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AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

October 16, 1972

TO: W. L. Kurtz

FROM: J. D. Sell

Reports and Memos
Superior East 1971-1972

A number of reports and memos have been written by various individuals covering facets of the Superior East project during the 1971-1972 drilling program. Most of the items have been covered in the Monthly Progress reports.

The attached table is an attempt to show the reports and drill hole coverage by author and date.

J. D. Sell

JDS:lad
Attach.

SUPERIOR EAST: 1971-1972

Report or Memo	Drill Hole A-1	A-2	A-2W	A-4	A-5	DCA-1A	M-1A
Daily Summary-Unit Contact (Rotary)	RBC 11/22/71	RBC 3/27/72	NA	RBC 11/22/71	RBC 11/15/71	NA	NA
Daily Summary-Unit Contact (Diamond)	RBC 10/27/71	JDS 5/18/72	JDS 5/23/72	RBC 10/27/71	NA	RBC 3/ 7/72	RBC 10/27/71
Drilling Progress	HLC 5/25/71	--	--	HLC 5/25/71	--	--	HLC 5/25/71
Coring Rates	JDS 11/8/71	--	--	JDS 11/ 8/71	--	--	JDS 11/ 8/71
Cost Summary Explanation	RBC 10/ 1/71	→	→	→	→	→	→
Cost Summary (Rotary)	RBC 10/ 1/71	JDS 9/26/72	NA	RBC 10/27/71	RBC 10/27/71	NA	NA
Cost Summary (Diamond)	RBC 10/ 1/71	JDS 9/26/72	JDS 9/26/72	RBC 1/13/72	NA	JDS 9/26/72	RBC 10/27/71
Cost Summary, Initial	HLC 6/16/71	--	--	HLC 6/16/71	--	--	HLC 6/16/71
Cost Summary, Direct Drilling	HLC In Preparation	→	→	→	→	→	→
Cost Summary, Project	JDS 9/28/72	→	→	→	→	→	→
Assay Data	RBC 11/11/71	RBC 3/24/72	JDS 5/20/72	RBC 11/ 9/71	NA	RBC 4/ 4/72	RBC 1/13/72
Graphic Log - Assay Results	JDS 10/ 5/71	JDS 7/ 8/72	JDS 7/ 8/72	RBC 12/ 2/71	JDS 5/25/72	JDS 3/31/72	JDS 7/ 8/71
Geology Log	RBC 5/ 1/72	RBC 5/ 1/72	JDS 6/ 1/72	RBC 5/ 1/72	RBC 5/ 1/72	RBC 5/ 1/72	RBC 5/ 1/72
Drill Hole Geology 1971-1972	RBC 5/30/72	→	→	→	→	→	→
1971-1972 Summation Report	JDS 8/31/72	→	→	→	→	→	→
Inclination Survey	--	HLC 5/30/72	HLC 5/30/72	HLC 11/ 2/71	--	HLC 3/16/72	SS 6/15/71
Temperature Survey	--	JDS 6/30/72	JDS 6/30/72	JDS 11/ 9/71	--	JDS 1/28/72	--
Porosity-Permeability	--	--	--	CL 2/ 4/72 JDS 2/ 7/72	--	CL 2/ 4/72 JDS 2/ 7/72	CL 2/ 4/72 JDS 2/ 7/72
Age-dates	--	--	--	GL 1/20/72	--	--	GL 1/20/72
Microprobe	--	WLK 3/ 9/72 VK 3/22/72	--	JDS 11/11/71 VK 12/10/71	--	--	JJC 6/23/71 VK 7/13/71
Copper in Biotite	--	--	--	--	--	--	LDJ 7/14/71
Fossil Identification	--	--	--	--	--	EJN 1/12/72	--
Origin of Native Copper	--	--	--	JK 2/24/72 FTG 5/31/72	--	--	--
Petrographic Examination	GJS 1/19/72	--	--	GJS 1/20/72	--	GJS 11/30/71	GJS 1/19/72 GJS 1/20/72

CL - Core Laboratories
EJN - Emanuel J. Nieves
FTG - Fred T. Graybeal
GJS - George J. Stathis
GL - Geochron Laboratories

HLC - Howard L. Crittendon
JDS - James D. Sell
JK - Jan Krason
JJC - John J. Collins
LDJ - Lloyd D. James

RBC - Robert B. Cummings
SS - Sperry-Sun
VK - Val Kudryk
WLK - William L. Kurtz
NA - Not Applicable

~~WLR~~ JDS - File

ASARCO

Southwestern Exploration Division

December 4, 1986

To: J.D. Sell

From: H.G. Kreis

Alteration and Petrography
of Igneous Rocks
Superior East Project
Pinal County, Arizona

Accompanying this memo is my report on the alteration and petrography of the Superior East igneous rock thin sections. As you know, this work was done as assessment work for the benefit of the Superior East unpatented mining claims.

H. G. Kreis

H. G. Kreis

HGK:mek
Att.

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FIGURES

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<u>Appendix</u>

I. Thin section descriptions by H.G.K. (1986)

II. G.J.S. memo on petrography of M-1A and A-4 (1-20-1972)

F.T.G. memo on alteration in A-1 and A-2 (6-17-1974)

F.T.G. memo on petrography of DCA-3A (11-8-1974)

F.T.G. notes on A-8 and A-9

G.J.S. memo on petrography X-14 and Z-1 to -4 (5-5-1972)

F.T.G. memo on fluid inclusions in LB-4 (2-13-1975)

Western Petrographic descriptions of LB-4 (circa 1974-1975)

III. J.D.S. list of reports on petrography, age dates, and metallurgy

J.D.S. list of thin section collection

IV. J.D.S. memo to H.G.K. requesting thin section study (2-26-1986)

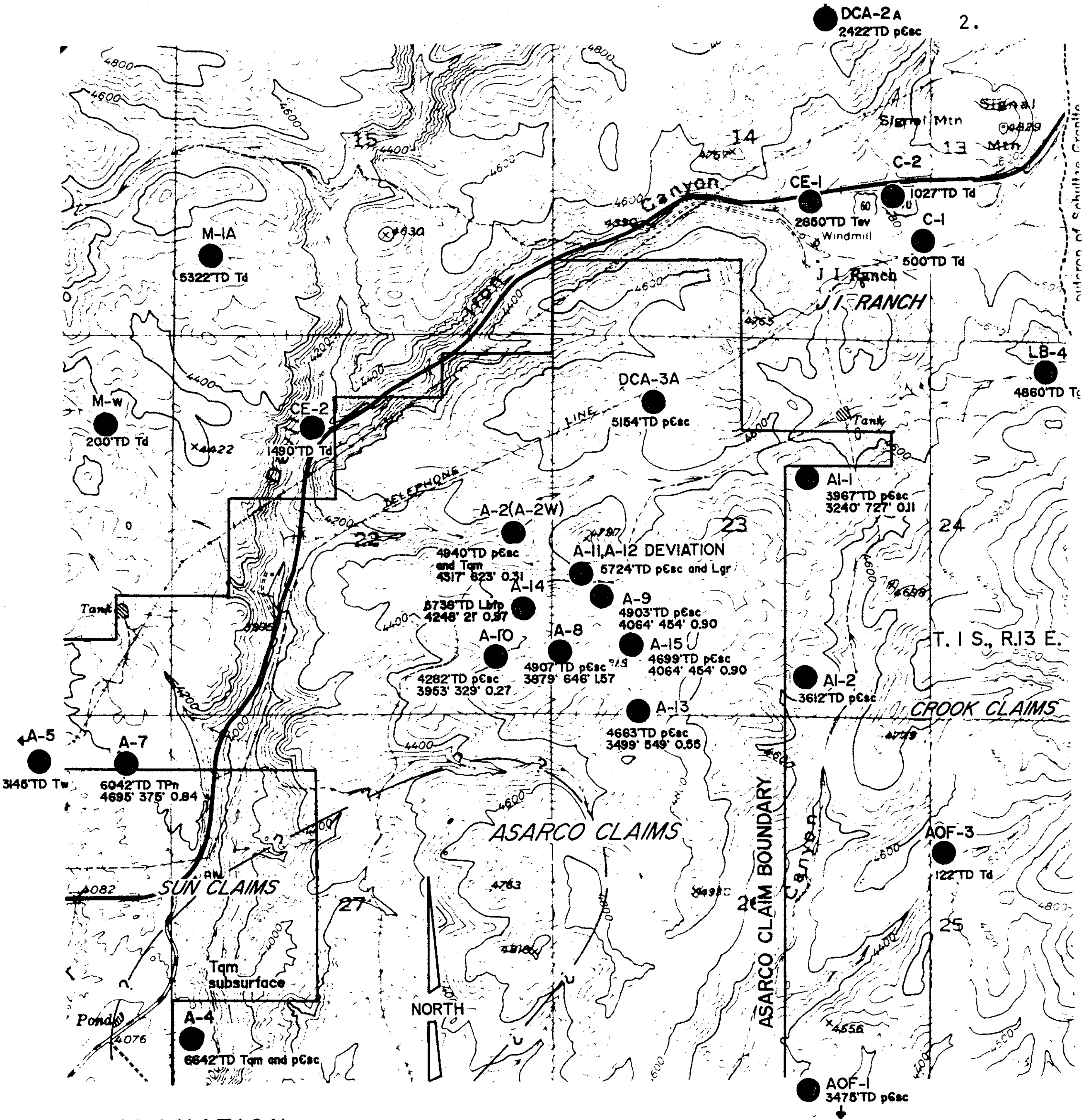
INTRODUCTION

This report examines the Superior East thin sections of igneous rocks. It was done at the request of J.D. Sell (memo in Appendix IV). The igneous rock thin sections are from the drill holes in and about the claim group shown in Figure 1. The locations of the thin sections evaluated in this report and the availability of Pinal Schist thin sections for future work are shown in Figure 2. Most of the thin sections were taken in the area of copper mineralization, a 2000' diameter area centered on A-14. Only a few of the thin sections are off the claim group, but the data gained from these sections is important to the evaluation of the geology within the claim group.

This report concentrates on the igneous rock petrography and alteration. The texture and modal composition of each thin section were determined, and this information became the basis for describing and categorizing the igneous rock types. The alteration of each rock forming mineral in each thin section was recorded; and, likewise, the alteration was described and categorized. The rock type and alteration categories are described in the following sections of this report, and remarks on the igneous rock types and alteration encountered in each drill hole are made in the last section of this report. The reports on the individual thin sections of this evaluation are in Appendix I, and reports by others are in Appendix II.

An evaluation of the sulfide mineralization and zoning patterns was not attempted using the petrographic microscope. Such a study can only be done by logging the core and taking selected samples at the time of logging. These samples would then be evaluated with a reflecting microscope and the results used to supplement the logging data. This is a study that should be done. Coupled with structural logging, the sulfide logging will give a far better understanding of the copper mineralization than any other type of evaluation.

Fluid inclusions of the igneous rocks were not examined at this time. Earlier work, present in Appendix II, found the fluid inclusions in A-2 (0.5% Cu) to be 99% two-phase inclusions (water with 10% to 40% gas). Thin sections from a couple of outlying drill holes showed rare, small fluid inclusions. A fluid inclusion evaluation would get the best results using the Precambrian schist thin sections and the heating-cooling stage at the Reno office.



EXPLANATION

- Drill holes in area of study showing rock type at T.D. and copper intercept (depth, thhickness, %Cu)
- Post mineral cover
- Premineral Schultze Granite

FIGURE 1

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DRILL HOLE AND LAND STATUS

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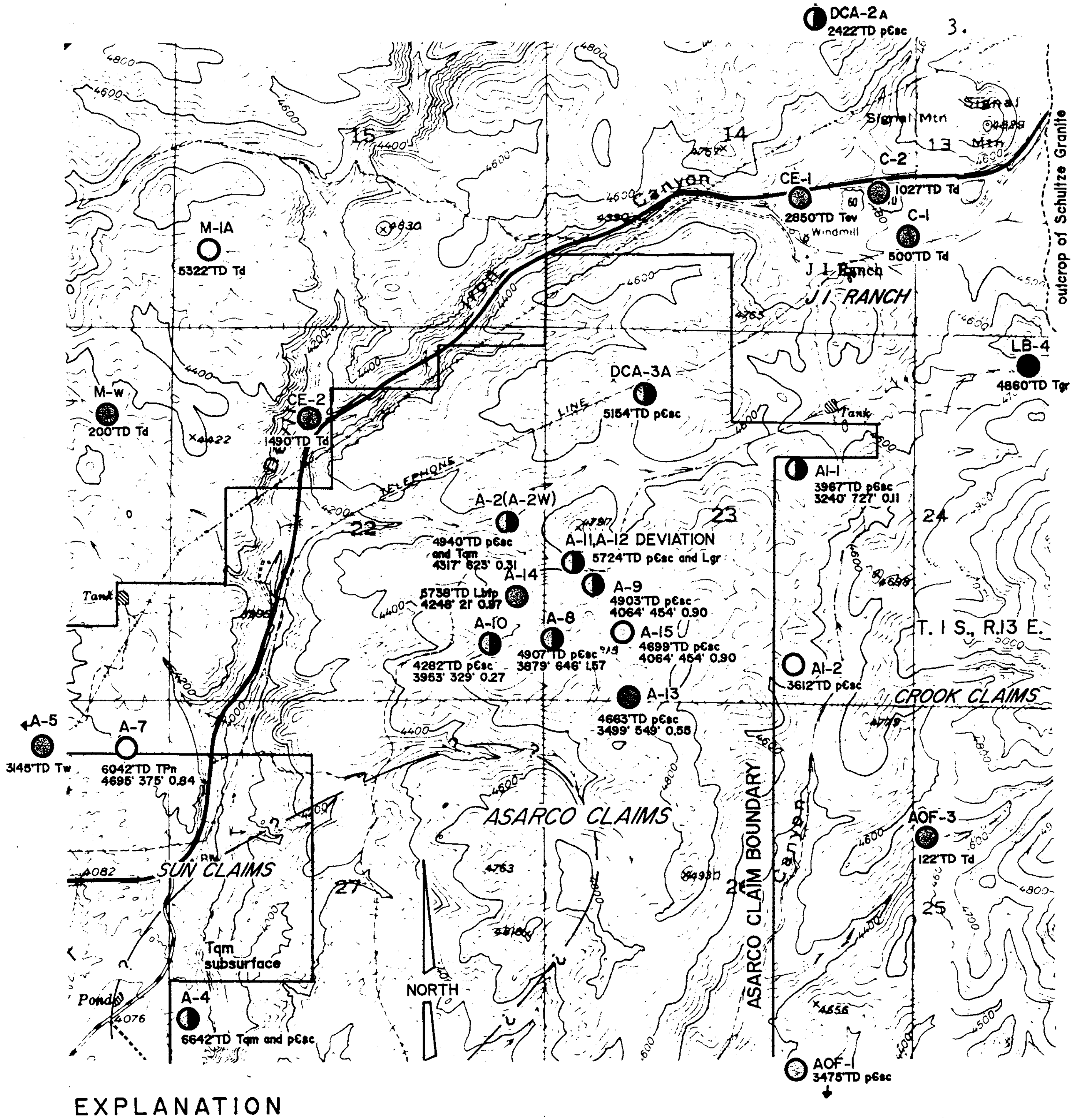

EXPLANATION

- ○ Drill holes in area of study showing rock type at T.D. and copper intercept (depth, thhickness, %Cu)
- ● Premineral igneous rock thin sections evaluated in this report.
- ◎ Pinal Schist thin sections available
- ◉ No thin petrographic thin sections; only doubly polished sections for temperature studies.
- ○ No thin sections of premineral igneous rocks or Pinal Schist.
- ● Hole bottomed in post mineral cover.

FIGURE 2

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THIN SECTION STATUS

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SUMMARY AND CONCLUSIONS

The mineral composition and texture of each igneous rock thin section was described, and the descriptions were used to classify the igneous rocks. The igneous rock types are: granodiorite, granodiorite porphyry, quartz monzonite, quartz monzonite porphyry, fine-grained granite, and quartz-feldspar porphyry. The thin section evidence suggests quartz-feldspar porphyry is the oldest igneous rock type, and there is a textural and compositional continuum from granodiorite (older) to granodiorite porphyry to quartz monzonite porphyry to fine-grained granite (younger).

The granodiorite in the Schultze Granite stock, and its texture and composition are very similar to the granodiorite Sacaton Peak and Mineral Mountain stocks (Casa Grande to Florence). The granodiorite porphyry is a porphyritic phase of the granodiorite, and it is not clear if the drill hole intercepts of granodiorite porphyry represent a contact phase of the stock or dikes from the stock. The quartz monzonite porphyry and fine-grained granite are common dike rocks, and they occur in the drill holes where there is strong copper mineralization. Quartz-feldspar porphyry dikes are not common, and they occur in only three drill holes.

Three types of alteration were observed in the igneous rock thin sections. In decreasing order of abundance in igneous rocks, they are kaolinite alteration, sericite alteration, and biotite-orthoclase alteration. Kaolinite alteration and sericite alteration were observed in all the igneous rock types. Biotite-orthoclase alteration occurs only in the quartz-feldspar porphyry. The kaolinite alteration is a pervasive form of alteration while the sericite alteration is confined to vein selvages. Stronger kaolinite alteration is associated with higher copper grades (Table 15). The same is probably true with sericite alteration, but it would take detailed core logging rather than a thin section examination to evaluate and utilize this relationship.

This evaluation of the igneous rock types and their alteration should be an integral part of any evaluation of the Superior East copper deposit. However, a detailed evaluation of the sulfide mineralization utilizing core logging and ore microscopy would be the most valuable tool for exploring the Superior East copper deposit. An evaluation of the alteration in the schist and an evaluation of the fluid inclusions would also be helpful. When most of these evaluations have been done, the results should be plotted on 1"=200' scale cross sections and interpreted. The resulting interpretation should improve the success of future drilling.

ROCK TYPES

As previously mentioned the following igneous rock type classification was derived on the basis of textural observation and modal analyses (eye estimates) from thin sections. The rock types are granodiorite (Schultze Granite), granodiorite porphyry, quartz monzonite, quartz monzonite porphyry, fine-grained granite, and quartz-feldspar porphyry. All of these igneous rocks are premineral in age and intrude the Precambrian Pinal Schist. None of the igneous rock thin sections appeared to be post mineral in age, and no thin sections of diabase were encountered. Not all of the igneous rock intercepts had thin sections made from them; so there could be a rock type classification or two that has yet to be identified.

Granodiorite

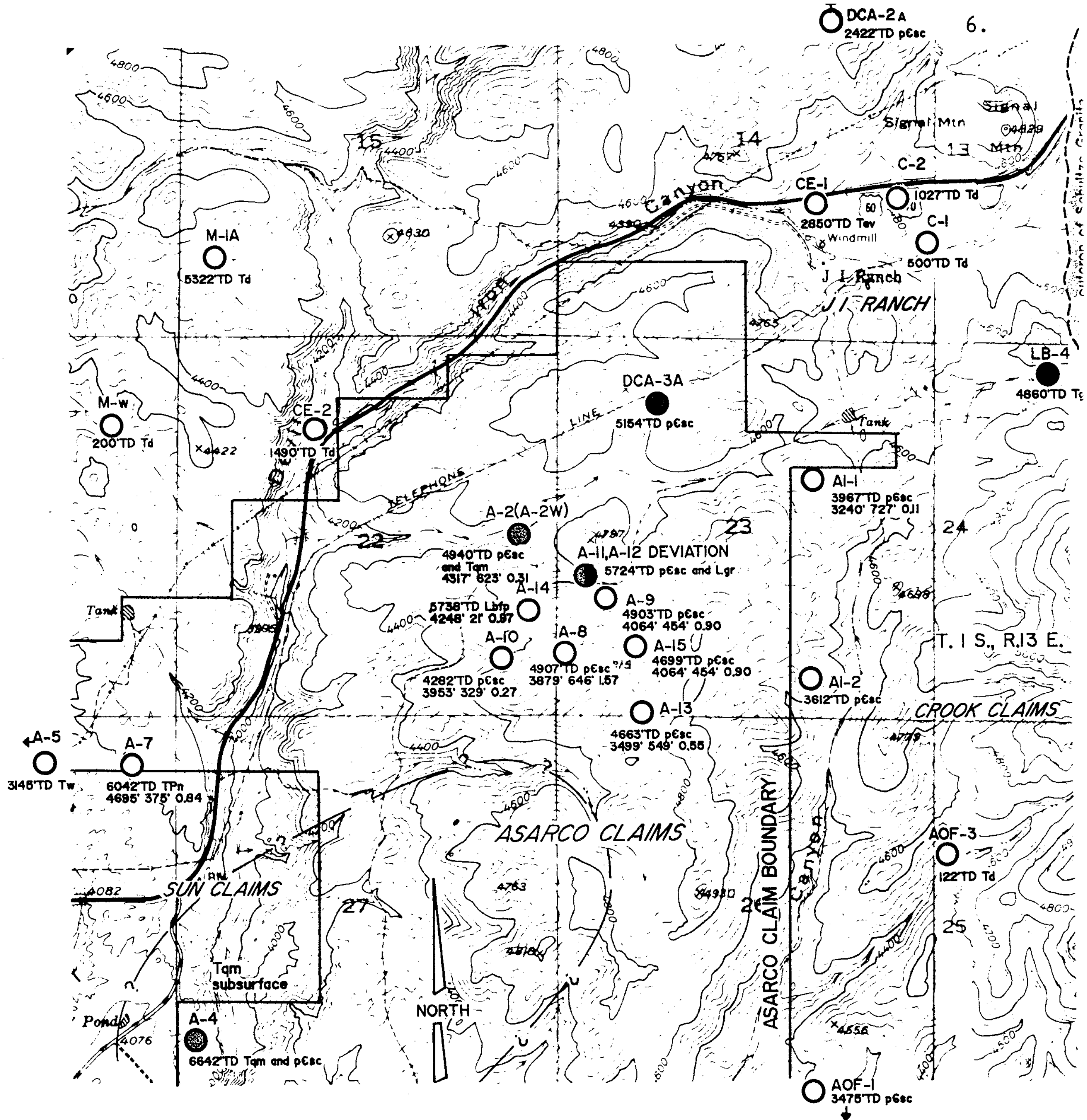
Granodiorite occurs in three drill holes: DCA-3A, LB-4, and A-12 (see map, Figure 3). The granodiorite in drill hole LB-4 is that of the Schultze Granite stock. The granodiorite in drill holes DCA-3A and A-12 are probably fault blocks off the outer edges of the stock.

The mineral composition (mode) of the granodiorite is: 4% biotite, 56% plagioclase, 19% orthoclase, and 21% quartz. The mineral composition of the individual thin sections is summarized in Table 1. As a double check, a 116-point count was done on LB-4, 3410'; and the results were: 3% biotite, 48% plagioclase, 16% orthoclase, and 33% quartz. The point count confirmed the granodiorite composition of the rock, and suggested eye estimates of the quartz content may be on the low side.

Table 1. Granodiorite Mineral Composition

		Composition (% of rock)				Grain Size
Hole	Depth	Biotite	Plag.	Ortho.	Qtz.	(mm)
DCA-3A	4747'	5	55	≤15	25	1-3
LB-4	2600'	3	55	20	20	1-3
	3410	3	56	15	26	1-3
	4850	3	57	20	18	1-3
A-12	5551	5	55	20	20	1-5
	5623	5	55	25	15	1-3
	Average	4	56	19	21	1-3

The texture of the granodiorite is hypidiomorphic granular. The grain size is fine to medium, 1 to 3mm, with little variation from section to section. The plagioclase grains are typically euhedral to subhedral. The orthoclase varies from being totally interstitial to part phenocrystal (poikiloblastic) and part interstitial. Quartz is interstitial with local



EXPLANATION

- ○ Drill holes in area of study showing rock type at T.D. and copper intercept (depth, thhickness, %Cu)
- ● Granodiorite (Schultze Granite)
- ◍ Granodiorite porphyry

FIGURE 3

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GRANODIORITE and GRANODIORITE PORPHYRY DISTRIBUTION

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minor phenocryst-like grains. The texture of DCA-3A, 4747', is interesting because it varies from hypidiomorphic-granular to the initial stages of porphyritic development (up to 10% fine-grained quartz-orthoclase groundmass). Conceivably, this initial stage of porphyritic development suggests the possibility of a suite of granodiorite textures that would be gradational into granodiorite porphyry.

The texture and composition of the granodiorite (Schultze Granite) is very similar to that in the granodiorite of the Poston Butte and Florence Pediment drill holes (Sacaton Peak Granite and Mineral Mountain Stock). The granodiorite at Poston Butte and Florence Pediment is composed of 9% biotite, 0-2% hornblende, 52% plagioclase, 15% K-feldspar, and 23% quartz.

Granodiorite Porphyry

Granodiorite porphyry is present in DCA-2A, A-2W, A-4, and A-12 (see map, Figure 3). The granodiorite porphyry has a mineral composition of 6% biotite, 59% plagioclase, 16% orthoclase, and 19% quartz. The mineral composition of the individual thin sections is summarized in Table 2.

Table 2. Granodiorite Porphyry Mineral Composition

Hole	Depth	Composition (% of rock) Biotite	Plag.	Ortho.	Qtz.
DCA-2A	1547'	6	64	12	18
A-2W	4910'	8	52	20	20
A-4	6612,6656, 6657'	8	58	15	18
A-12	5417'	4	60	16	20
	Average	6	59	16	19

The texture of the granodiorite porphyry is obviously porphyritic with 76% phenocrysts, typically 1 to 4 mm in size, and 24% fine-grained, aplitic groundmass, 0.2 mm in size. The texture of the granodiorite porphyry and the distribution of the minerals in the porphyry texture are shown in Table 3. A characteristic of the porphyry is a high percentage of plagioclase phenocrysts, 1 to 4 mm size, comprising 55 to 60% of the rock.

Table 3. Granodiorite Porphyry Texture and Mineral Distribution

Hole*	Grain Size (mm) Pheno.	Gm.	Phenocrysts % Rock	Plag. (% Pheno)	Quartz (% Pheno)	Ortho. (% Pheno)	Bio. (% Pheno)	Groundmass % Rock	Plag. (% Gm)	Quartz (% Gm)	Ortho. (% Gm)	Bio. (% Gm)
DCA-2A	2-6	.1	80	80	10	5	5	20	0	50	40	10?
A-2W	1-4	.2	75	65	15	10	10	25	10	35	55	?
A-4	1-3	.3	70	83	10	0	7	30	0	35	55	10
A-12	1-4	.1	80	75	15	5	5	20	-	40	60	0
Average	1-4	.2	76	76	12	5	7	24	3	40	52	5

*See Table 2 for depths of thin sections.

The granodiorite porphyry has the same mineral composition as the granodiorite (compare Table 2 with Table 1). Likewise, the size of the phenocrysts in the granodiorite porphyry is the same as the grain size of the granodiorite. For these two reasons, it is apparent that the granodiorite porphyry is simply a textured variation of the granodiorite.

However, it is not clear if the granodiorite porphyry is a contact phase of the granodiorite Schultze Granite stock or dikes from the stock or both. The granodiorite porphyry intercept in DCA-2A, 1540' to 1620', is bounded by faults. The granodiorite porphyry in A-2W, 4910' to 4940' T.D., is open at depth. Likewise, the granodiorite porphyry in A-4, 6610' to 6664' T.D., is open at depth. In A-12 the granodiorite porphyry in the 5417' thin section apparently grades into the granodiorite of thin sections 5486', 5551', and 5623'; and the hole bottoms in granodiorite at 5724'.

Quartz Monzonite

Quartz monzonite is present in three drill holes: DCA-3A, A-2, and A-12 as shown in Figure 4. The quartz monzonite's mineral composition is listed in Table 4. I am not sure this quartz monzonite classification actually exists. This classification may exist simply because of errors inherent in making eye estimations (particularly so in sections not stained for K-feldspar such as DCA-3A and A-2), or it may exist because they are plagioclase rich members of the fine-grained granite classification (to be described).

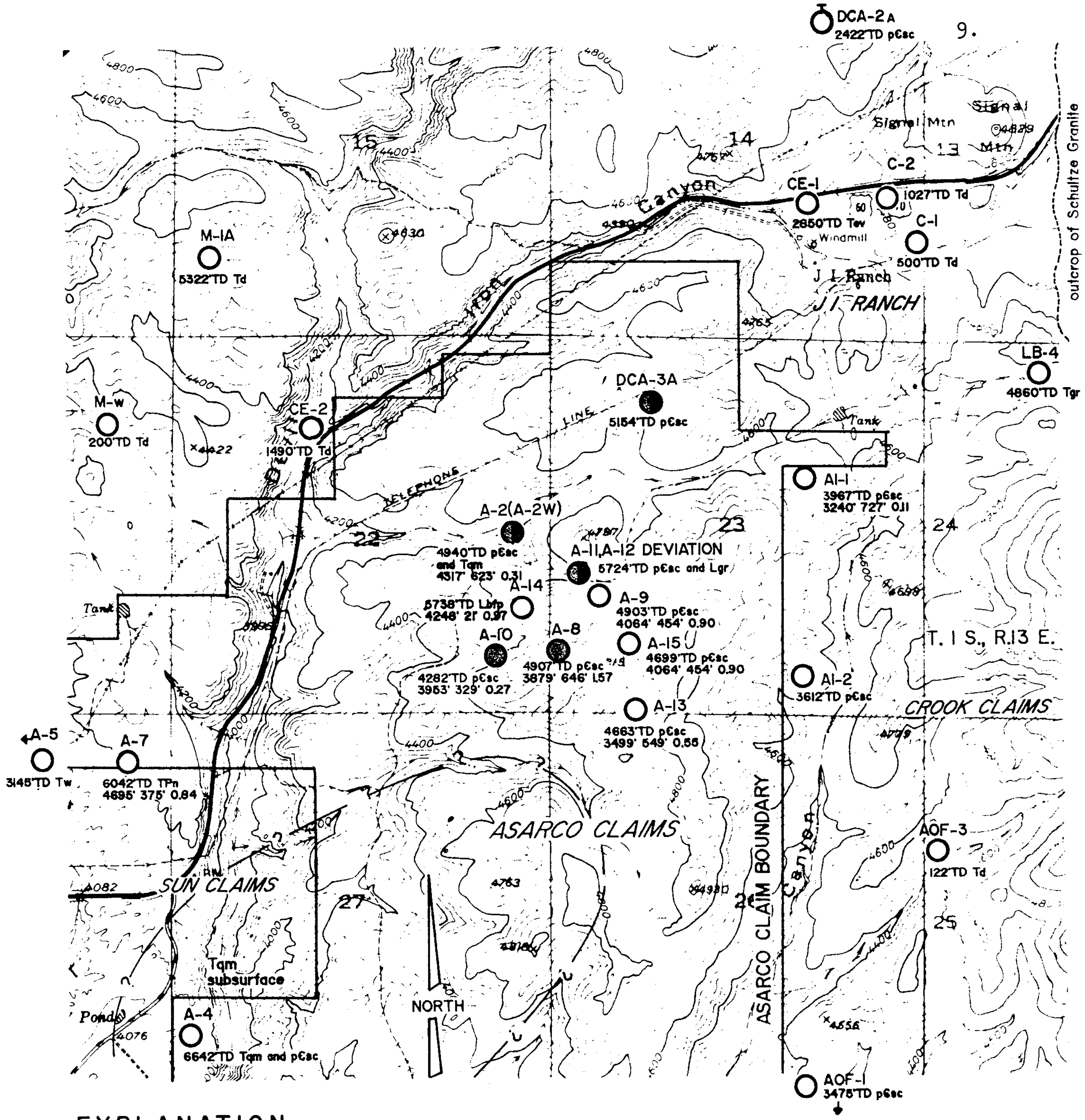
Table 4. Quartz Monzonite Composition

Hole	Depth	Composition (% of rock)				Grain Size
		Biotite	Plag.	Ortho.	Qtz.	(mm)
DCA-3A	4512'	5	30	40	25	.2-1
A-2	4394'	3	32	35	30	.2-.4
A-12	5368'	3	28	34	35	.5-1
	Average	4	30	36	30	.2-1

The texture of the quartz monzonite is fine-grained hypidiomorphic granular. The typical grain size is 0.2 to 1 mm.

Quartz Monzonite Porphyry

Quartz monzonite porphyry is a common dike rock type. It's mineral composition is 5% biotite, 38% plagioclase, 32% orthoclase, and 25% quartz. The mineral composition of the individual thin sections is shown in Table 5.



EXPLANATION

- ○ Drill holes in area of study showing rock type at T.D. and copper intercept (depth, thhickness, %Cu)
- Quartz monzonite porphyry
- Quartz monzonite

FIGURE 4

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QUARTZ MONZONITE and QUARTZ MONZONITE PORPHYRY DISTRIBUTION

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Table 5. Quartz Monzonite Porphyry Composition

Hole	Depth	Composition (% of rock) Biotite	Plag.	Ortho.	Qtz.
DCA-3A	4334'	6	44	28	22
A-2W	4242'	3	50	27	20
A-2	4308'	3	45	32	20
	4541'	6	38	33	23
A-8	4111'	6	39	32	23
	4622'	6	34	36	24
A-10	4052'	5	25	43	27
	4264'	6	41	25	28
A-12	4589'	2	30	40	28
	5393'	6	43	23	28
	Average	5	38	32	25

The texture of the quartz monzonite porphyry is comprised of 45% medium-grained phenocrysts, typically 1 to 3 mm in size, set in 55% aplitic-granitic groundmass, 0.05 to 0.2 mm in size. The quartz monzonite porphyry's texture and distribution of minerals in its texture are listed in Table 6.

Table 6. Quartz Monzonite Porphyry Texture and Mineral Distribution

Hole*	Grain Size (mm) Pheno.	Gm.	Phenocrysts %Rock	Plag. (% Pheno)	Quartz (% Pheno)	Ortho. (% Pheno)	Bio. (% Pheno)	Groundmass % Rock	Plag. (% Gm)	Quartz (% Gm)	Ortho. (% Gm)	Bio. (% Gm)
DCA-3A	.5-1	.05-.1	60	67	15	10	8	40	10	50?	50?	2
A-2W	1-2	.2	60	75	10	10	5	40	20	25	55	-
A-2	1-3	.1	50	75	15	5	5	50	15	25	60	-
	1-2	.2	35	75	15	-	10	65	18	27	50	5
A-8	1-2	.06	50	70	10	10?	10	50	10	32	53	5
	1-3	.06	35	50	20	20	10	65	25	25	45	5
A-10	1-3	.02-.1	30	60	20	10	10	70	10	30	57	3
	1-3	.1	50	73	20	-	7	50	10	35	50	5
A-12	1-3	.2	25	75	15	-	10	75	13	32	55	-
	1-3	.5	60	65	20	5	10	40	15	35	50	-
Average	1-3	.05-.2	45	70	15	5	10	55	15	30	53	2

*See Table 5 for depths.

It is interesting to note that the composition of the phenocrysts (Table 6) is very similar to that of the granodiorite porphyry (Table 3). Consequently, the difference in mineral composition between the two rock types is due to the abundance of fine-grained aplitic-granitic groundmass.

Fine-Grained Granite

Fine-grained granite exists in drill holes A-8, A-9, A-10, and A-12A (see Figure 5). Fine-grained granite has a mineral composition of 3% biotite, 17% plagioclase, 51% orthoclase, and 29% quartz. The mineral composition of the individual thin sections is presented in Table 7.

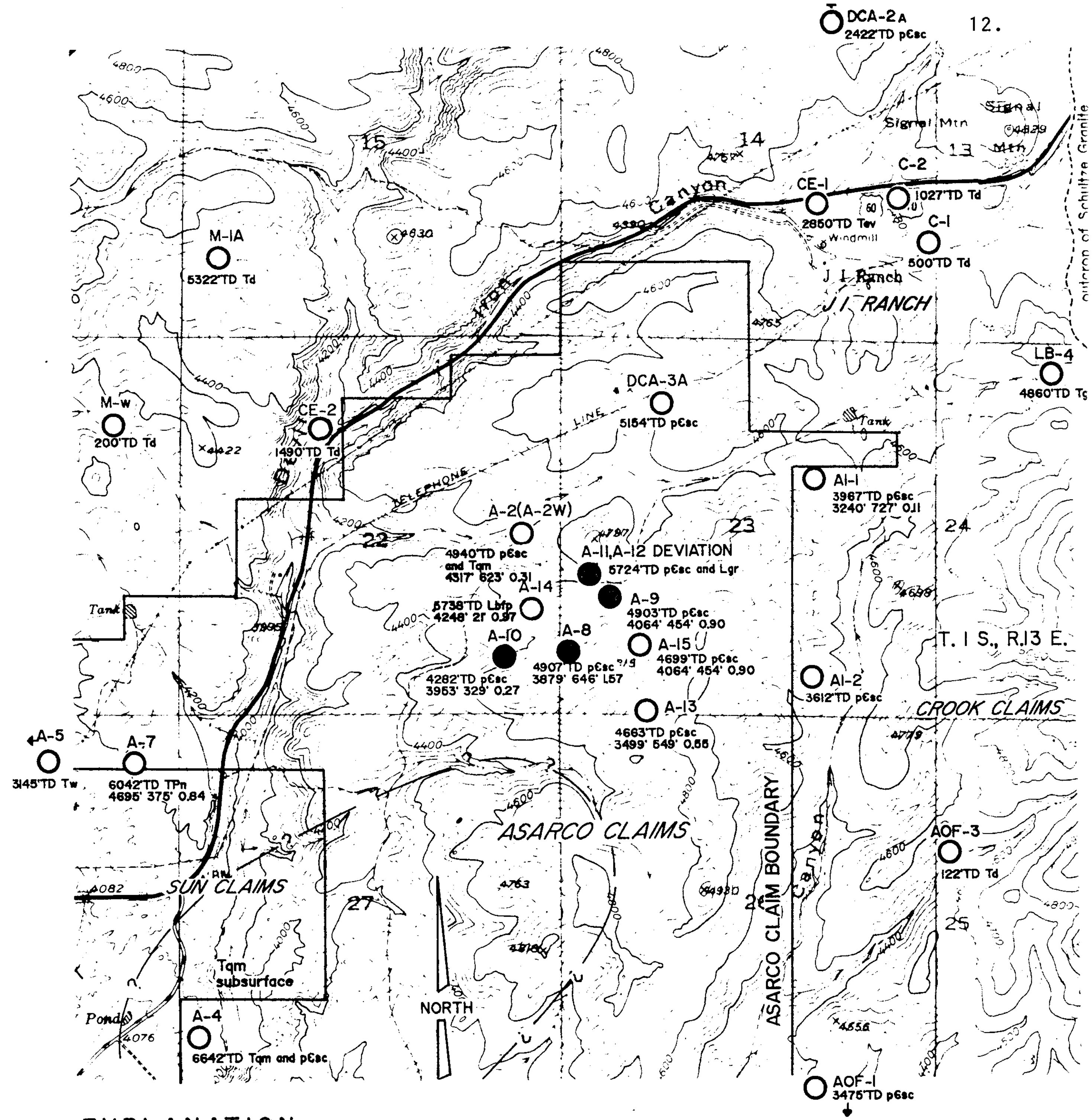
Table 7. Fine-Grained Granite Composition

Hole	Depth	Composition (% of Rock)				Grain Size
		Biotite	Plag.	Ortho.	Qtz.	(mm)
A-8	4726'	3	15	50	32	.4-3
A-9	4026'	3	22	45	30	.2-2
	4159'	4	15	56	25	.1-.7
	4734'	4	15	51	30	.1-2
A-10	3436'	3	23	47	27	.1-.2
	3697'	3	22	45	30	.1-.3
	3891'	3	15	47	35	.1-.7
	4163'	3	15	50	32	.1-1
	4278'	3	25	42	30	.1-3
A-12A	4129'	2(?)	15	58	25	.3-.6
	4195'	2(?)	10	68	20	.1-.2
	4627'	2	15	48	35	.5-2
	Average	3	17	51	29	.1-2 Range .2-.7 Av

The texture of the fine-grained granite is somewhat variable. The texture is hypidiomorphic-granular but grades into allotriomorphic-granular in sections where the orthoclase is less euhedral. In addition the granular texture grades into varying degrees of porphyritic texture. A few of the fine-grained granite thin sections are sufficiently porphyritic to be called granite porphyry.

Quartz-Feldspar Porphyry

Quartz-feldspar porphyry is a category of rocks that are too fine-grained to determine mineral composition. The thin sections of rock in this category are listed in Table 8. Typically 85% or more of the rock is groundmass with a grain size of 0.03 mm and an apparent quartz-feldspar composition. The remainder of the rock is 1mm-sized phenocrysts of dominantly plagioclase. The location of the drill hole intercepts of quartz-feldspar porphyry are shown in Figure 6.



EXPLANATION

○ Drill holes in area of study showing rock type at T.D. and copper intercept (depth, thhickness, %Cu)

● Fine-grained granite

FIGURE 5

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FINE-GRAINED GRANITE DISTRIBUTION

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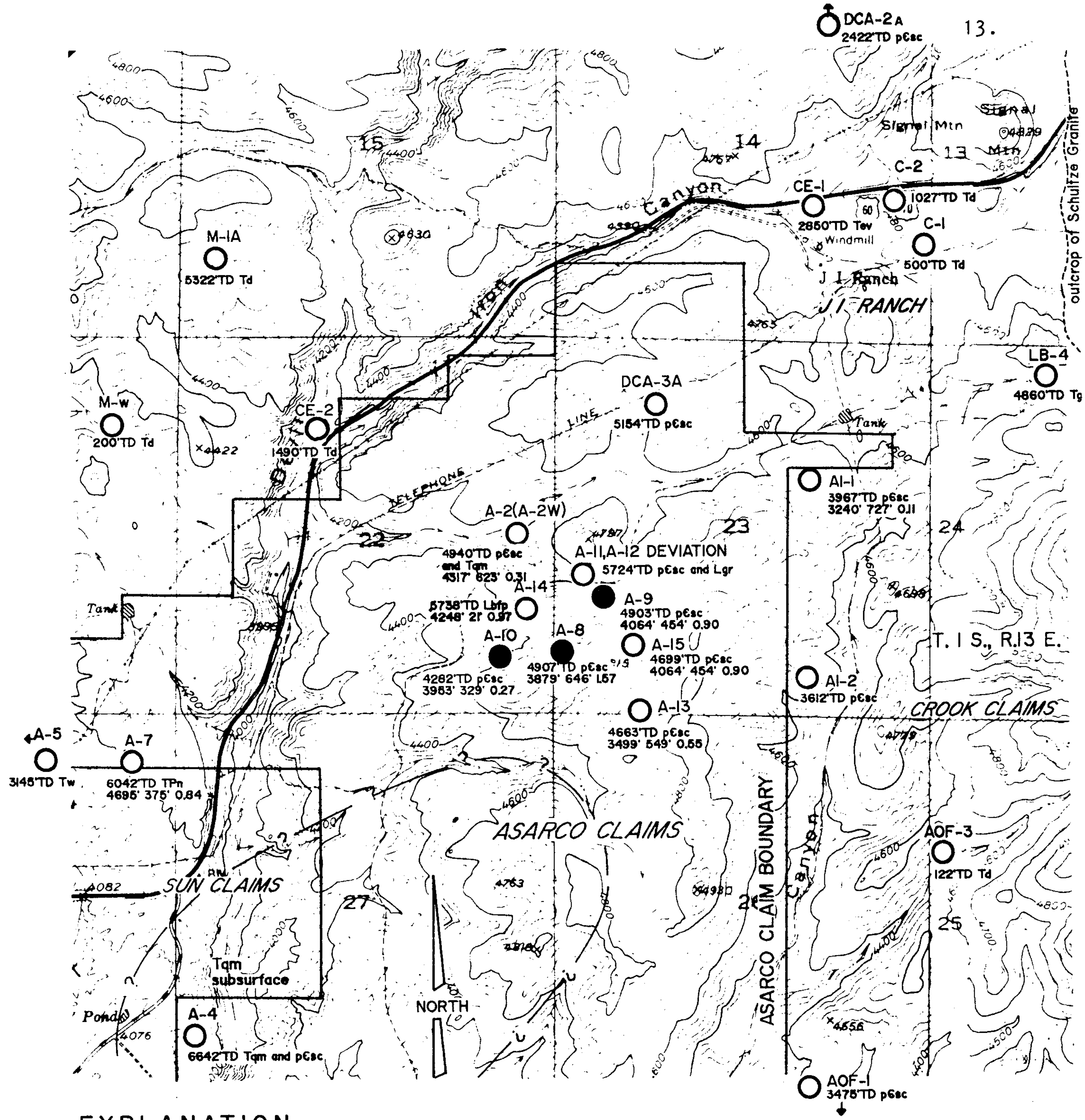

EXPLANATION

○ Drill holes in area of study showing rock type at T.D. and copper intercept (depth, thhickness, %Cu)

● Quartz-feldspar porphyry

FIGURE 6

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QUARTZ-FELDSPAR PORPHYRY DISTRIBUTION

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mn 6395 HGK/dam tucson 6/86

Table 8. Quartz-Feldspar Porphyry Texture and Phenocryst Composition

Hole	Depth	Rock Name	Grain Size (mm) Pheno.	Grain Size (mm) Gm.	Phenocrysts % of Rock	Plag. (% Pheno)	Qtz. (% Pheno)	Biotite (% Pheno)
A-8	3883'	Quartz-feldspar porphyry	.5-1	.04	15	85	15	-
A-9	4202'	Quartz-feldspar porphyry	1	.02	6	95	5	-
A-9	4580'	Aphanite	-	.02	0	-	-	-
A-10	3691'	Feldspar porphyry	1	.02	15	90	-	15

One of the characteristics of this rock type is an abundance (5-15%) of fine-grained biotite, most of which appears to be secondary. About half of this fine-grained biotite occurs in pseudomorphs of an elongate mineral that was probably primary biotite or possibly hornblende.

Rock Type Comparisons

There is a resonable textural and compositional continuum from granodiorite to granodiorite porphyry to quartz monzonite porphyry to fine-grained granite. The features that give evidence of the continuum are summarized in Table 9 and shown in detail in Tables 10, 11, 12, and 13.

This continuum of texture and composition may reflect the actual sequence of intrusion. Although there is no convincing thin section evidence as to which rock type was first, the granodiorite (Schultze Granite) was probably the first to be intruded and fine-grained granite the last.

The quartz monzonite and quartz-feldspar rock types are not included in the continuum. The quartz monzonite rock type was not included because it is too poorly defined. The quartz-feldspar porphyry rock type was not included, because alteration evidence suggests it predates the other rock types. The quartz-feldspar porphyry may be pre-Mesozoic in age.

Table 9. Textural-Compositional Continuum

FEATURE	ROCK TYPE SIMILARITIES: Granodiorite	Granodiorite Porphyry	Quartz Monz. Porphyry	Fine-grained Granite	SEE TABLE FOR DETAILS
Texture:					
Abundance of pheno. sized grains	→ Continuous Decrease			→	Table 10
Size of phenocryst sized grains	X Same	X Same	X		Table 11
Size of groundmass sized grains		X Same	X Similar	X	Table 12
Composition:					
Whole rock mineral composition	X Same	X			Table 13
Comp. of phenocryst sized grains	X Similar	X Same	X		Table 11
Comp. of groundmass sized grains		X Similar	X Same	X	Table 12

Table 10. Textural Comparisons

	Grano-diorite	Grano. Porphyry	Qtz.Monz. Porphyry	Fine-g. Granite
Abundance Phenocryst-Sized Grains	100%	76%	45%	<15%
Abundance Groundmass-Sized Grains	0%	24%	55%	>85%

Table 11. Comparison of Phenocryst-Sized Grains

Rock Type	Grain Size (mm)	Abundance (% of rock)	Plag. (% of pheno.)	Quartz (% of pheno.)	Ortho. (% of pheno.)	Biotite (% of pheno.)
Granodiorite	1-3	100	56	21	19	4
Granodio. Porp.	1-4	76	76	12	5	7
Qtz.Monz. Porp.	1-3	45	70	15	5	10

Table 12. Comparison of Groundmass-Sized Grains

Rock Type	Grain Size (mm)	Abundance (% of gm.)	Plag. (% of gm.)	Quartz (% of gm.)	Ortho. (% of gm.)	Biotite (% of gm.)
Granodio. Porp.	.2	24	0-10	40	52	5
Qtz.Monz. Porp.	.05-.2	55	15	30	53	2
F-g. Granite	.2-.7	>85	17	29	51	3

Table 13. Whole Rock Mineral Composition Comparison

Rock Type	Plag. (%)	Quartz (%)	Ortho. (%)	Biotite (%)
Granodiorite	56	21	19	4
Granodiorite Porphyry	59	19	16	6
Quartz Monz. Porphyry	38	25	32	5
Fine-grained Granite	17	29	51	3

ALTERATION

An examination of the thin sections of Superior East premineral igneous rocks shows two dominent types of alteration in the immediate area of copper mineraliztion. They are kaolinite alteration and sericite alteration. An apparently minor type of alteration exists in the quartz-feldspar porphyry, and it is biotite-orthoclase-kaolinite alteration.

Judging from the collection of igneous rock thin sections, the kaolinite alteration is a pervasive dissemination type of alteration while most, if not all, of the stronger sericite alteration is vein selvage type alteration. The selvage nature of sericite alteration was obvious in a number of thin sections and strongly suspected in a number of others.

Kaolinite Alteration

Kaolinite alteration of the igneous rocks is best displayed in the area of copper mineralization, the area bounded by A-2, A-9, A-8, and A-10 (Figure 7). Typical kaolinite alteration consists of 50 to 100% replacement of plagioclase by kaolinite. Kaolinite does not replace orthoclase, and the orthoclase is virtually always fresh outside of sericite alteration selvates. Usually biotite is fresh or altered to muscovite, but this muscovite alteration of biotite is believed to be related to sericite alteration.

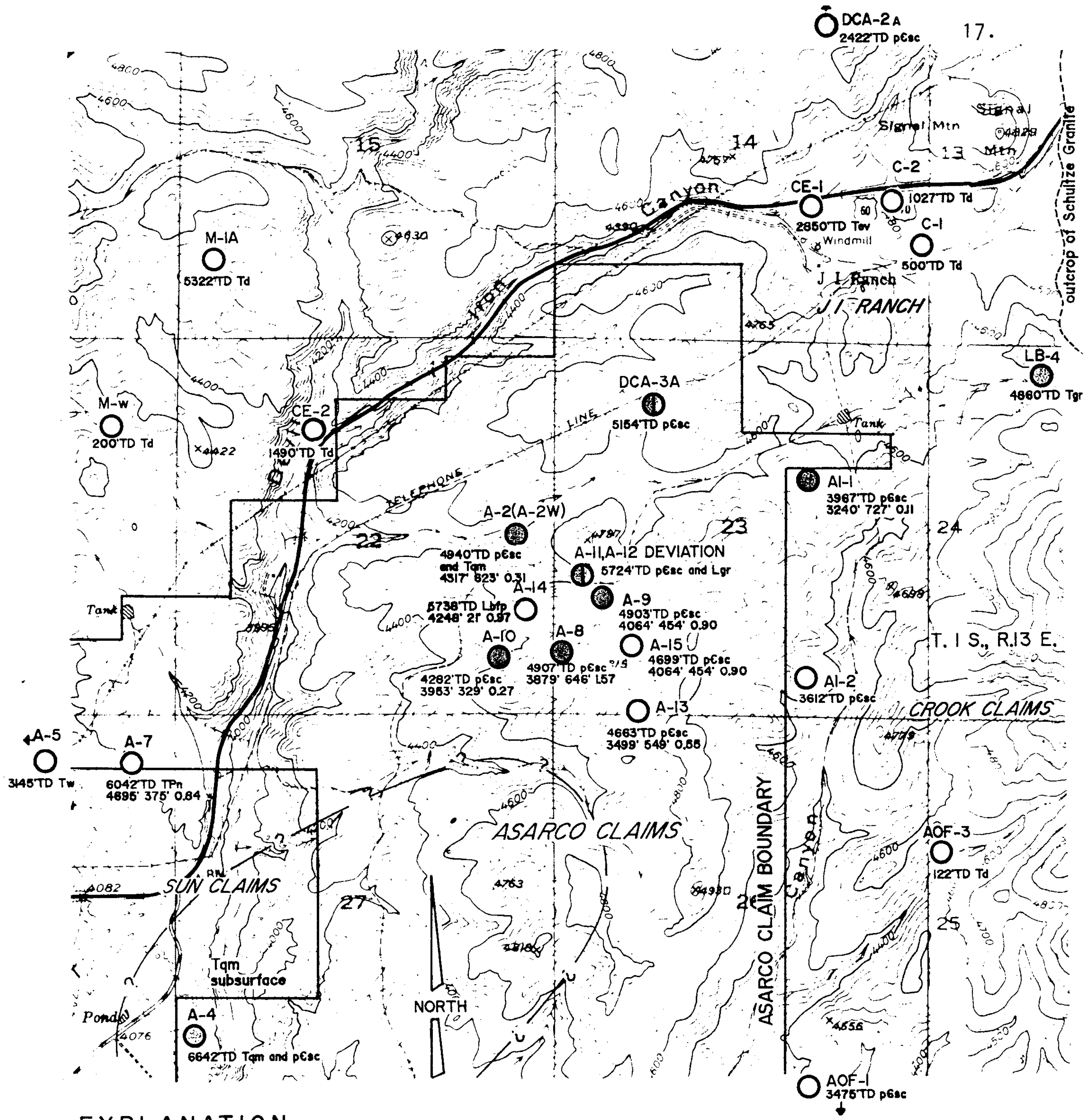
Virtually every rock type exhibits some degree of kaolinite alteration. Most of the thin sections are either quartz monzonite porphyry or fine-grained granite so most observations of argillic alteration were made in these rock types. A compilation of the degree of alteration in the various rock types is in Table 14 (page 18).

Holes A-2, A-8, A-9, A-10, and A-12 all have good examples of kaolinite alteration. The kaolinite alteration and associated copper grades in drill hole A-12 (and A-12A) are summarized in Table 15.

(Table 14. Follows on page 18)

Table 15. Alteration of Igneous Rocks in A-12

A-12 Depth (ft.)	Rock Type	Copper Grade	Plagio. Abund. (% rock)	Plagio. Alter. (% repl.)	Plagio. Alt.Prod. (% rock)	Biotite Alter. (% repl.)	Ortho. Alter. (% repl.)
4129'	f.g.gr	≥0.3% & some 1-4% assays (cc,bn,cpy)	15-30%	100%	15% kaol 5% ser.	30% to 100% altered to muscov.	Essentially Fresh
4136'	pqm.						
4195'	f.g.gr						
4589'	qmp						
4627'	f.g.gr						
4826'	f.g.gr			35% ↓ 15%	1-7% kaol. 0-3% ser.		
5368'	f.g.qm	Typically 0.01-0.09% (cpy)					
5393'	qmp					Fresh	
5417'	gdp		55%	15% ↓ 5%	Tr-5% kaol. 0-2% ser. 2% calc. Tr anhy.		
5486'	gd						
5551'	gd						
5623'	gd						



EXPLANATION

- Drill holes in area of study showing rock type at T.D. and copper intercept (depth, thhickness, %Cu)
- Kaolinite alteration with sericite selvage alteration
- Fresh and weakly altered granodiorite and granodiorite porphyry
- Fresh quartz monzonite porphyry
- Sericitized in the one and only thin section but drill log says fresh(DCA-2A)

FIGURE 7

ASARCO Incorporated

SUPERIOR EAST PROJECT
PINAL COUNTY, ARIZONA

ALTERATION MAP

H.G.Kreis **May, 1986**

0 2000'

mn 6396 HGK/dam tucson 6/86

TABLE 14. THIN SECTION EXAMINATION

ROCK NAME *Igneous Rocks* — *Superior East HGK 1986*

Biot. alteration products

Hole	Depth	Rock Type	Degree of Alt.	Bio.	K-f.	Qtz.	Ser.	Clay	Chl.	Mg.	Epid.	Cal.	Mus.
AI-1	3261	Qmp	0										
DCA-2A	1547	Gdp	100							+			###
DCA-3A	4334	Qmp	15							+			+
	4512	Qm	0										
	4747	Gd	0										
LB-4	2600	Gd	0						Tr				
	3410	Gd	0						Tr				
	4850	Gd	0						Tr				
A-2W	4242	Qmp	100					###					
A-2	4301	Qmp	100										###
	4308	Qmp	Tr						Tr				
	4394	Qm	0										
	4499	Qmp	0										
A-2W	4541	Qmp	10						+				
	4910	Gdp	100				+						###
A-4	6656	Gdp	10						+				
A-8	3883	Qfp	50	###									
	4111	Qmp	0										
	4614	Fgr	100				###						
	4622	Qmp	60					##	+				
	4726	Fgr	0										
A-9	4026	Fgr	10					Tr	Tr				
	4159	Fgr	Tr										Tr
	4202	Qfp	100	###									
	4580	Qfp	100	###									
	4734	Fgr	80										###
A-10	3436	Fgr	0										
	3691	Qfp	90	###									
	3687	Fgr	0										
	3891	Fgr	0										
	4052	Qmp	0										
	4163	Fgr	0										
	4180	Qmp	100				##						###
	4264	Qmp	0										
	4278	Fgr	0										
A-12A	4129	Fgr	100										###
	4136	Qm	100										###
	4195	Fgr	100				+?	+?					
A-12	4589	Qmp	80										###
	4627	Fgr	100										###
	5368	Qm	30										+
	5393	Qmp	0										
	5417	Gdp	0										
	5486	Gd	Tr									Tr	
	5551	Gd	0										
	5623	Gd	0										

Plag. alteration products

Hole	Depth	Rock Type	Degree of Alt.	Bio.	K-f.	Qtz.	Ser.	Clay	Chl.	Mg.	Epid.	Cal.	Allophane	Mus.	
AI-1	3261	Qmp	2				+					+			
DCA-2A	1547	Gdp	90		Tr?		###								
DCA-3A	4334	Qmp	50				+	###							
	4512	Qm	Tr				Tr	Tr				Tr			
	4747	Gd	5				+	+							
LB-4	2600	Gd	0												
	3410	Gd	Tr				Tr	Tr							
	4850	Gd	Tr				Tr					Tr			
A-2W	4242	Qmp	100					###							
A-2	4301	Qmp	90				###								
	4308	Qmp	100				+	###				Tr			
	4394	Qm	25				##	+							
	4499	Qmp	100				+	###							
A-2W	4541	Qmp	50				+	###				+			
	4910	Gdp	100				###								
A-4	6656	Gdp	5				+	Tr				Tr			
A-8	3883	Qfp	100?					###							
	4111	Qmp	100?					###				Tr	+		
	4614	Fgr	100				###	+							
	4622	Qmp	70				+	###				Tr			
	4726	Fgr	50				+	###				Tr			
A-9	4026	Fgr	90			Tr		###							
	4159	Fgr	50?					###				+			
	4202	Qfp	100 of phenos		+			###							
	4580	Qfp	?		+			+							
	4734	Fgr	80		+		+	###				+			
A-10	3436	Fgr	50				+	###							
	3691	Qfp	70?	+	+?		+	###							
	3687	Fgr	10				+	###							
	3891	Fgr	100				+	###							
	4052	Qmp	80	+			+	###				Tr			
	4163	Fgr	30					###				+			
	4180	Qmp	100			+	###								
	4264	Qmp	20				##	###							
	4278	Fgr	10				+	##						+	
A-12A	4129	Fgr	100				##	###							
	4136	Qm	100				##	###							
	4195	Fgr	100		?		Tr	###							
A-12	4589	Qmp	100				##	###							
	4627	Fgr	100				Tr	###							
	5368	Qm	15				###	+				+			
	5393	Qmp	15				+	Tr			+	+			+
	5417	Gdp	15					###				+			Tr
	5486	Gd	10		Tr		+	###				##			
	5551	Gd	6					+				+		Tr	Tr
	5623	Gd	5				Tr	Tr				##			

Ortho. alteration products

Hole	Depth	Rock Type	Degree of Alt.	Bio.	K-f.	Qtz.	Ser.	Clay	Chl.	Mg.	Epid.	Cal.
AI-1	3261	Qmp	0									
DCA-2A	1547	Gdp	Tr				Tr					
DCA-3A	4334	Qmp	0									
	4512	Qm	0									
	4747	Gd	0									
LB-4	2600	Gd	0									
	3410	Gd	0									
	4850	Gd	0									
A-2W	4242	Qmp	0									
A-2	4301	Qmp	40				###					
	4308	Qmp	0									
	4394	Qm	Tr									
	4499	Qmp	0									
A-2W	4541	Qmp	0									
	4910	Gdp	0									
A-4	6656	Gdp	0									
A-8	3883	Qfp	0									
	4111	Qmp	0									
	4614	Fgr	100			+	###					
	4622	Qmp	0									
	4726	Fgr	0									
A-9	4026	Fgr	0									
	4159	Fgr	3									+
	4202	Qfp	–									
	4580	Qfp	–									
	4734	Fgr	0									
A-10	3436	Fgr	0									
	3691	Qfp	?	##				+?				
	3687	Fgr	0									
	3891	Fgr	0									
	4052	Qmp	Tr	Tr			Tr					
	4163	Fgr	0									
	4180	Qmp	100			+	###					
	4264	Qmp	0									
	4278	Fgr	Tr				+					
A-12A	4129	Fgr	<5				+					
	4136	Qm	≤10				+					
	4195	Fgr	0									
A-12	4589	Qmp	0									
	4627	Fgr	0									
	5368	Qm	0									
	5393	Qmp	0									
	5417	Gdp	0									
	5486	Gd	2				+					
	5551	Gd	0									
	5623	Gd	0									

% alteration products

Hole	Depth	Rock Type	Bio.	K-f.	Qtz.	Ser.	Clay	Chl.	Mg.	Epid.	Cal.	Mus.	Anh.	Allophane
AI-1	3261	Qmp				½					1			
DCA-2A	1547	Gdp		Tr?		58			3			3		
DCA-3A	4334	Qmp				3	17		2			1		
	4512	Qm				½	½		½		Tr	1		
	4747	Gd				1	2		½					
LB-4	2600	Gd						Tr						
	3410	Gd				Tr	Tr	Tr						
	4850	Gd				Tr		Tr			Tr			
A-2W	4242	Qmp					48		1			Tr		
A-2	4301	Qmp				40			½			2		
	4308	Qmp		Tr		3	40	Tr	Tr		Tr			
	4394	Qm				4	4		Tr		Tr	Tr		
	4499	Qmp				4	31							
A-2W	4541	Qmp				2	14	Tr			4	Tr		
	4910	Gdp				50						6		
A-4	6656	Gdp				3	Tr	1			Tr			
A-8	3883	Qfp	4	1		1	12							
	4111	Qmp					30		½		Tr			9
	4614	Fgr			12	47	7							
	4622	Qmp				3	20	1	Tr		1	1		
	4726	Fgr				1	6				Tr			
A-9	4026	Fgr			Tr		20		Tr					
	4159	Fgr	?			1	5				3			
	4202	Qfp	12	5			5				4			
	4580	Qfp	15	3		2	4				2			
	4734	Fgr	?	1		1	10					3		
A-10	3436	Fgr				2	10		Tr					
	3691	Qfp	9	4?		2	12		2		½	Tr		
	3687	Fgr				1	4		Tr					
	3891	Fgr				2	12		½					
	4052	Qmp	2			2	17		½		Tr			
	4163	Fgr		?		1	5	Tr	½		1		½	
	4180	Qmp			10?	48	5					Tr		
	4264	Qmp				1	4	Tr	½		2	Tr		
	4278	Fgr				2	1					Tr		
A-12A	4129	Fgr				4	8		Tr			2		
	4136	Qm				10	17					2		
	4195	Fgr				1	9							
A-12	4589	Qmp				7	23		Tr		2	1		
	4627	Fgr				1	14					2		
	5368	Qm	Tr			3	1				½	1		
	5393	Qmp				1	1		½		3		4	
	5417	Gdp					7		½		2		Tr	
	5486	Gd		Tr		2	5		½				½	
	5551	Gd				½	2		Tr		2	Tr	½	
	5623	Gd				Tr	Tr		1		2			

Explanation

Degree of Alteration: shows percentage of mineral replaced by alteration products.

+ : relative abundance of the particular alteration mineral replacing the specified rock forming mineral. ### is the most abundant.

% Alteration Productions: percentage of whole rock.

SUPERIOR EAST PROJECT

Compilation of Alteration in Igneous Rocks

H.G. Kreis May 1986

Compiled from Individual Thin Section Reports

In the kaolinite alteration the total kaolinite content of the rock varies from 5 to 30%. Typically 1 to 5% sericite, 0 to 2% calcite, and local traces of secondary biotite also occur with the kaolinite in the altered plagioclase sites. Kaolinite selectively replaces the plagioclase by starting in the cores of plagioclase phenocrysts and then, as its degree of replacement increases, in the rims of plagioclase phenocrysts and in the groundmass plagioclase.

Sericite Alteration

Strong sericite alteration was observed in a number of thin sections. In several of these sections it was obvious that the sericite alteration was occurring along quartz veins or fractures in selvage form. A few thin sections showed uniformly pervasive sericitization throughout the thin section, but these are thought to be thick alteration selvages rather than an area of pervasive sericitization

In every case this sericitization occurs in igneous rocks having varying degrees of kaolinite alteration. Apparently the sericitization is superimposed upon the kaolinite alteration. Commonly, the sericitization is accompanied by disseminated sulfides and minor amounts of quartz (vein flooding and/or alteration quartz). The effects of sericite alteration are summarized in Table 16.

Table 16. Sericite Selvage Alteration

Alteration Type	Kaolinite and minor sericite	Sericite with some quartz flooding	Quartz Vein with or without sulfides.
Rock Type	Igneous host rock, mostly Qmp and F-g.Gr.		
Alteration of Biotite	Fresh to strongly altered to muscovite. Local minor chlorite and clay replacement.	Moderately to strongly to muscovite and/or sericite	
Alteration of Plagioclase	Moderately to strongly altered to kaolinite with minor sericite and traces of calcite.	Strongly altered to sericite	
Alteration of Orthoclase	Fresh	Weakly to strongly altered quartz sericite	
Sulfides	Sulfides with weak to moderate copper grades.	Stronger sulfides and higher copper grades.	

One of the common characteristics of sericite alteration is the variable grain size of the sericite. Some of the sericite becomes sufficiently coarse and plately that it could be called muscovite. Occasionally some of the coarser sericite formed with a rosette texture.

Some examples of sericite alteration are: A-10 4180', A-10 4614', A-2 4301', A-2 4412', A-2 4445', and A-2W 4910'. Thin section DCA-2A, 1547' has strong sericite replacement of plagioclase and strong muscovite replacement of biotite. The DCA-2A geologic log describes the interval from 1540' to 1620' as being fresh granite; so, presumably the DCA-2A, 1547' thin section represents sericite selvage type alteration.

No zone of pervasive sericite alteration, such as that observed at Santa Cruz, exists in the examined thin sections. In all probability such a zone exists in the Superior East project area, but it has yet to be located. An examination of the thin sections used in this report provides an inadequate data base to predict the location of such a sericite zone. Predicting the location of a sericite zone will require logging the core using appropriate logging criteria.

Biotite-Orthoclase Alteration

Biotite-orthoclase alteration affects the quartz-feldspar porphyry rocks (Table 8). This type of alteration is characterized by strong biotite replacement of biotite (and/or hornblende) phenocrysts and weak orthoclase replacement of plagioclase. The secondary biotite is fine grained and pseudomorphic. The secondary orthoclase partially replaces plagioclase phenocrysts in disseminated form and in vein selvages. Most, if not all, of the plagioclase not replaced by orthoclase is replaced by kaolinite.

The effects of biotite-orthoclase alteration are somewhat difficult to assess because of the texture of quartz-feldspar porphyry. The phenocrysts are fine-grained in size and sparse in abundance. The groundmass, ≥80% of the rock, is aphanitic so its composition and alteration cannot be evaluated with the microscope used in this report.

Biotite-orthoclase alteration is not exhibited in the other igneous rock type categories. This is probably a function of alteration-intrusive timing rather than a function of rock chemistry. The biotite-orthoclase alteration appears to be the first alteration event, postdating the quartz-feldspar porphyry dikes and predating the other igneous rock types and the other alteration types.

DRILL HOLE REMARKS

This section is composed of remarks about the igneous rock petrography and alteration encountered in the individual drill holes. As previously mentioned the descriptions of each thin section are in Appendix I.

A-2 and A-2W Drill Holes

The thin sections of A-2 (and A-2W) presented something of a problem for petrographic descriptions. A number of the thin sections are in poor physical condition because of cracked balsam, and some slides had too small an area of rock to obtain a representative description. Many of the thin sections are predominated by thick quartz veins and strong sericite selvages along the quartz veins.

The igneous rocks of A-2 (and A-2W) consist of two types: quartz monzonite porphyry and porphyritic quartz monzonite. Although there are not many appropriate thin sections for texture and composition determinations, some reconnaissance grade comparisons can be made. The compositions of the two rock types are similar, but the quartz monzonite porphyry has a higher ratio of plagioclase to orthoclase.

The quartz monzonite porphyry contains equal amounts of phenocrysts and groundmass. The phenocrysts are typically 1 to 5 mm in size, and the groundmass is 0.1 to 0.2 mm in size.

The porphyritic quartz monzonite is composed of grains 0.2 to 0.4 mm in size which are coarser than the groundmass of the quartz monzonite porphyry. A small percentage of phenocrysts, 1 to 1.5 mm in size, give the rock a weakly developed porphyritic texture.

The quartz monzonite porphyry of A-2 exhibits total replacement of plagioclase by kaolinite at 4242', 4308', and 4499'. The degree of biotite alteration varies from fresh to totally clay altered. In all the sections the orthoclase is unaltered.

A thin section of quartz monzonite porphyry at 4301' has strong sericitization of plagioclase, weak sericitization of orthoclase, and strong replacement of biotite by muscovite. It appears that this alteration is selvage type alteration associated with quartz veining.

Three thin sections of porphyritic quartz monzonite (4394', 4412', and 4445') are sericite and quartz-sericite altered, and this is probably quartz vein selvage type alteration. Away from the stronger selvage alteration the plagioclase is moderately altered to a mixture of kaolinite and sericite.

A-4 Drill Hole

Three thin sections of granodiorite porphyry in A-4, 6610-6664'T.D., exhibit very weak chlorite-calcite-sericite-sulfide-anhydrite. The total abundance of these minerals is 10% at 6612', but less than 5% at 6656' and 6657'. All the sections contain 1 to 2% magnetite and traces of sulfide. There is no supergene oxidation and the interval averages 0.04% Cu and 0.0024% Mo. The composition of this porphyry is similar to that of the Schultze Granite. Although definitely porphyritic, the porphyry texture of A-4 6656' is gradational between the strongly porphyritic texture of A-4 6612' and the Schultze Granite (as in LB-4). The weak chlorite-calcite and fluid inclusions suggest fringe alteration-mineralization, while the texture of the porphyry and the presence of anhydrite suggest the possibility of an interior position.

A-8 Drill Hole

The thin sections of A-8 igneous rocks show three rock types: quartz-feldspar porphyry, quartz monzonite porphyry, and fine-grained granite. The quartz-feldspar porphyry, 3883', is composed of 15% plagioclase >> quartz phenocrysts and a groundmass that is too fine-grained to determine its composition.

Both thin sections of quartz monzonite porphyry, 4111' and 4622', are typical of quartz monzonite porphyry in other holes, but these two sections contain more K-feldspar phenocrysts. The K-feldspar phenocrysts make up 7 to 10% of the rock and 20% of the amount of phenocrysts. In one section the phenocrysts are 1 to 3 mm in size and in the other 10 mm in size.

Thin sections of fine-grained granite are from 4614' and 4726'. The fine-grained granite is of the same composition and texture of fine-grained granite in other holes.

The alteration in A-8 is typical, total to near total replacement of plagioclase by kaolinite with local strong sericitization in selvages along veins. There are a few minor variations of this kaolinite alteration. In the quartz-feldspar porphyry at 3883' an elongate mafic mineral was replaced by secondary biotite; so there is 4-8% secondary biotite associated with total (?) kaolinite replacement of the plagioclase. In the quartz monzonite porphyry at 4111' allophane, probably of supergene origin, occurs with kaolinite in totally altered plagioclase sites.

A-9 Drill Hole

There are two types of igneous rocks in A-9: porphyritic fine-grained granite and quartz-feldspar porphyry. The porphyritic fine-grained granite, as seen in thin sections at 4026', 4159', and 4734', is a porphyritic variety of fine-grained granite. Its porphyritic texture is composed of K-feldspar and/or plagioclase phenocrysts 1 mm to 2 mm in size set in a quartz-K-feldspar-plagioclase matrix 0.1 mm to 0.7 mm in size. Some of the K-feldspar phenocrysts exhibit Carlsbad twinning.

The quartz-feldspar porphyry occurs at 4202' in a 6' thick vertical intercept. It is composed of 8% plagioclase phenocrysts (0.6 mm in size) and 1% quartz phenocrysts set in an aphanitic groundmass 0.02 mm in size. The texture and the apparent composition of this groundmass appears to be the same as the rock called aphanite at 4580'. Although the aphanite at 4580' is not porphyritic it is thought to be the same igneous rock as the quartz-feldspar porphyry. Both the aphanite and the quartz-feldspar porphyry had a former mafic mineral, biotite or hornblende, that was totally replaced by secondary biotite.

Both the quartz-feldspar porphyry (4202') and the aphanite (4580') exhibit biotite-orthoclase alteration. As previously mentioned, secondary biotite completely replaces a former mafic mineral. In addition there is abundant (10%) fine-grained biotite disseminated throughout the rock, and it appears to be secondary biotite. Five to 8% of the rock consists of biotite-orthoclase replacement veins that are up to 3 mm in thickness. Some clay alteration was noted along one of these veins. Pervasive alteration is not readily discernible because of the aphanitic texture of the rock.

The alteration of the porphyritic fine-grained granite in A-9 is typical of that observed in nearby drill holes. Plagioclase is moderately to strongly replaced by kaolinite and very small amounts of calcite. Biotite is fresh except in one thin section where it was nearly totally altered to muscovite.

A-10 Drill Hole

There are three igneous rock types in A-10: fine-grained granite (3436', 3697', 3891', 4163', and 4278'), feldspar porphyry (3691'), and quartz monzonite porphyry (4052' and 4264'). The fine-grained granite has a hypidiomorphic granular texture with most grains 0.1 to 0.3 mm in size. The fine-grained granite is weakly porphyritic with 5 to 10%, 0.5 to 1.5 mm sized phenocrysts in the upper three thin sections. The porphyritic texture is more strongly developed in the lower two thin sections where 15%, 1 to 3 mm sized phenocrysts are present. Distinctive 1 to 3 mm sized quartz phenocrysts (eyes) are a characteristic of the lower two fine-grained granite thin sections. These quartz phenocrysts are similar to those in the quartz monzonite porphyry.

The quartz monzonite porphyry has 40% phenocrysts, 1 to 6 mm in size, and 60% groundmass, 0.02 to 0.1 mm in size. The phenocrysts are composed of 66% plagioclase (1 to 3 mm in size), 20% quartz (1 to 6 mm in size), 9% biotite (1 mm in size), and 0 to 10% orthoclase (4 mm in size). The groundmass is composed of 54% orthoclase, 32% quartz, 10% plagioclase, and 4% biotite.

Feldsapr porphyry at 3691' consists of 15% phenocrysts (1 mm in size) and 85% groundmass (0.02 mm in size). The phenocrysts are composed of 90% plagioclase and 10% biotite. The groundmass is too fine-grained to determine its composition. There is abundant fine-grained biotite in the feldspar porphyry. Some of this biotite is obviously secondary, occurring in clumps, along veins, and in altered plagioclase sites. In the feldspar porphyry most of the rock forming biotite is replaced by secondary biotite, and most of the plagioclase is replaced by kaolinite with minor sericite and biotite. A small amount of secondary orthoclase occurs in vein form.

The alteration of the gine-grained granite and quartz monzonite porphyry is typical kaolinite type alteration. The plagioclase in these rock types is 10% to 100% replaced by kaolinite with small amounts of sericite, calcite, and biotite. The plagioclase appears to be less altered with depth. The biotite and orthoclase in these rock types are unaltered except where sericite selvages are present. Every one of the thin sections of these rock types has 1% to 3% quartz veining present.

A-12 and A-12A Drill Hole

There are three igneous rock types in A-12 (and A-12A): fine-grained granite, quartz monzonite porphyry, and granodiorite (Schultze Granite). The fine-grained granite occurs as ≤10' thick dikes above a depth of 4900'. The granodiorite is part of an igneous rock intercept from 5450' to 5650', and it may have been part of the Schultze Granite stock as the lower contact at 5650' is a strong fault. The quartz monzonite porphyry is at 4589'.

The fine-grained granite has a composition of 3% biotite, 15% plagioclase, 57% orthoclase, and 25% quartz. The texture is fine-grained, allotriomorphic-granular with grains 0.2 to 1 mm in size. Many of the orthoclase grains exhibit Carlsbad twinning.

The geologic log of A-12 describes porphyry from 5357' to 5650'. Thin sections at 5368', 5393', and 5417' are respectively quartz monzonite (fine-grained texture), quartz monzonite porphyry, and granodiorite porphyry. Thin sections at 5486', 5551', and 5623' are granodiorite of uniform texture and composition, and they have the same texture and composition as the granodiorite (Schultze Granite) in drill hole LB-4. This granodiorite may have been faulted off the Schultze Granite stock as suggested by rock type similarities and a strong fault at the lower contact (5650' according to the geologic log). The granodiorite porphyry at 5417' is simply the granodiorite with 20% 0.1 mm sized, quartz-orthoclase groundmass. The quartz monzonite at 5368' and the quartz monzonite porphyry at 5393' are either a contact phenomena of the granodiorite or a separate intrusive phase.

The alteration ofthe igneous rocks in A-12 is summarized in Table 15. There are essentially two types of alteration in the igneous rocks of A-12. In the upper part of the hole, 4129' to 4627', there is 100% alteration of plagioclase to kaolinite >> sericite, and 30% to 100% replacement of the biotite by muscovite. This alteration is associated with pervasive copper grades of ≥0.3% Cu. Below 5417', in the granodiorite, the plagioclase is very weakly altered to kaolinite-sericite-calcite-trace anhydrite. This alteration is associated with weak copper mineralization having a grade of 0.01 to 0.09% Cu. This weak alteration and mineralization are suggestive of the interior (core) of the sulfide system.

AI-1 Drill Hole

Drill hole AI-1 has one igneous rock thin section, quartz monzonite porphyry at 3261'. This quartz monzonite porphyry has 20% phenocrysts, 1 to 3 mm in size, and 80% groundmass, 0.05 mm in size. The rock forming minerals are unaltered except for some very minor calcite-sericite (2%) in the plagioclase. There is 8% fine-grained biotite in the groundmass of the porphyry, but it is primary in origin. It is often elongated, and it may be the mineral now represented by elongate, secondary biotite pseudomorphs in quartz-feldspar porphyry.

DCA-2A Drill Hole

There is only one igneous rock thin section in DCA-2A, and it is of granodiorite porphyry (1547'). It was taken from an interval, 1540' to 1676', described in the log as fresh Schultze Granite. The texture and composition of this granodiorite porphyry is the same as that in A-4, 6610' to 6664' (T.D.).

The DCA-2A 1547' thin section shows strong sericitization of plagioclase and strong muscovite-magnetite replacement of biotite. Since the geologic log describes the interval in which this thin section occurs as being fresh, this sericitization is probably selvage type alteration.

DCA-3A Drill Hole

Thin sections of DCA-3A igneous rocks from depths of 4334', 4512', and 4747' were examined. The rock at 4747' is quartz monzonite porphyry. It is composed of 60% phenocrysts, most being 0.5 to 1 mm in size. Forty percent of the quartz monzonite porphyry is groundmass, and it has a variable 0.05 to 1 mm grain size. The quartz monzonite porphyry has moderate kaolinite replacement of the plagioclase and weak muscovite replacement of the biotite.

Quartz monzonite at 4512' may be a compositional variation of fine-grained granite. It has a 0.2 to 1 mm sized, hypidiomorphic granular texture and is slightly porphyritic. The quartz monzonite is virtually fresh with only 2% sericite-muscovite-clay alteration.

At 4747' the rock is fine-to-medium-grained, porphyritic granodiorite. The texture varies from hypidiomorphic granular to the initial stages of porphyritic textural development with up to 10% fine-grained quartz-orthoclase. Several 5 mm sized quartz eyes give the rock an obvious porphyritic texture. The alteration in this porphyritic granodiorite is very weak clay-sericite replacement of plagioclase.

LB-4 Drill Hole

Drill hole LB-4 penetrated unmineralized, unaltered granodiorite from 334' to the bottom of the hole at 4860' T.D. This granodiorite is part of the Schultze Granite stock that outcrops from the east edge of the Superior East project to the west side of the town of Miami. Thin sections from 2600', 3410', and 4850' have an average composition of 3% biotite, 56% plagioclase, 19% orthoclase, and 22% quartz. The texture is medium-grained, hypidiomorphic granular, and the grains of plagioclase are typically 1 to 3 mm in length. The plagioclase is commonly zoned with some weakly developed polysynthetic twinning. The orthoclase varies from interstitial to poikiloblastic (8 mm in size).

The texture and mineral composition of this granodiorite (Schultze Granite) are typical of a Laramide stock having associated porphyry copper mineralization. The mineral composition of the granodiorite is very similar to that of the Three Peaks-Sacaton Peak-Mineral Mountain stock (9% biotite, 53% plagioclase, 15% K-feldspar, 22% Quartz, and 0 to 1% hornblende).

The fluid inclusions of LB-4 are the subject of a memo by F.T. Graybeal, February 13, 1975. Graybeal found locally abundant, low temperature fluid inclusions. The abundance of Type I inclusions is <1% and Types II and III are absent.

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