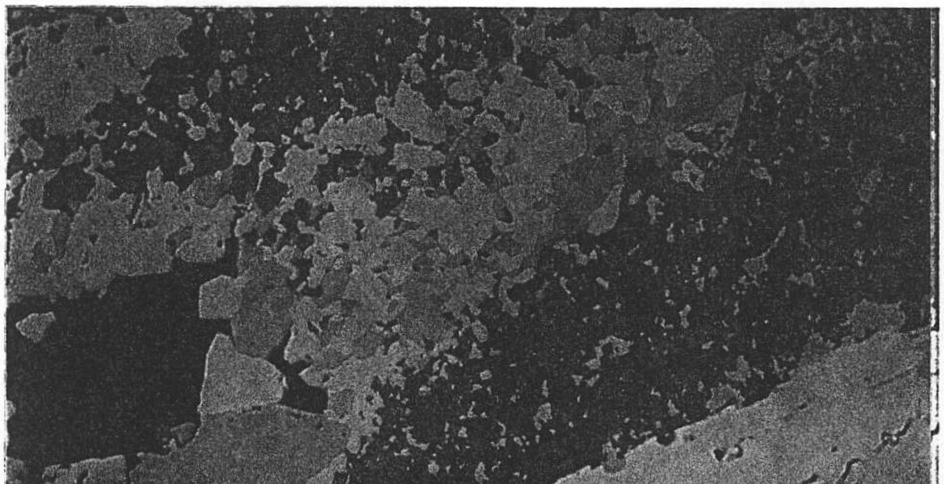


(6) RG-108-35.8 (Zone I): Coarse tetrahedrite and gangue (quartz+carbonate). Minor sphalerite in gangue. Three electrum grains (1 au/tt=12u; 1 au/sp=6u; 1 au/gn(qz)=14u).





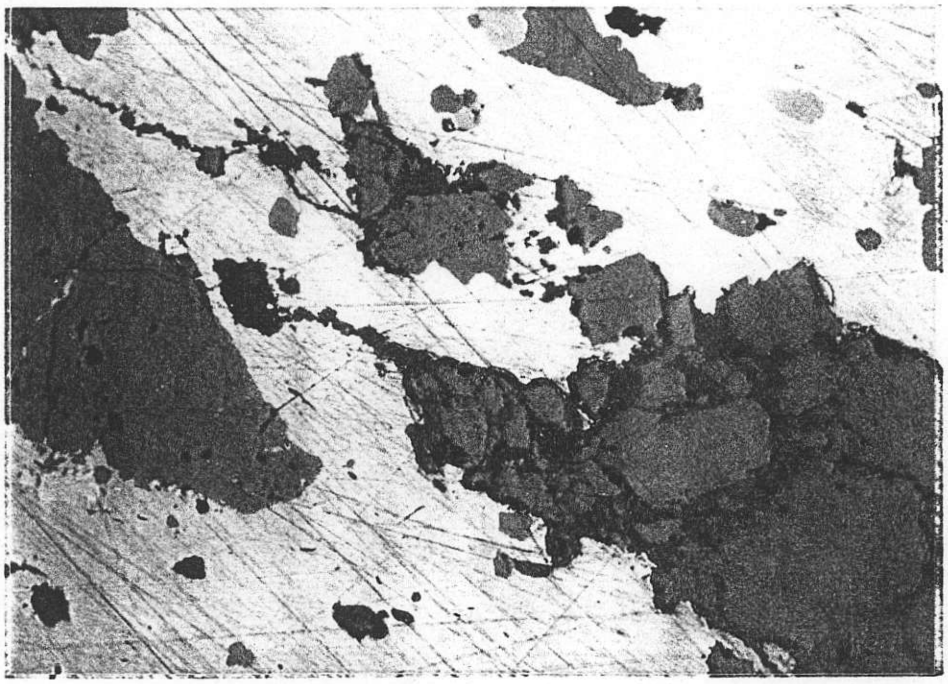
(3) RG-97-19 (Zone I): Chalcopyrite (yellow). Fine (typical) galena inclusions in pyrite (ga/py=5). Minor sphalerite (dark grey).

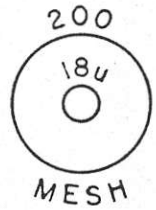


(4) RG-97-19.7 (Zone I): Sphalerite with chalcopyrite inclusions (cp/sp=6). Tetrahedrite intergrown with chalcopyrite (typical association). Pyrite crystal with chalcopyrite inclusions (lower-right). Gangue (dark grey-black).

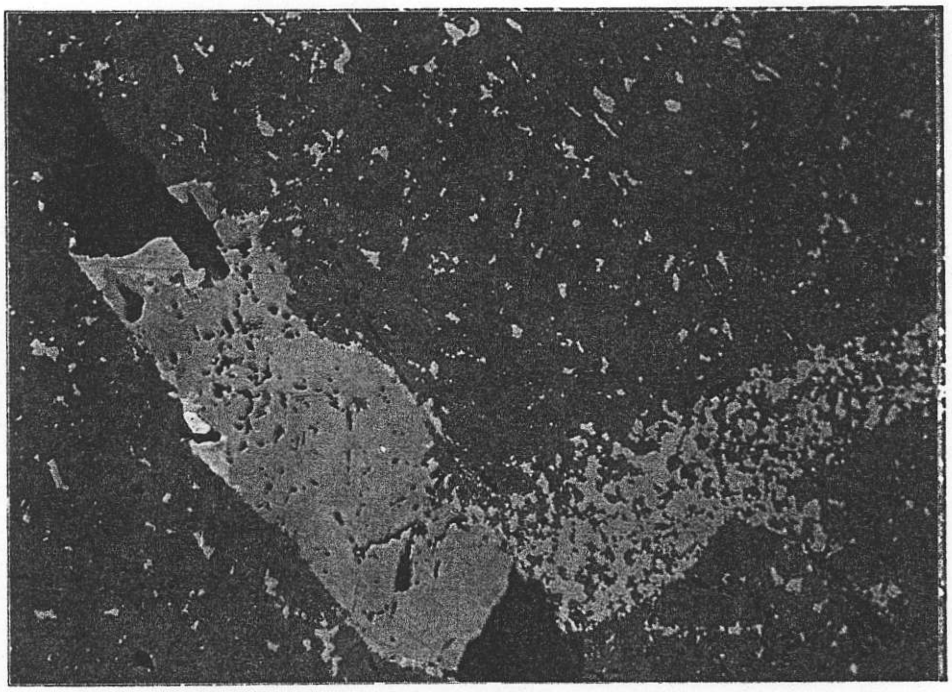
PHOTOMICROGRAPHS

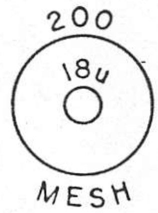
(PM-1 to PM-8 are from Zone I, PM-9 to PM-34 from Zones II and III)





(1) TR-3a (Zone I_O): Covellite veinlets (blue, upper center to upper-left) in sphalerite (grey) and galena (silver-white). Sphalerite in lower-right has network veinlets of oxidation product (smithsonite?). Black spots are pits in the polished surface.





(2) RG-97-17 (Zone I): Coarse sphalerite with "chalcopyrite disease" (cp/sp=6). Coarse tetrahedrite grain (light grey) with associated electrum grains (1 au/tt-sp-ga-gn=12u; 1 au/tt=3u). Minor silvery-white galena on left side of tetrahedrite grain. Dark grey gangue. Black pits.