CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
416 W. Congress St., Suite 100
Tucson, Arizona 85701
520-770-3500
http://www.azgs.az.gov
inquiries@azgs.az.gov

The following file is part of the

James Doyle Sell Mining Collection

ACCESS STATEMENT

These digitized collections are accessible for purposes of education and research. We have indicated what we know about copyright and rights of privacy, publicity, or trademark. Due to the nature of archival collections, we are not always able to identify this information. We are eager to hear from any rights owners, so that we may obtain accurate information. Upon request, we will remove material from public view while we address a rights issue.

CONSTRAINTS STATEMENT

The Arizona Geological Survey does not claim to control all rights for all materials in its collection. These rights include, but are not limited to: copyright, privacy rights, and cultural protection rights. The User hereby assumes all responsibility for obtaining any rights to use the material in excess of "fair use."

The Survey makes no intellectual property claims to the products created by individual authors in the manuscript collections, except when the author deeded those rights to the Survey or when those authors were employed by the State of Arizona and created intellectual products as a function of their official duties. The Survey does maintain property rights to the physical and digital representations of the works.

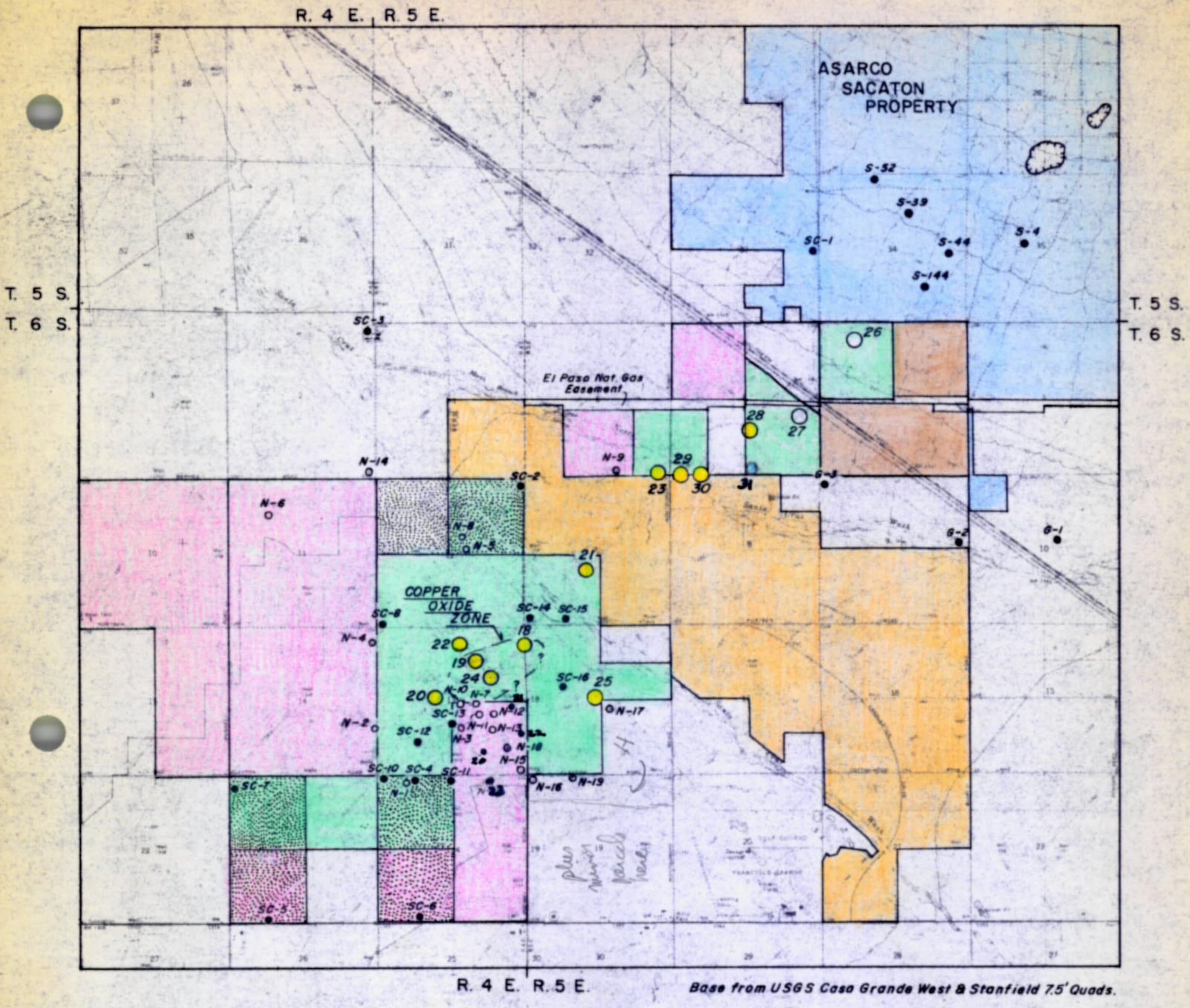
QUALITY STATEMENT

The Arizona Geological Survey is not responsible for the accuracy of the records, information, or opinions that may be contained in the files. The Survey collects, catalogs, and archives data on mineral properties regardless of its views of the veracity or accuracy of those data.

TO-FRED GRAYBEAL

FROM— R.E. LEHNER

[redacted]



Base from USGS Casa Grande West & Stanfield 7.5' Quads.

EXPLANATION

🟩 ASARCO-FREEPORT
▨ Newmont Federal Lode Claims

🟪 NEWMONT
▨ Newmont Federal Lode Claims

🟧 NAAC

🟫 AMOCO

● PREVIOUS ASARCO DRILL HOLES

○ RECENT ASARCO DRILL HOLES

∘ NEWMONT DRILL HOLES

🟡 SIGNIFICANT INTERCEPTS

SC-18	1670'-120'-0.71 ox	(2513' T.D.)
SC-19	1193'-127'-0.84 ox 16 20'-150'-2.98 ox	(2826' T.D)
SC-20		(2423' T.D.)
SC-21		(2969' T.D.)
SC-22		(2326' T.D.)
SC-23	2430'-220'-1.27 sulf	(2671' T.D.)
SC-24	1180'-100'-0.51 ox 1550'-110'-1.10 ox 2220'-200'-0.58 sulf	(2441' T.D.)
SC-25		(1684' T.D.)
SC-29	2626'-76'-0.94 sulf	
SC-28		(3364 T.D.)
SC-30	2875'-114'-2.03 sulf (2875'-530'-0.75 sulf)	

ASSAY DATA KEY
depth-length-%Cu
1620'-150'-2.92

north

DRILLING PROGRESS
for the ______ quarter of 1976

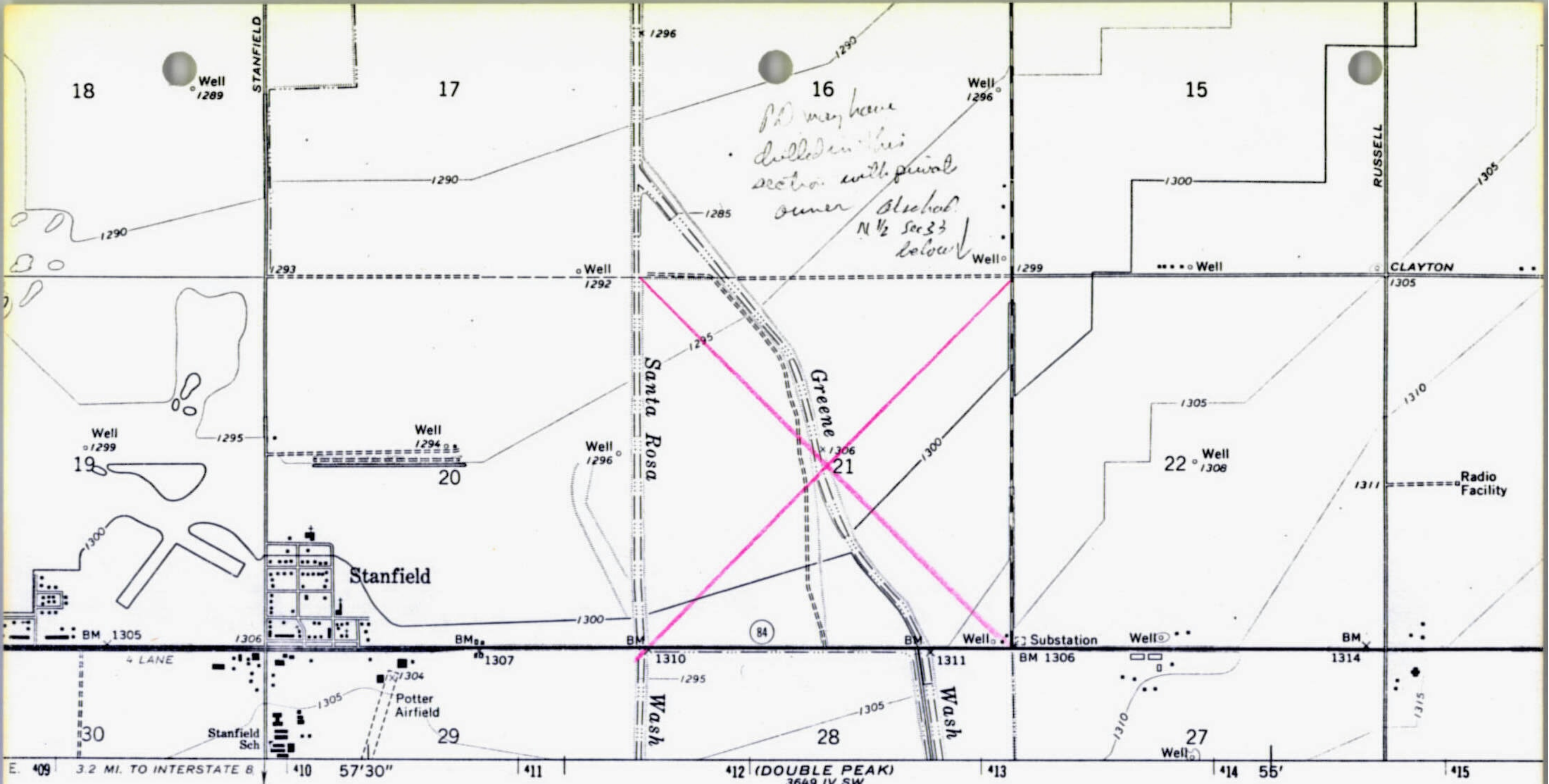
SANTA CRUZ PROJECT
(ASARCO- FREEPORT JOINT VENTURE)

Pinal County., Arizona

SCALE 1" = 1 mile

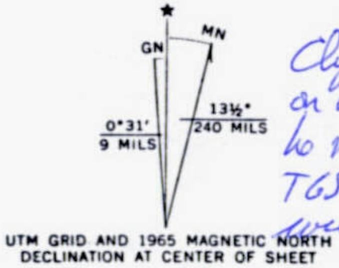
H.G.K
Rev.
June-1976

MVK 2806-A



PD may have drilled in this section with private owner. Also had N½ Sec 33 below

SCALE 1:24 000



UTM GRID AND 1965 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

CONTOUR INTERVAL 5 FEET
DATUM IS MEAN SEA LEVEL

Clyde Caviness called on 8/22/77 to say that he now had State Section 21 T6S, R4E. It is an ex PD section but they did not drill on it. However, Clyde will offer the section to them — if they don't want it he will call back.

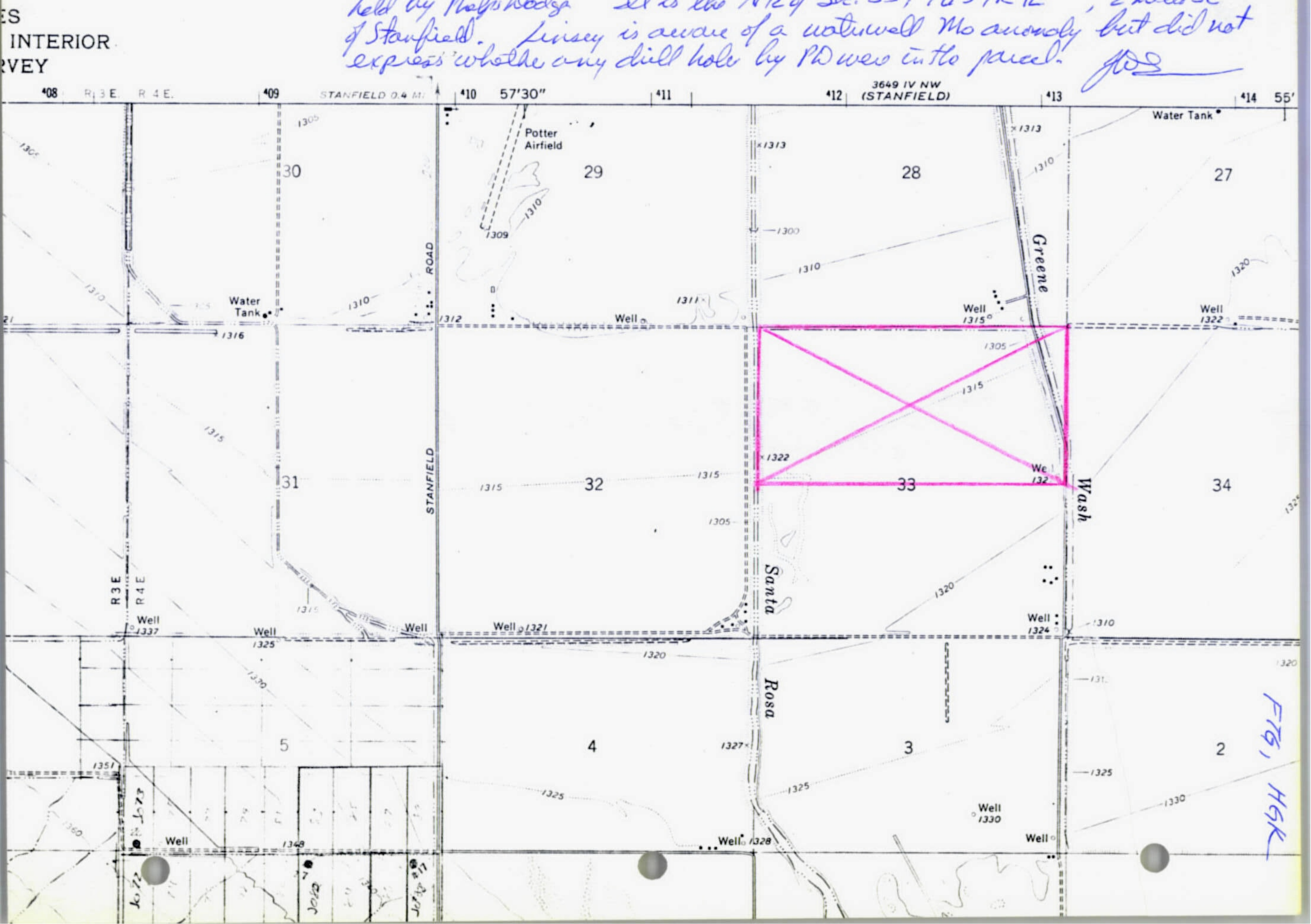
JWS

QUADRANGLE LOCATI

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR WASHINGTON, D. C. 20242
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

cc FTG, HGK.
RBC.

Clyde Reese, SLC, verbal 8/10/77, stated that Jim Linsey of Salt Lake called to say that he was now in the possession of the School Section formerly held by Phelps Dodge. It is the N½ of Sec. 33, T6S, R4E, 2 miles SE of Stanfield. Linsey is aware of a waterwell Mo anomaly but did not express whether any drill hole by PD were in the parcel.



F76, H6K

FOR Ariz file JDS

RECEIVED
DEC 4 1978
EXPLORATION DEPARTMENT

FREEPORT

FREEPORT EXPLORATION COMPANY • SECURITY NATIONAL BANK BUILDING, RENO

ADDRESS CORRESPONDENCE P. O. BOX 1911
RENO, NEVADA 89505
702-323-2251
TELEX: 910-395-7008

DOUGLAS R. COOK
President

December 1, 1978

Mr. John T. Cumberlidge
Chief Geologist
The Hanna Mining Company
100 Erieview Plaza
Cleveland, Ohio 44114

Dear John:

Enclosed herewith are four copies of the Letter Agreement and Confidentiality Agreement pertaining to the Santa Cruz - Casa Grande West Drill Hole Trade signed by Tom Osborne and me. Kindly sign all four copies of the Agreements and forward them to Sig Muessig for signature and distribution to each party. Once the Agreements are signed Tom and I suggest that our respective Tucson staffs get together with your Tucson people to arrange details.

Sincerely yours,

DS.

Douglas R. Cook

DRC:tw

Enclosures

cc: T. C. Osborne (w/encs.)
W. Kurtz (w/encs.)
B. T. Walsham (w/encs.)

CONFIDENTIALITY AGREEMENT

FREEPORT COPPER COMPANY, a Delaware corporation, and ASARCO SANTA CRUZ, INC., a Delaware corporation (hereinafter referred to together as "FREEPORT-ASARCO" or a "party") and CASA GRANDE MINING COMPANY, a Delaware corporation, and GETTY OIL COMPANY, a Delaware corporation (hereinafter referred to together as"CASA-GETTY" or a "party") have conducted mineral exploration programs on certain lands (the "Properties") located near Casa Grande, Arizona, as outlined in red on the map attached hereto as Annex A. FREEPORT-ASARCO and CASA-GETTY propose at no cost or expense to the disclosing party to make available to each other from time to time over a period to end December 31, 1988, all assay and core recovery data, of a factual and not interpretive nature, and to permit each other to examine all drill core, related to such parties' exploration activities on the Properties. All such factual data has been or will be marked as "Confidential" and is, together with such drill core, herein referred to as "Confidential Information." It is understood that the term Confidential Information does not include, and this Agreement does not apply to, any information that is printed or published or otherwise known to the public or that is known to the party to which it is disclosed at the time of disclosure as evidenced by written records made available to the disclosing party.

In mutual consideration of the disclosure by such parties to each other of Confidential Information, both parties hereto agree as follows:

(1) The parties will not reveal any Confidential Information of the other party to any third person provided, however, that a party may reveal such Confidential Information to (a) any person, firm or corporation with which such party is carrying on bona fide negotiations for the assignment, sale or other transfer of such party's interest in the Properties, and (b) to a party's officers, directors and employees, to its subsidiaries and affiliates and to their respective officers, directors and employees, but, in every case, only if such persons are directly involved in evaluating such Confidential Information for the purpose of aiding such party in its geological interpretation of mineralization within the Properties. Officers, directors and employees of either party, its subsidiaries and its affiliates are herein called "Employees."

(2) Subject to Paragraph (1) above, the parties will keep, and will cause all persons to whom the Confidential Information is disclosed to keep, all Confidential Information of the other party strictly secret and confidential.

(3) The parties will not make use of, and will not permit any of their subsidiaries, affiliates or Employees to make use of, any of such Confidential Information except for the purposes referred to in Paragraph (1) above.

(4) The parties will restrict access to such Confidential Information to only those subsidiaries, affiliates and Employees who require such access for the purposes referred to in Paragraph (1) above.

(5) All employees of a disclosing party who shall have access to Confidential Information of such party shall be excluded from working for the other party, or for any of its subsidiaries or affiliates within the Properties or within a zone five (5) miles in width adjoining the boundaries of such Properties, for a period of five (5) years from the date of this Agreement unless the party who employs such person shall otherwise consent in writing.

Each party's obligations under Paragraph (1) through (4) above shall terminate at the end of ten (10) years from the date of this Agreement.

It is further understood that no right or obligation of any kind except as herein stated is granted to or acquired by, or assumed by or may be implied against either party hereto unless and until a subsequent formal written agreement has been entered into by the parties, at which point the mutual obligations of the parties to each other shall be only as expressed in said formal written agreement.

The parties hereto make no warranty or representation of any nature with respect to any Confidential Information or the accuracy thereof or with respect to any other information or data supplied to the other party, and no warranty or representation with respect thereto shall be implied.

This Agreement may not be assigned or modified, nor may any provision hereof be waived, except by an instrument in writing signed by both parties hereto.

This Agreement shall be construed in accordance with and shall be governed by the laws of the State of Arizona except that such laws shall not govern the rules relating to the choice or conflict of laws.

The date of this Agreement is December 1, 1978.

FREEPORT COPPER COMPANY

By ______________________

ASARCO SANTA CRUZ, INC.

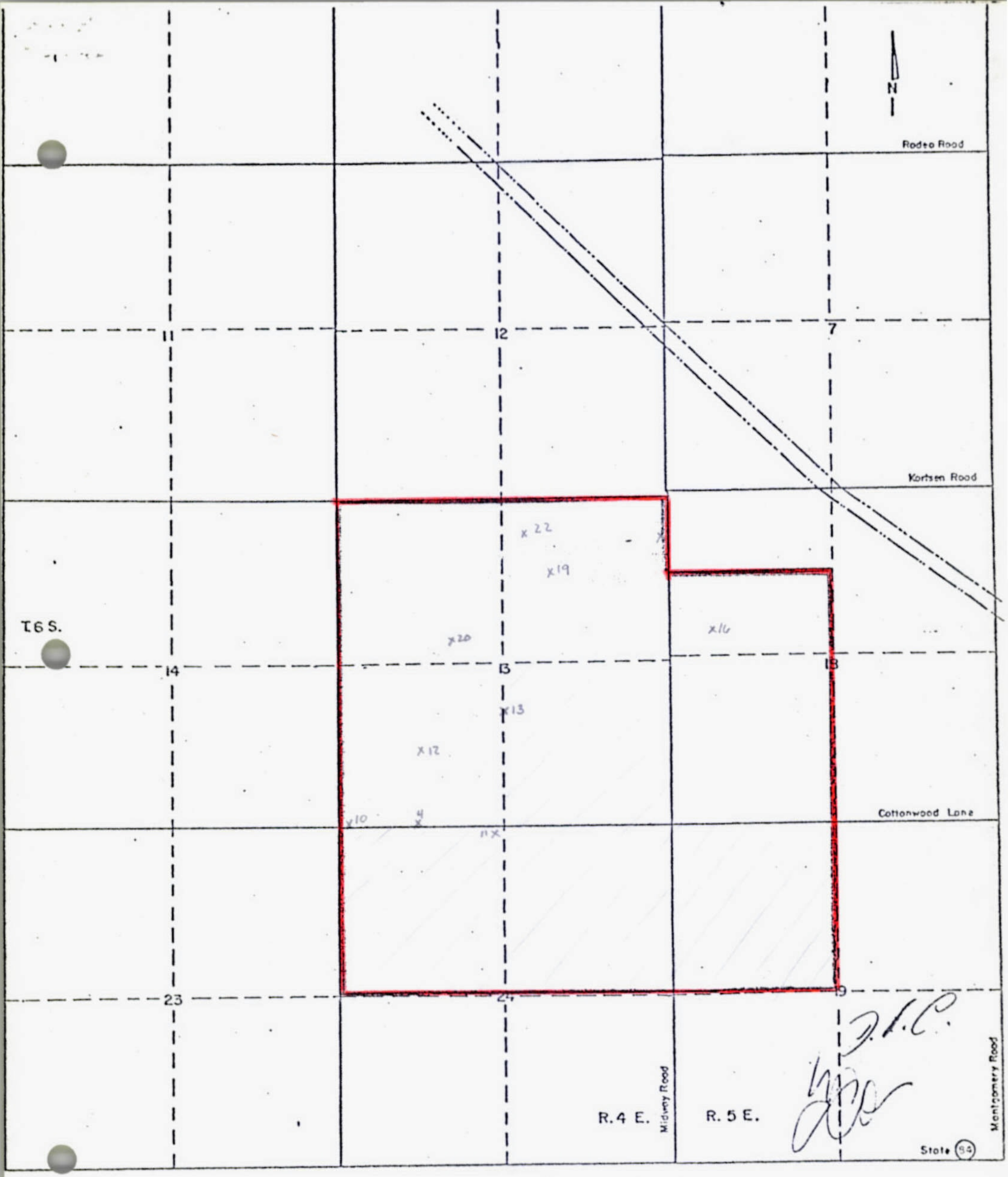
By ______________________

CASA GRANDE MINING COMPANY

By ______________________

GETTY OIL COMPANY

By ______________________



J.L.C.

SANTA CRUZ PROJECT
PINAL COUNTY, ARIZONA
A PORTION OF "THE LANDS"
1"= 2000'

mn 3087 dom

ASARCO SANTA CRUZ INC.
FREEPORT COPPER COMPANY

Mr. Siegfried Muessig
etty Oil Company
3810 Wilshire Blvd.
Los Angeles, California 90010

Mr. John T. Cumberlidge
The Hanna Mining Company
100 Erieview Plaza
Cleveland, Ohio 44114

Dear Sirs:

Freeport Copper Company and Asarco Santa Cruz Inc. (hereinafter called "Freeport-Asarco") propose that Casa Grande Copper Company and Getty Oil Company (hereinafter called "Casa-Getty") exchange with Freeport-Asarco all assay and core recovery data and drill collar coordinates for all surface exploration holes drilled by Casa-Getty and Freeport-Asarco within the area (hereinafter called "exchange area") outlined in red on the enclosed map attached hereto as Annex A. Further, Freeport-Asarco proposes that Casa-Getty and Freeport-Asarco permit at mutually agreeable reasonable times the mutual examination of each other's drill cores from the holes for which it is proposed to exchange assay and core recovery data. The proposed exchange of data and the mutual examinations are to be at no cost and expense to the disclosing party and are intended to cover not only exploration holes drilled to date within the exchange area, but also from time to time until December 31, 1988 the exchange of data and mutual examination of drill cores from xploration holes as they are drilled within the exchange area by both Casa-Getty nd Asarco-Freeport.

If you agree to this proposed exchange, kindly sign all four copies of this letter in the space provided below and execute all four copies of the attached confidentiality agreement, keeping two copies for Casa-Getty and returning two signed copies to Freeport-Asarco.

Very truly yours,

ASARCO SANTA CRUZ INC.

By ____________________
T. C. Osborne

FREEPORT COPPER COMPANY

By ____________________
D. R. Cook

ACCEPTED:

GETTY OIL COMPANY

By ____________________

CASA GRANDE COPPER COMPANY

By ____________________

ASARCO

Southwestern Exploration Division

February 2, 1979

FILE MEMORANDUM

Hanna-Getty Data Exchange

Asarco-Freeport traded data according to the Exchange Agreement with Hanna-Getty on Thursday, February 1. Hanna-Getty had misunderstood the Exchange Agreement and had planned to exchange geologic logs as well as the other information mentioned in the agreement. This misunderstanding was corrected and the exchange was made as stated in the agreement. Current plans are to move Asarco-Freeport core for holes in the exchange area to the Hanna-Getty warehouse where they plan to log them in detail over the next few months. This will eliminate the problem of Hanna-Getty working in our core shack where holes in Peripheral Lands are also stored. Included in our data were assays for hole SC-18 which actually lies 15' outside the area of exchange and Hanna-Getty similarly included several holes close to but outside the area of exchange.

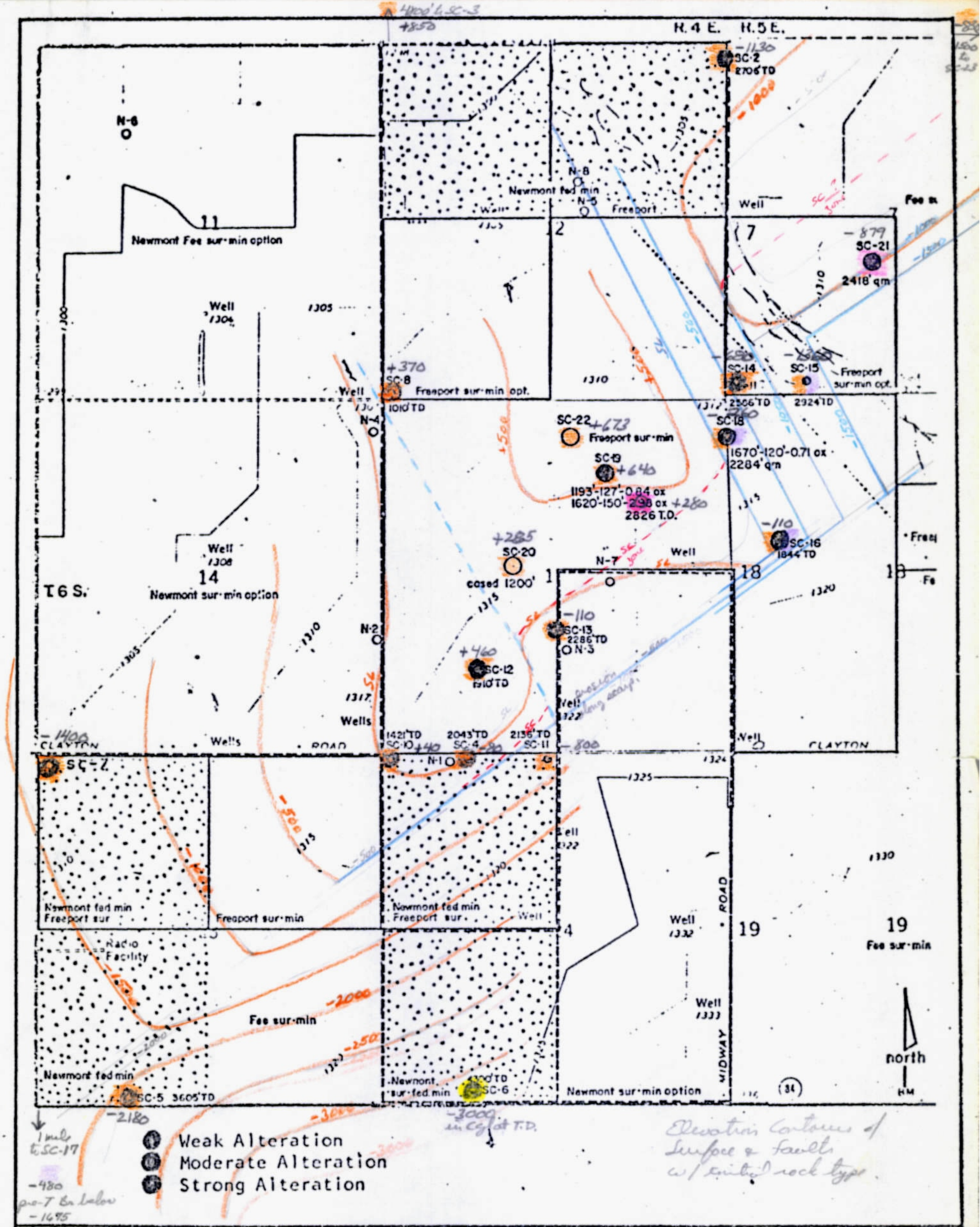
We plan to start moving Asarco-Freeport core by February 6 or 7 and anticipate that logging by Messrs. Kreis and Sell will commence before the middle of February. Asarco-Freeport logging will be done by H. G. Kreis and J. D. Sell at the Hanna-Getty warehouse. Initially we plan to scan briefly all their holes within 500' of the joint boundary and other holes scattered throughout the deposit to the extent that we will be able to draw cross sections which would provide guidance for possible drilling during the second half of 1979. It is possible that additional data may also be exchanged, particularly down-the-hole deviation surveys, thin sections, and possibly other factual information of this type.

F. T. Graybeal

F. T. Graybeal

FTG:lb

cc: WLKurtz
JDSell ✓
HGKreis
BTWalsham



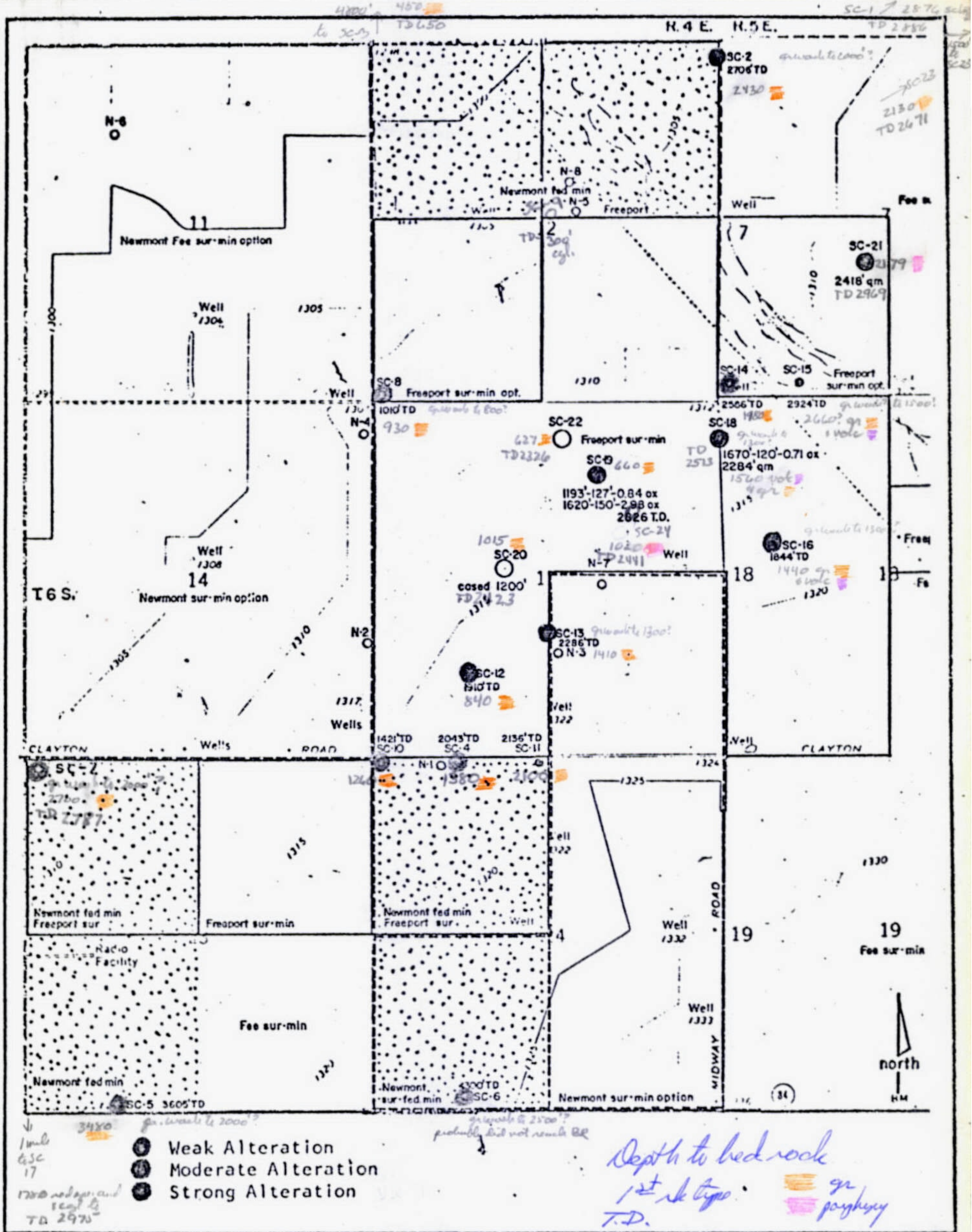
● Weak Alteration

● Moderate Alteration

● Strong Alteration

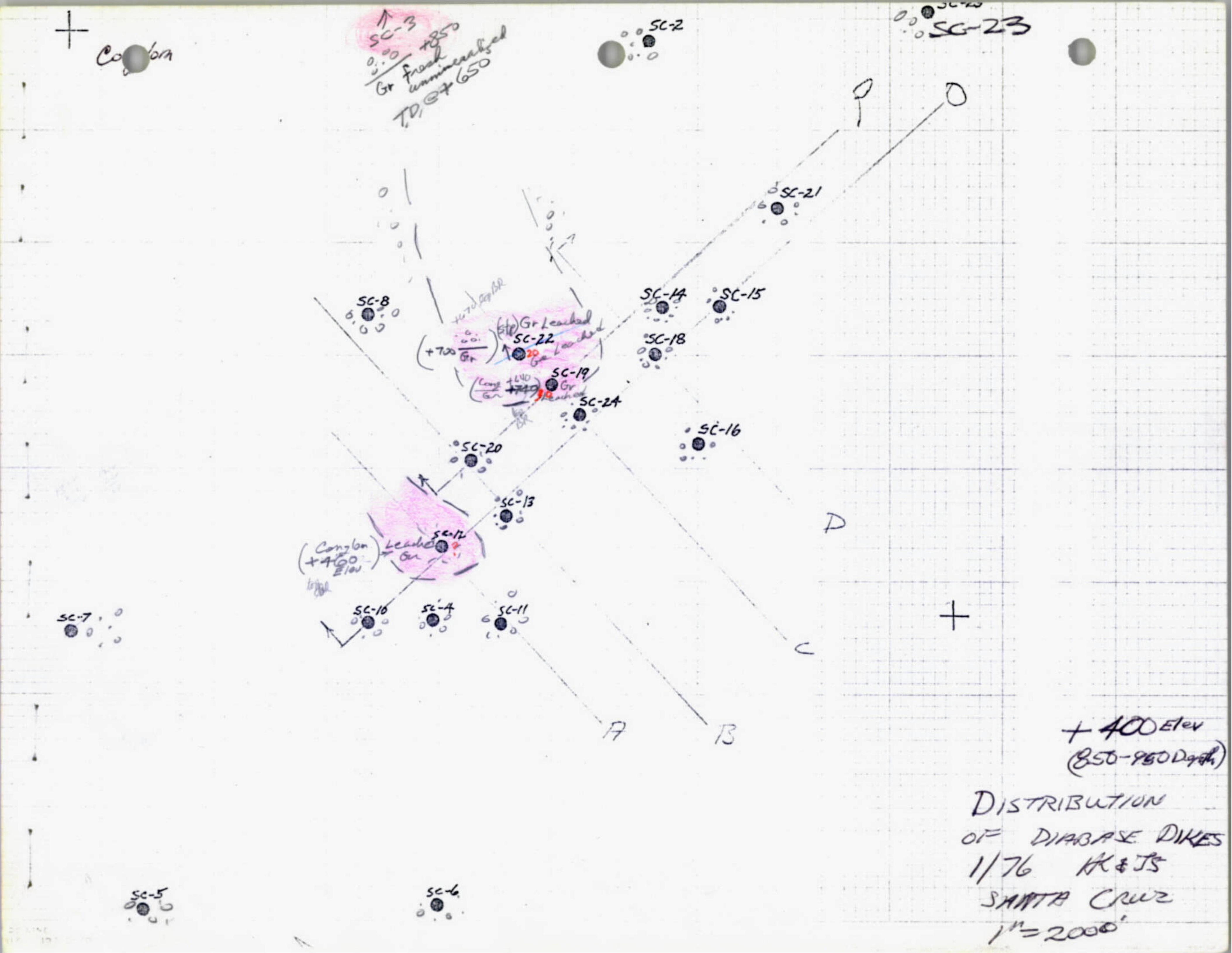
AMERICAN SMELTING AND REFINING COMPANY

area SANTA CRUZ PROJECT	data by GJS	state Arizona	township-range	revisions - date
		county Pinal	map number	PLATE 1
title ALTERATION	drawn by GJS	2000 0 2000 4000 ft		
mining district Casa Grande	date April 75			

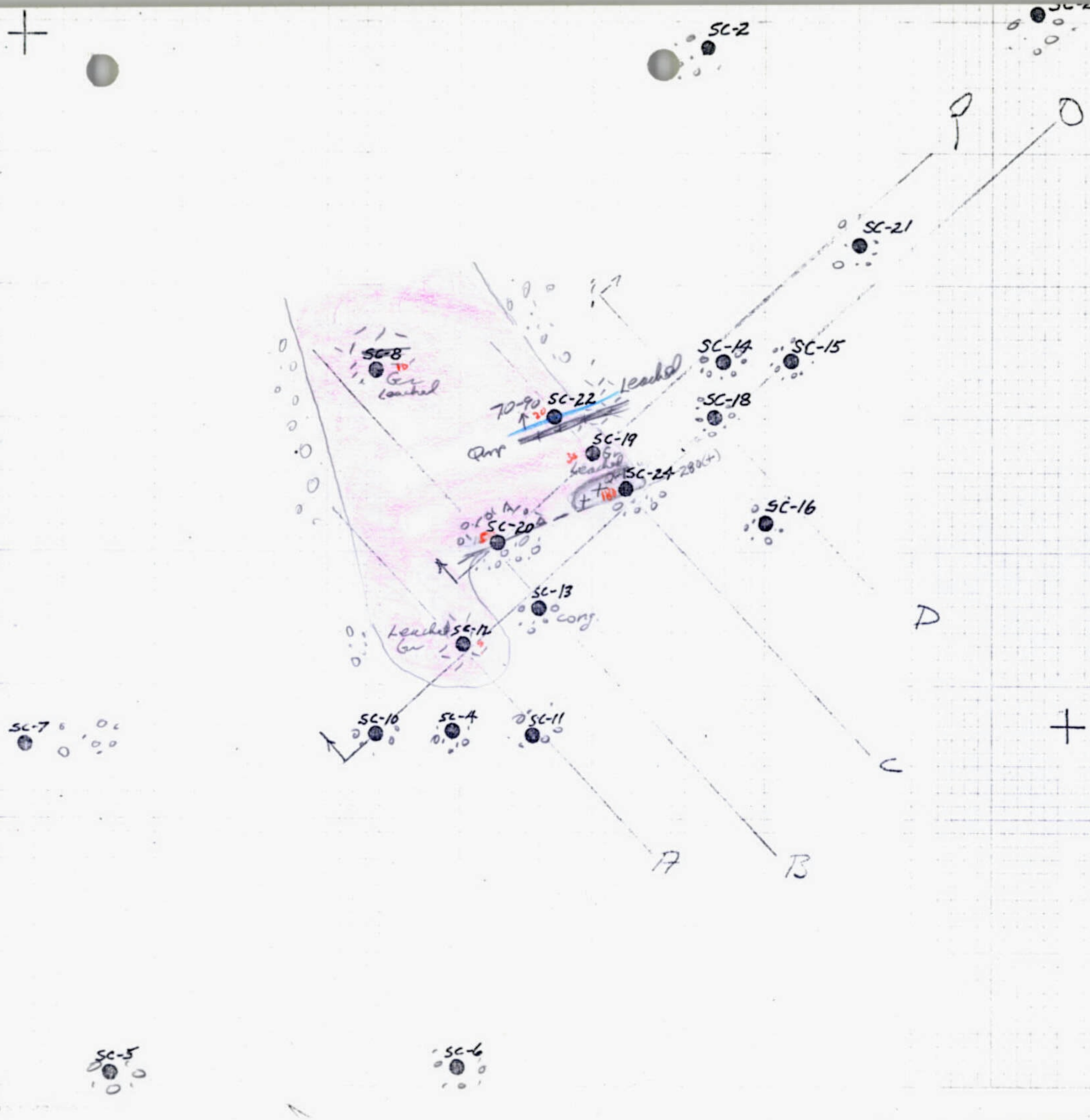


AMERICAN SMELTING AND REFINING COMPANY

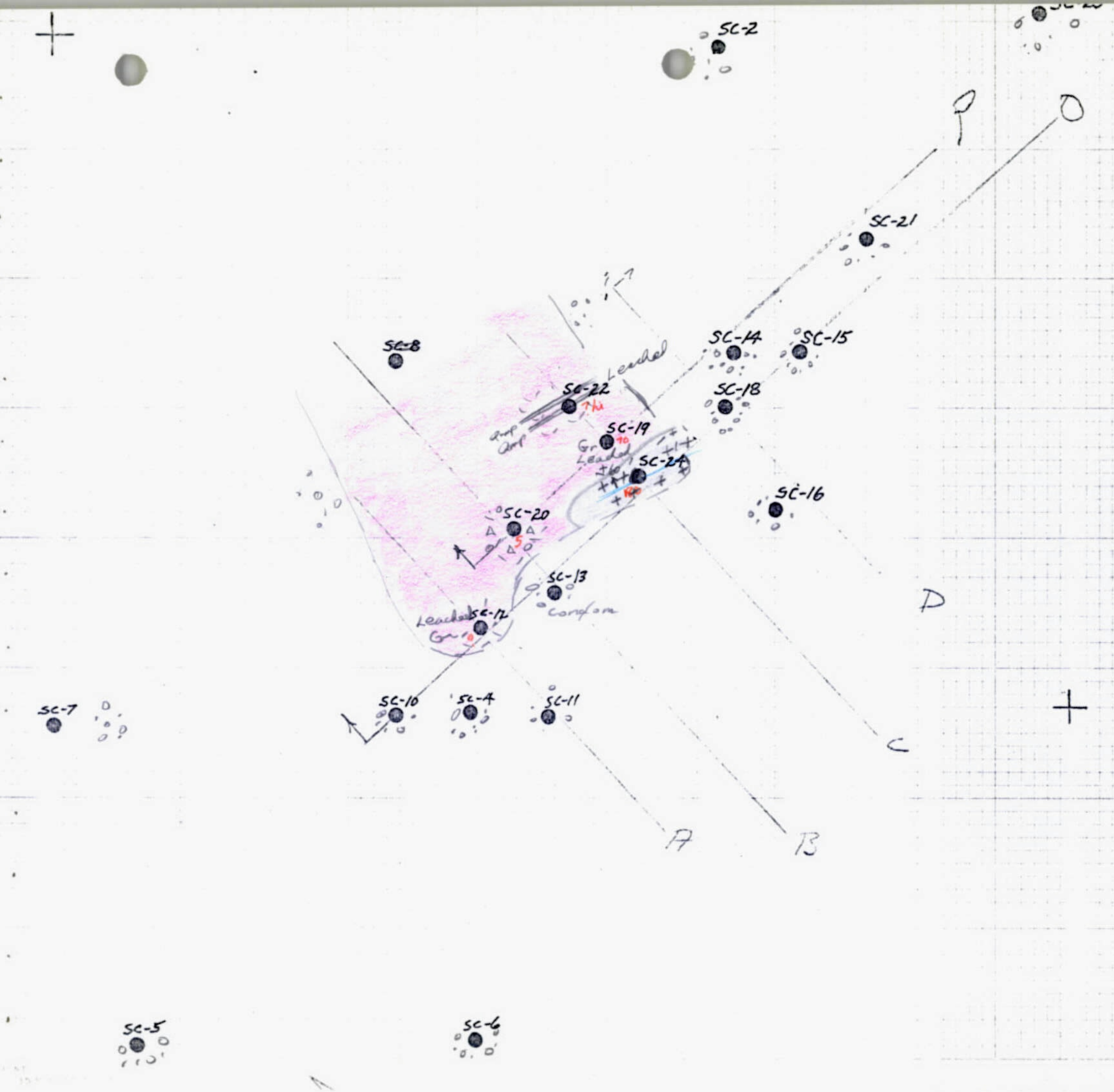
area SANTA CRUZ PROJECT
data by GJS
state Arizona
township-range
revisions - date
county Pinal
map number
PLATE 1
title ALTERATION
drawn by GJS
mining district Casa Grande
date April 75
2000 0 2000 4000ft



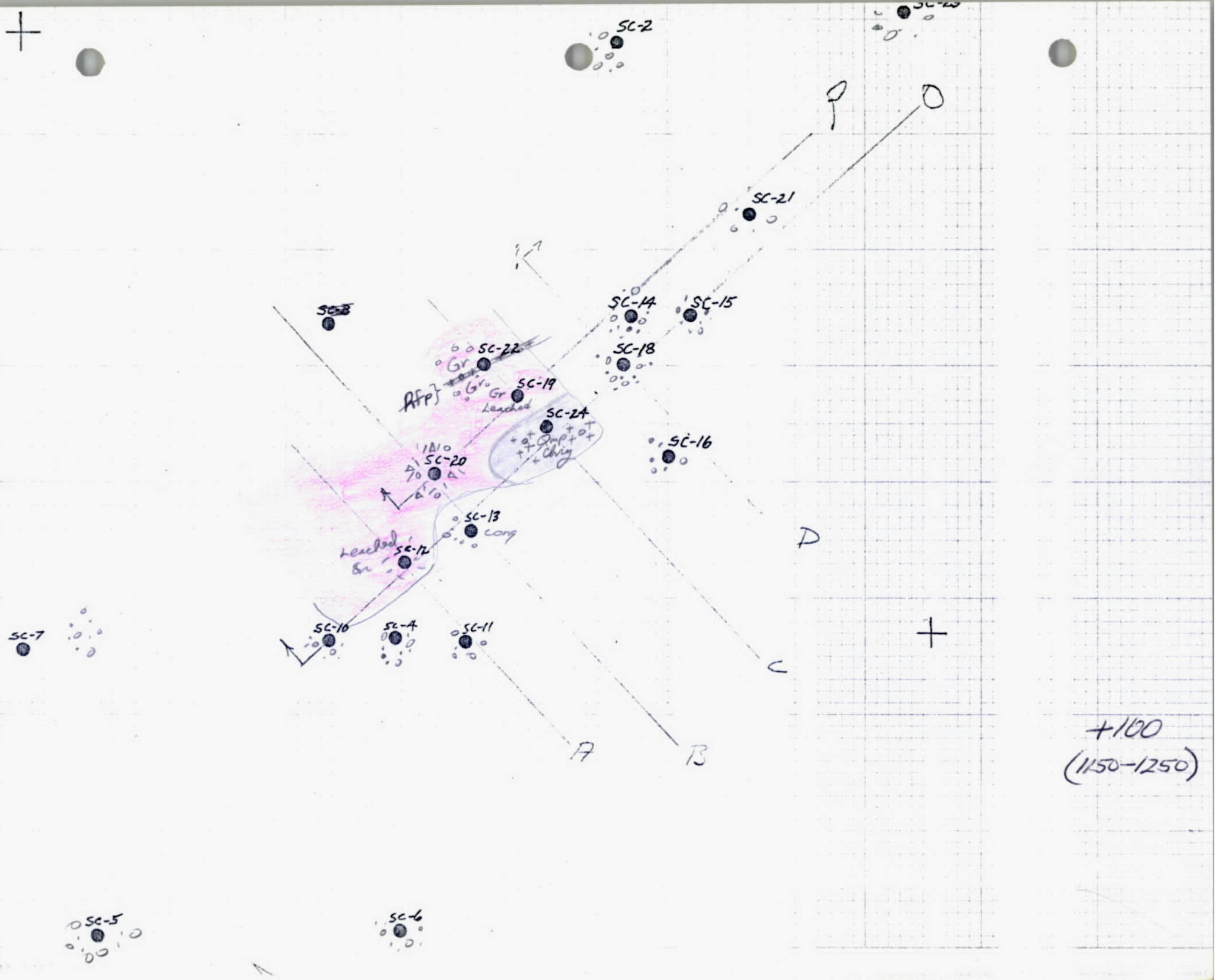
DISTRIBUTION
OF DIABASE DIKES
1/76 KK & JS
SANTA CRUZ
1" = 2000'

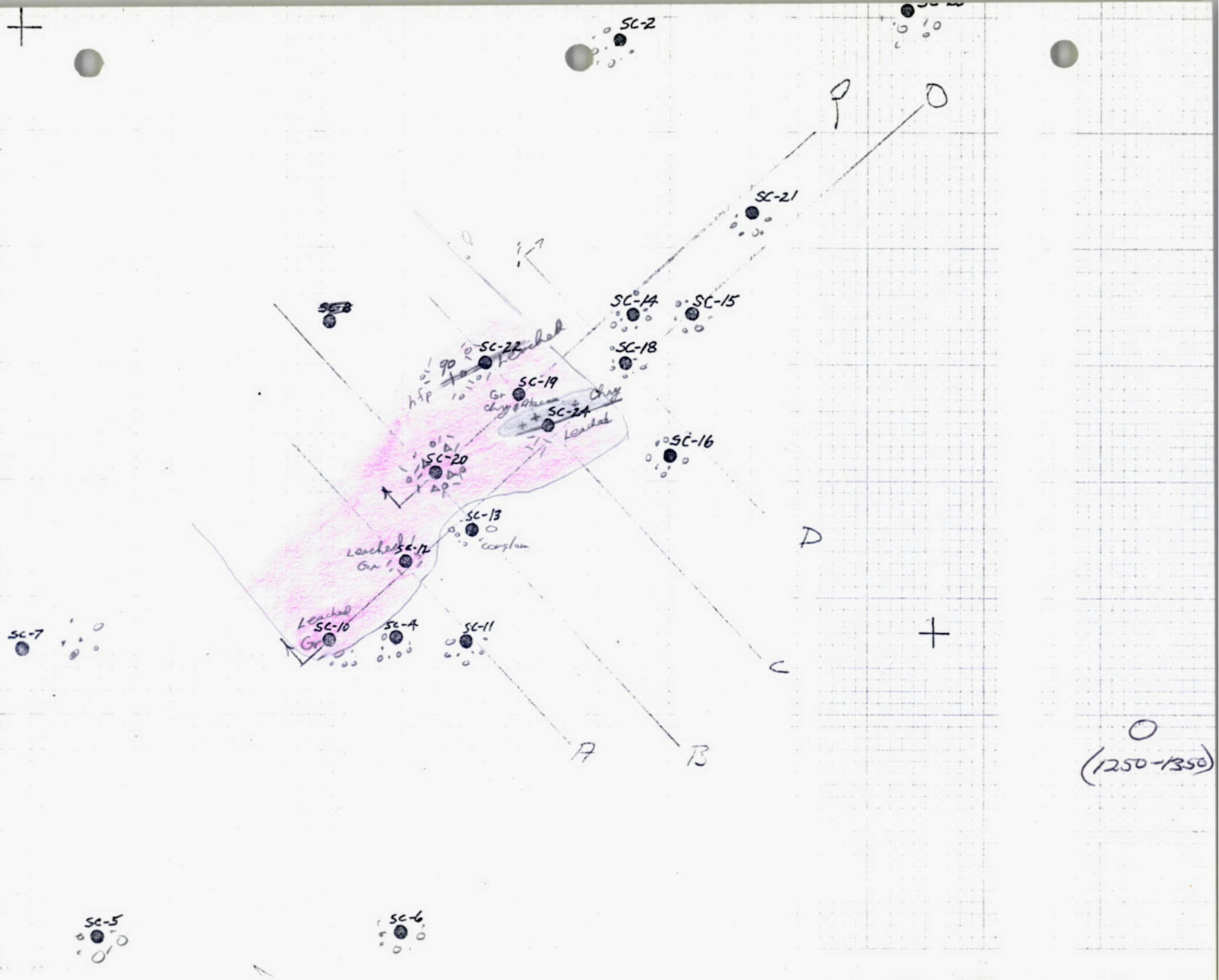

SC-2
SC-21
P
O
SC-14
SC-15
SC-8
70
Gr
Leached
70-90
SC-22
20
Leached
Qmp
SC-18
SC-19
34
Leached
SC-24
280(+)
180
SC-16
SC-20
5
SC-13
cong.
Leached
Gr
SC-12
D
SC-7
SC-10
SC-4
SC-11
C
A
B
SC-5
SC-6

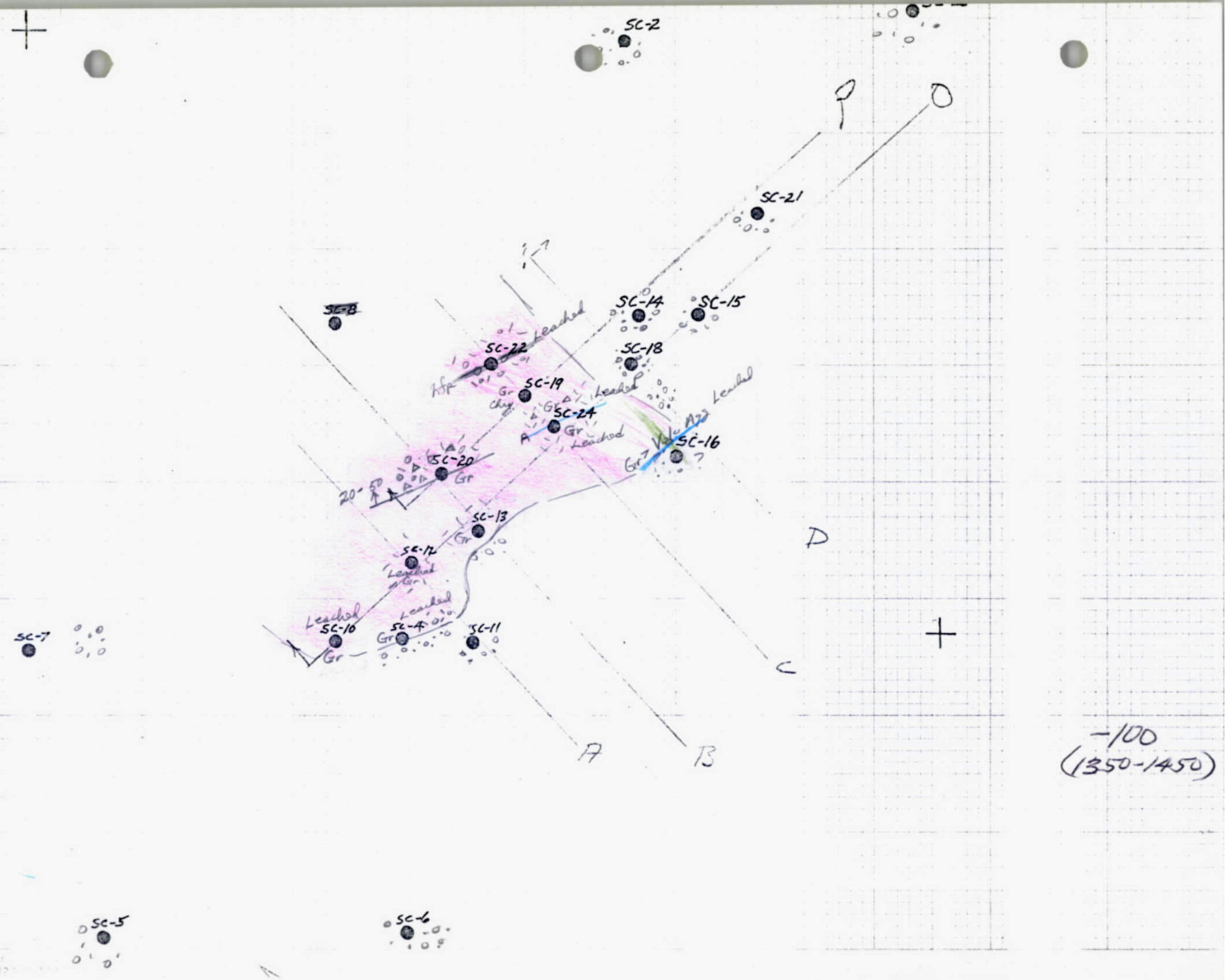
+300
(950-1050)



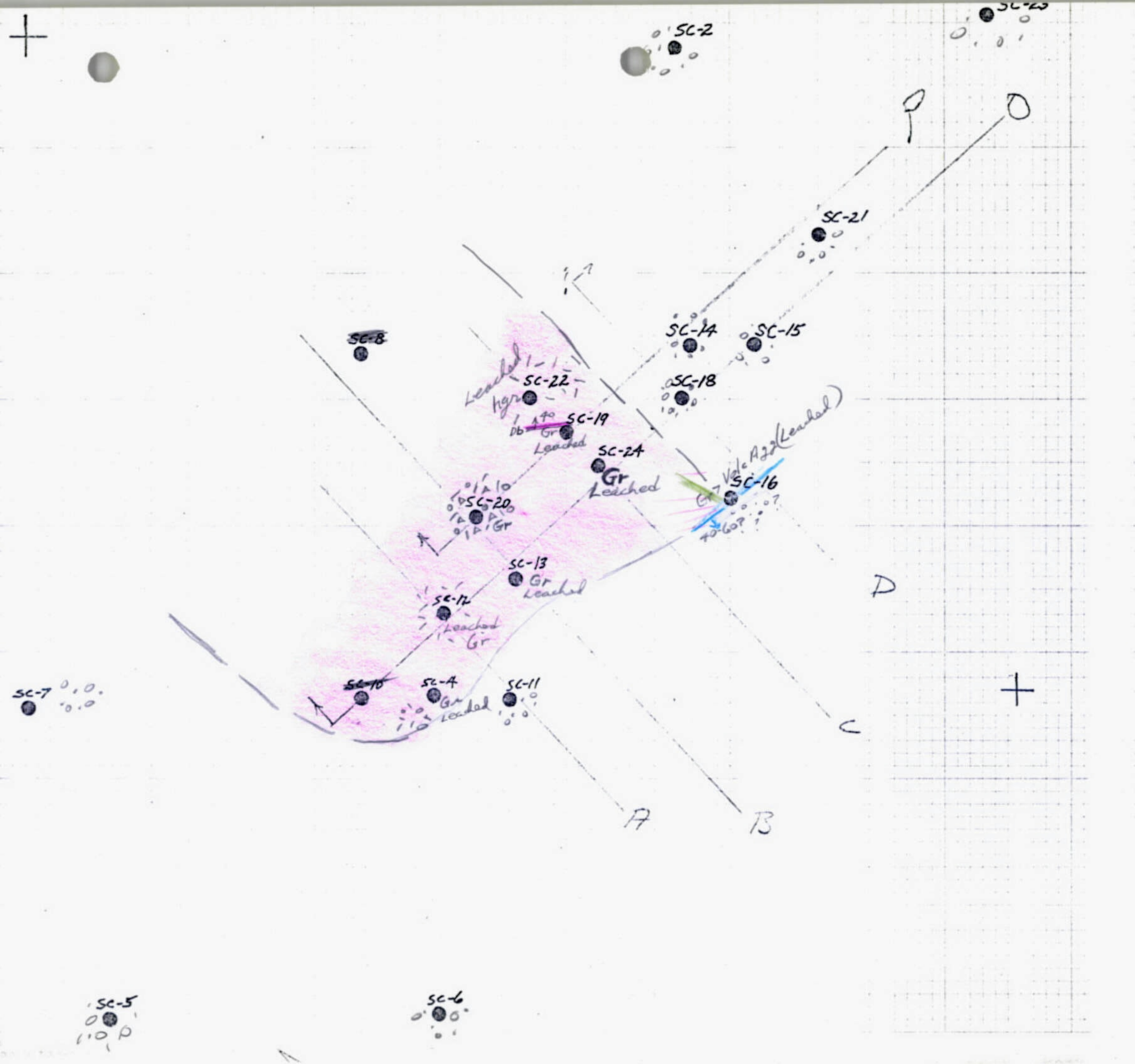
+200
(1050-1150)


SC-2
SC-21
O
P
SC-14
SC-15
SC-3
SC-22
Gr
Afp}
Gr
Gr
Leached
SC-19
SC-18
SC-24
Qmp
Chry
SC-16
SC-20
SC-13
cong
Leached
Gr
SC-12
D
SC-7
SC-10
SC-4
SC-11
C
A
B
SC-5
SC-6
+100
(1150-1250)

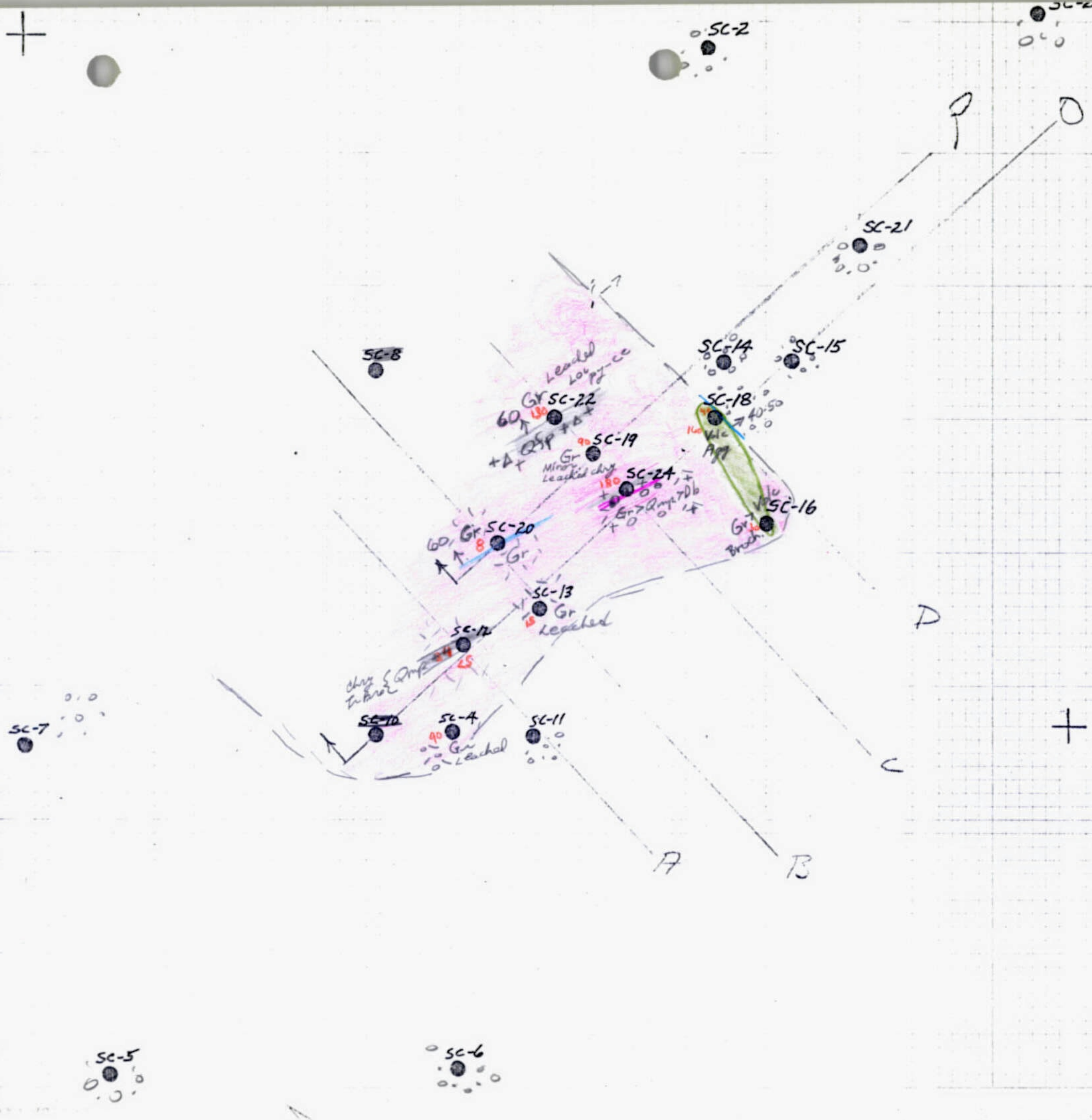

SC-2
P
O
SC-21
SC-8
SC-14
SC-15
SC-22
90
hfp
Leached
SC-18
SC-19
Gr
chry & Atacam
Chry
SC-24
Leached
SC-16
SC-20
SC-13
corslam
D
Leached SC-12
Gr
Leached
SC-10
Gr
SC-4
SC-11
SC-7
C
A
B
O
(1250-1350)
SC-5
SC-6



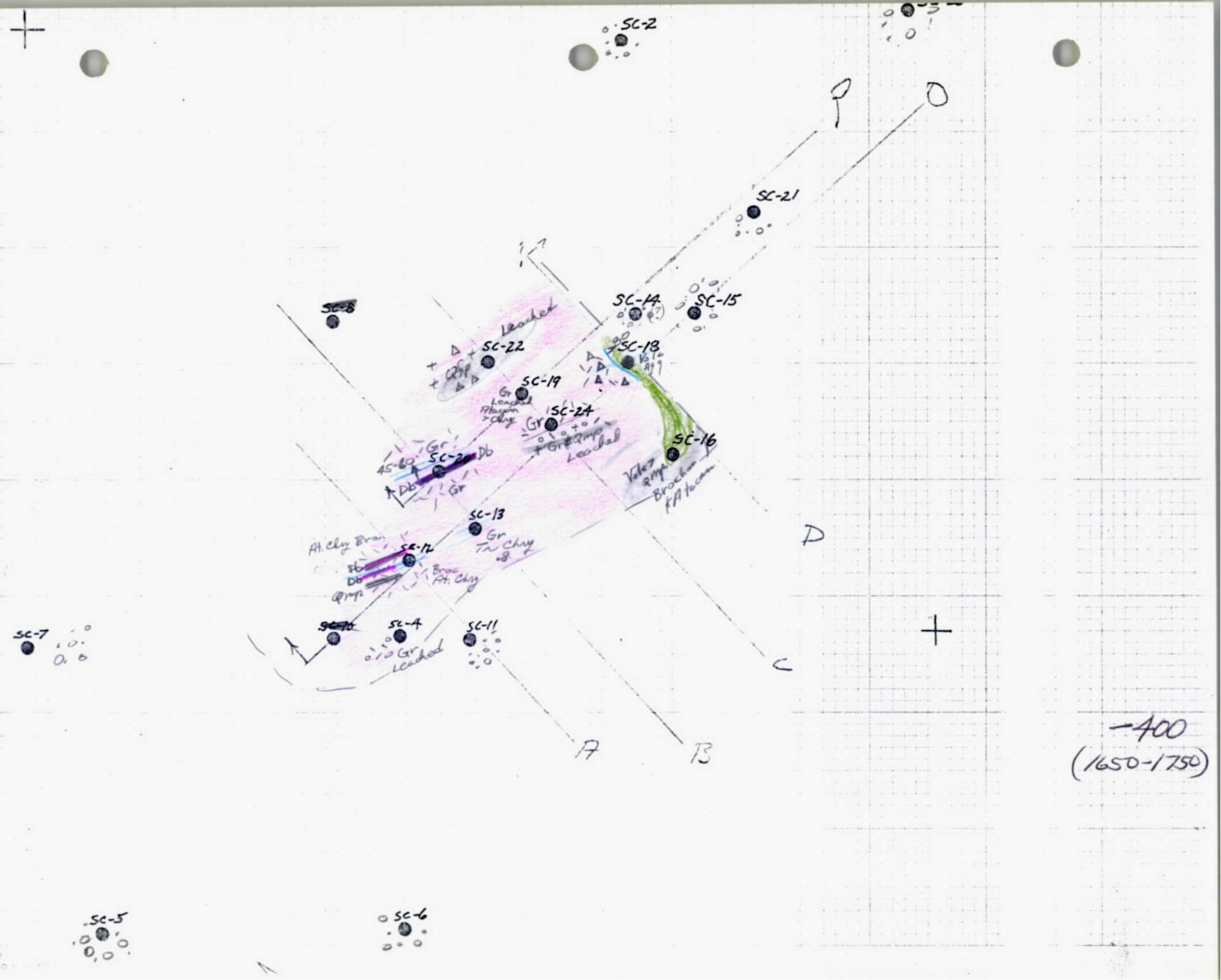
-100
(1350-1450)

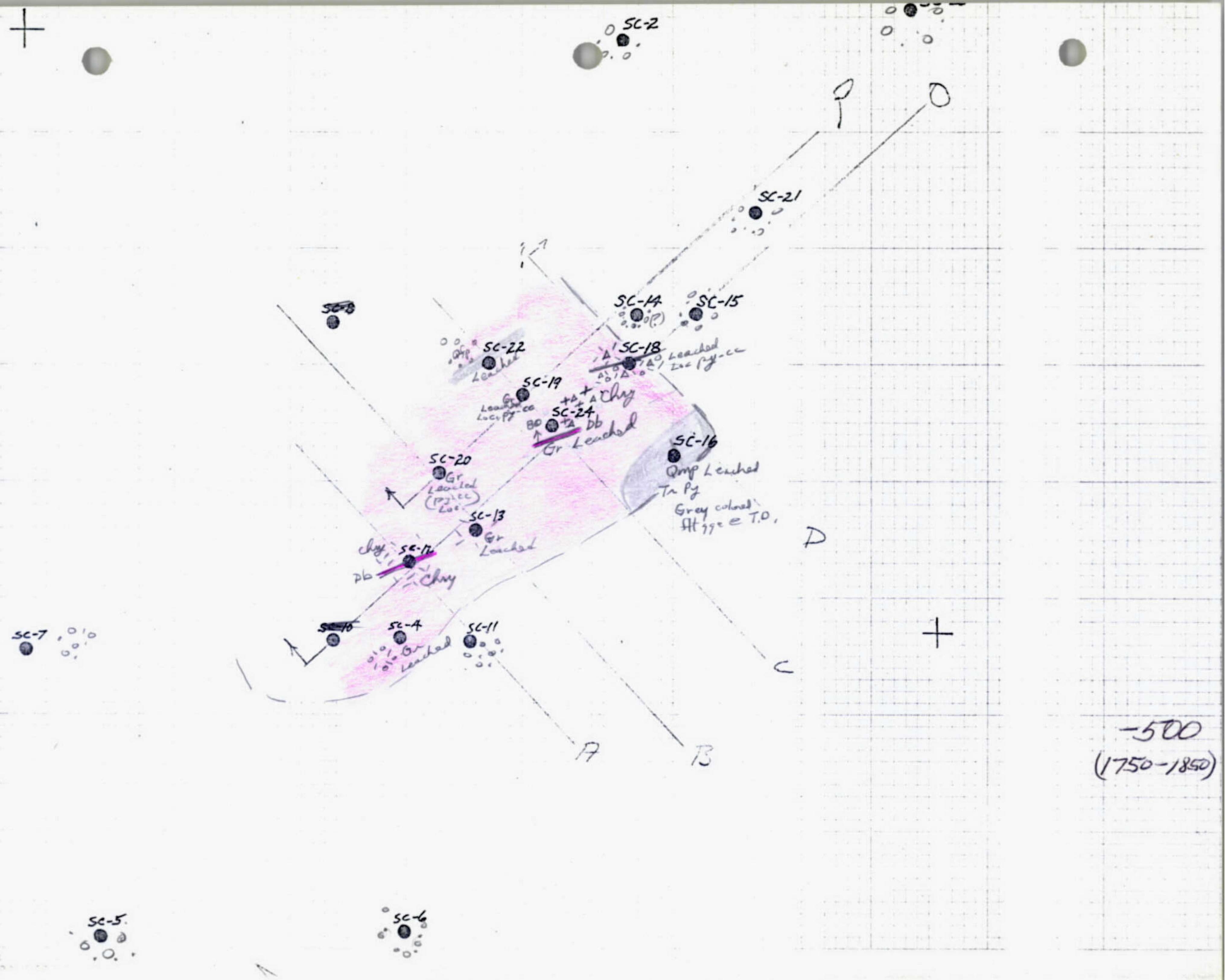


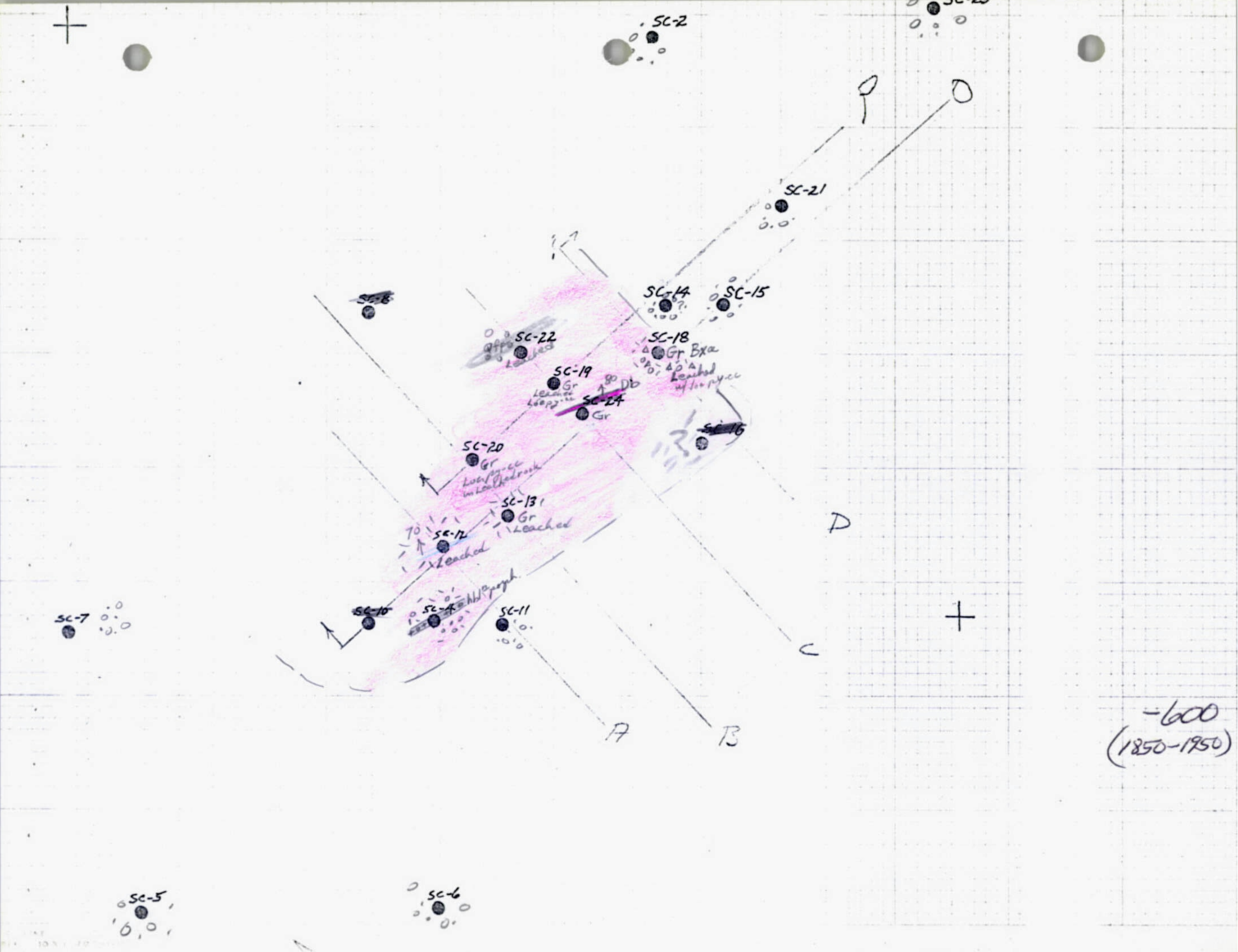
-200
(1450-1550)

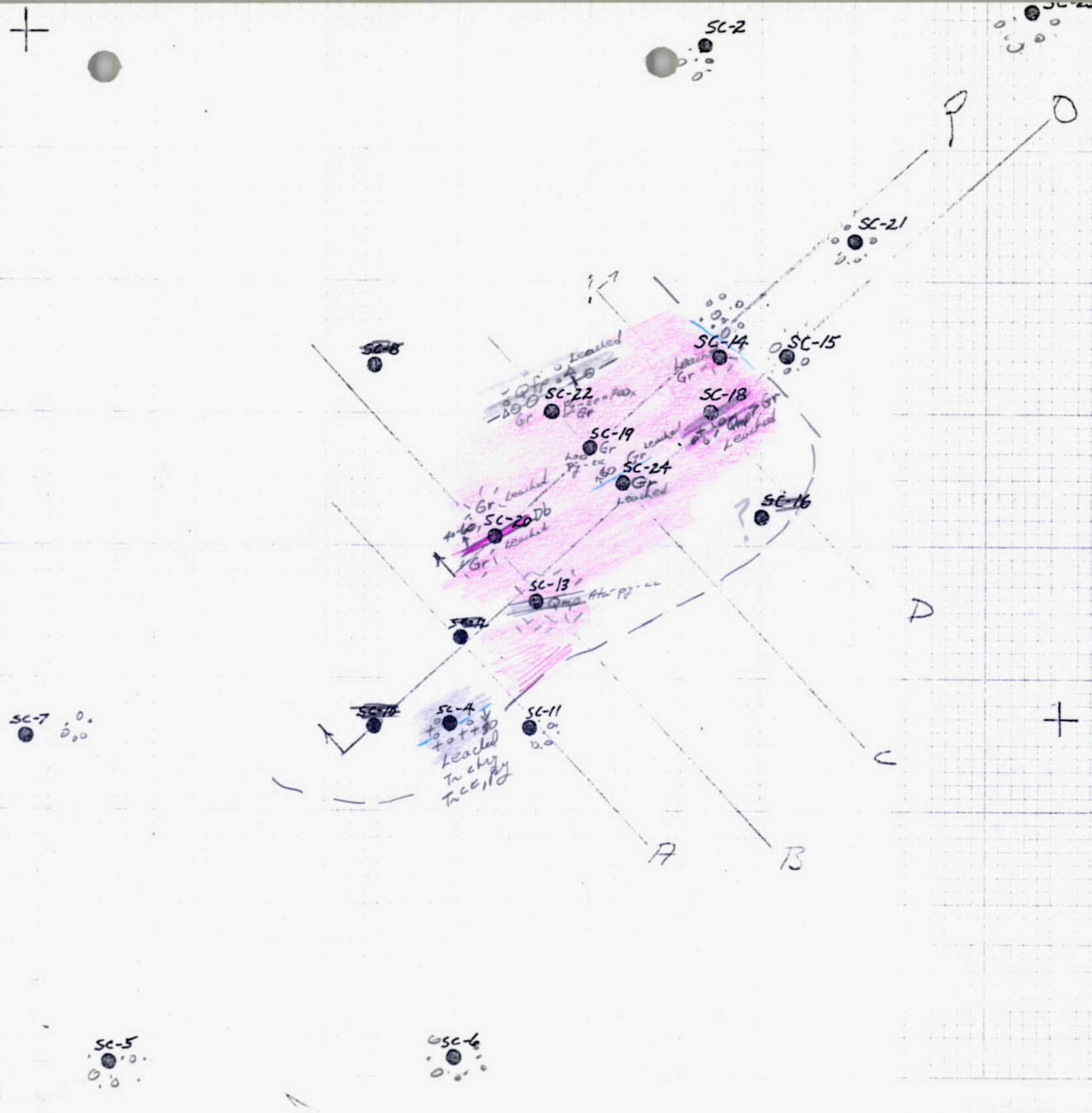


-300
(1550-1650)

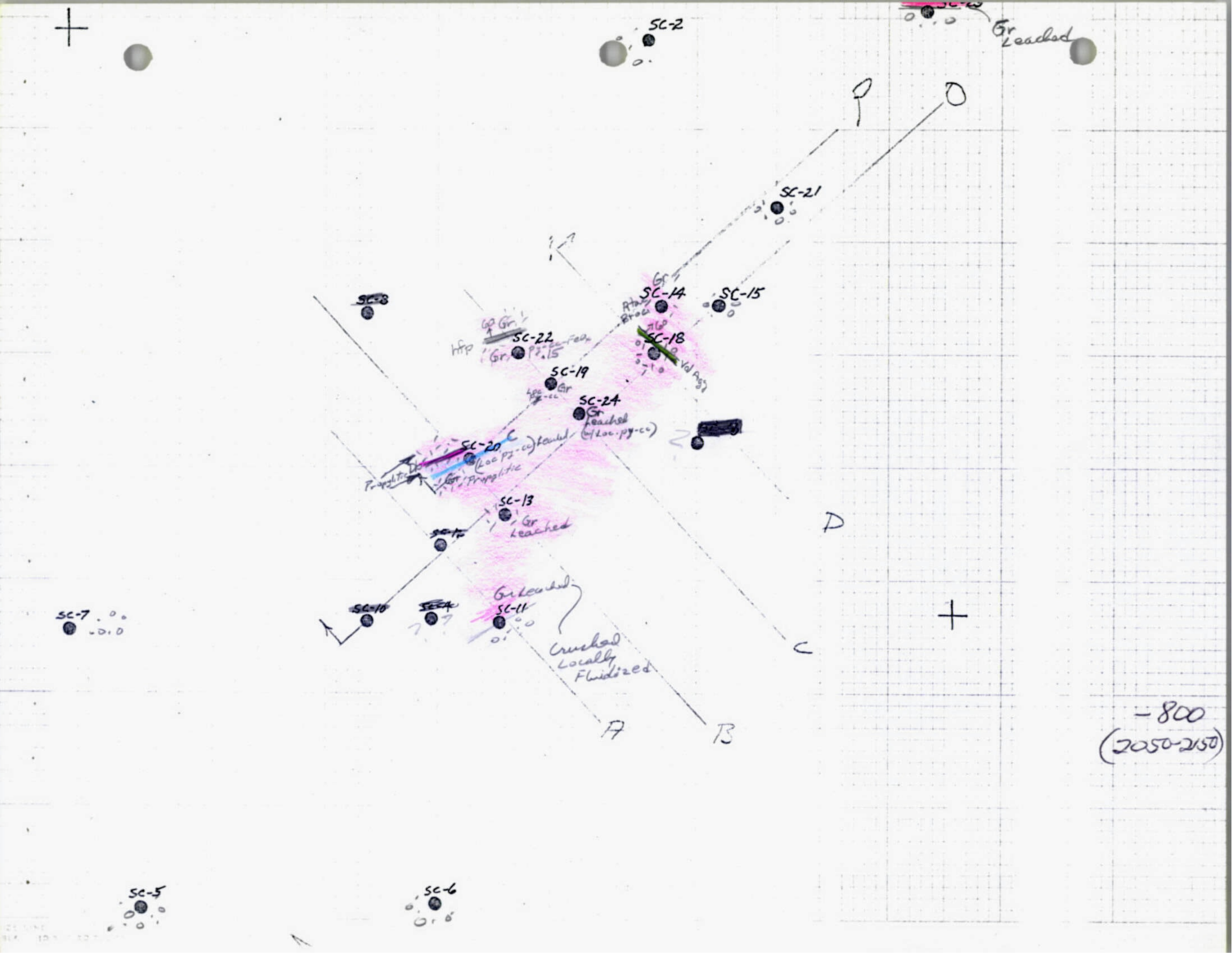

SC-2
P
O
SC-21
SC-8
SC-14
SC-15
SC-22
Leached
QSP
SC-18
Vol
SC-19
Gr
Leached
Atacam
Chry
SC-24
Gr
Gr Qmp
Leached
SC-16
Volc
Qmp
Brochan
Atacam
45-60
SC-20
Gr
Db
SC-13
Gr
Tn Chry
D
At. Chry Broc
SC-12
Db
Qmp
Broc
At. Chry
SC-7
SC-10
SC-4
Gr
Leached
SC-11
C
A
B
-400
(1650-1750)
SC-5
SC-6

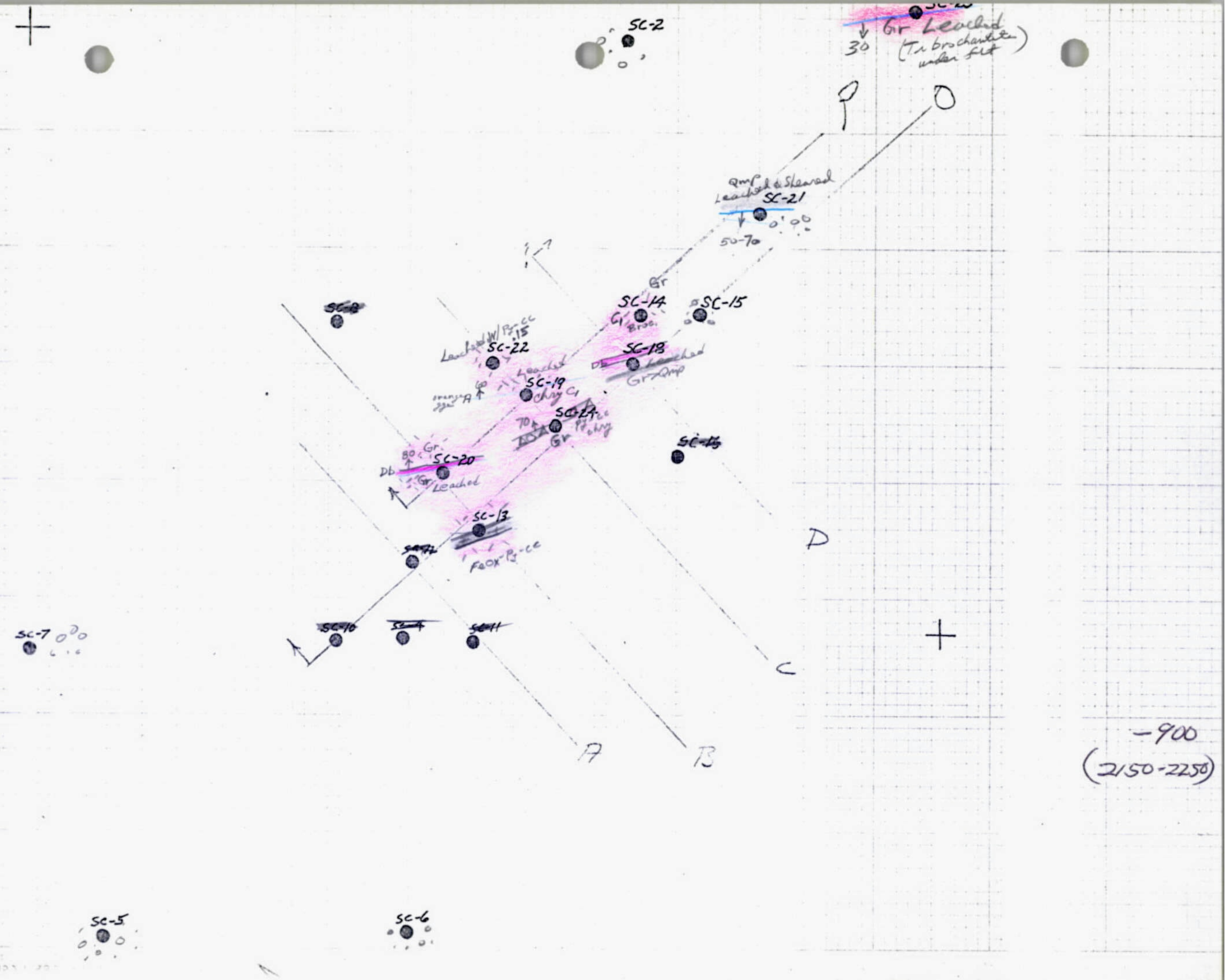

SC-2
SC-21
SC-8
SC-14
(?)
SC-15
SC-22
Qfp
Leached
SC-18
Leached
Loc py-cc
SC-19
Gr
Leached
Loc py-cc
Chy
SC-24
BD
Db
Gr Leached
SC-16
Qmp Leached
Tr Py
Grey colored
Alt 99' e T.D.
SC-20
Gr
Leached
(py-cc
Loc.)
SC-13
Gr
Leached
SC-17
Chy
Db
Chy
D
SC-7
SC-10
SC-4
Gr
Leached
SC-11
C
A
B
-500
(1750-1850)
SC-5
SC-6


SC-2
SC-21
P
O
SC-8
SC-14
SC-15
SC-22
Qfp
Leached
SC-18
Gr Bxa
Leached
w/ loc py-cc
SC-19
Gr
Leached
Loc py-cc
80
Db
SC-24
Gr
SC-16
SC-20
Gr
Loc py-cc
in Leached rock
SC-13
Gr
Leached
70
SC-12
Leached
D
hbl porph
SC-10
SC-4
SC-11
SC-7
C
A
B
-600
(1850-1950)
SC-5
SC-6



-700
(1950-2050)

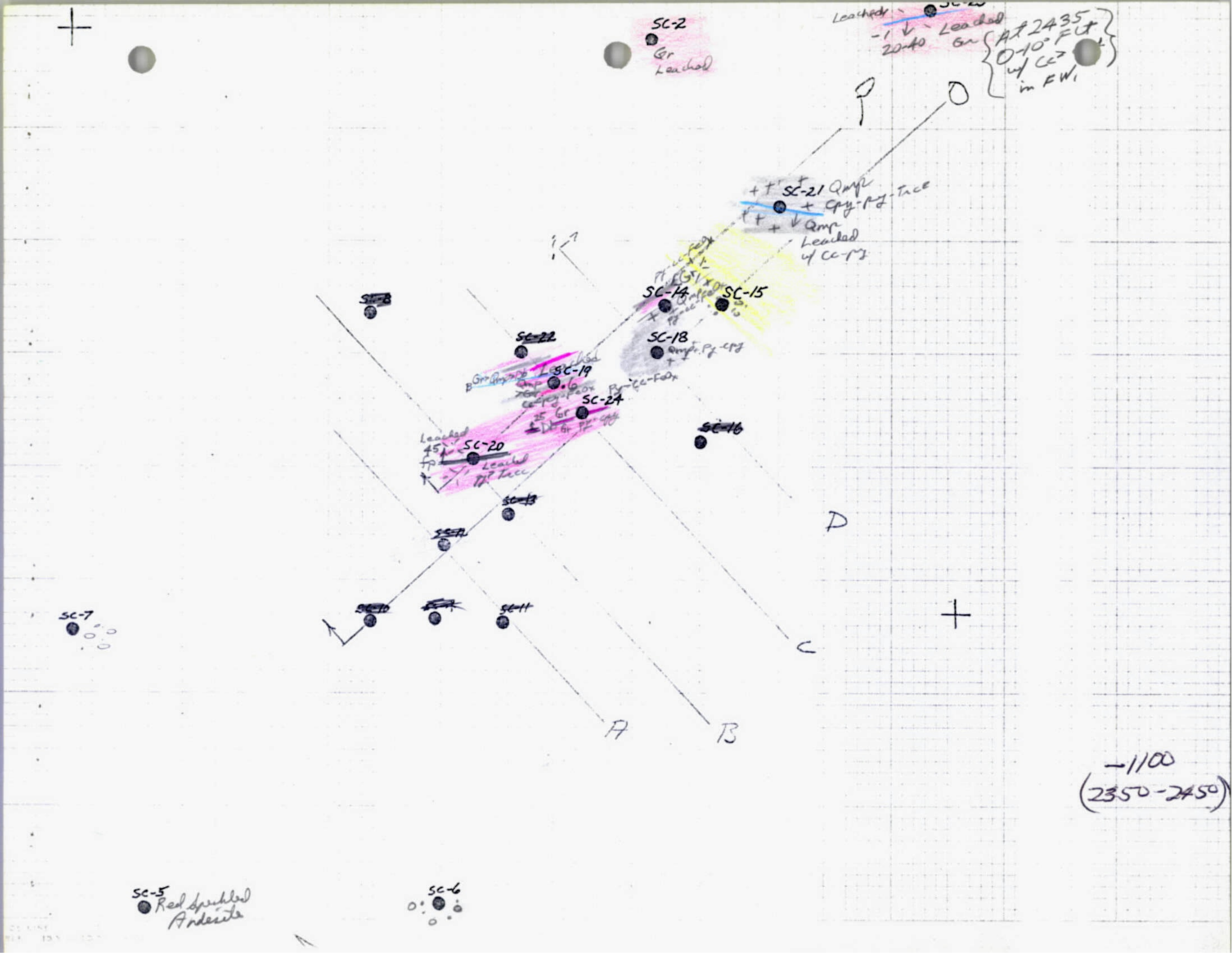

SC-23
Gr Leached
SC-2
P
O
SC-21
Gr
SC-14
Rtay Brec
SC-15
SC-8
Gp Gr
hfp
SC-22
Gr
py-cc-Fe0x .15
GP
SC-18
Vol Agg
SC-19
Gr
Loc py-cc
SC-24
Gr Leached (w/Loc. py-cc)
2
[redacted]
SC-20
C
(Loc py-cc) Leached
Propylitic
Db
Gr
Propylitic
SC-13
Gr Leached
SC-12
D
Gr Leached
SC-11
SC-10
SC-9
SC-7
Crushed Locally Fluidized
C
A
B
SC-5
SC-6
-800
(2050-2150)

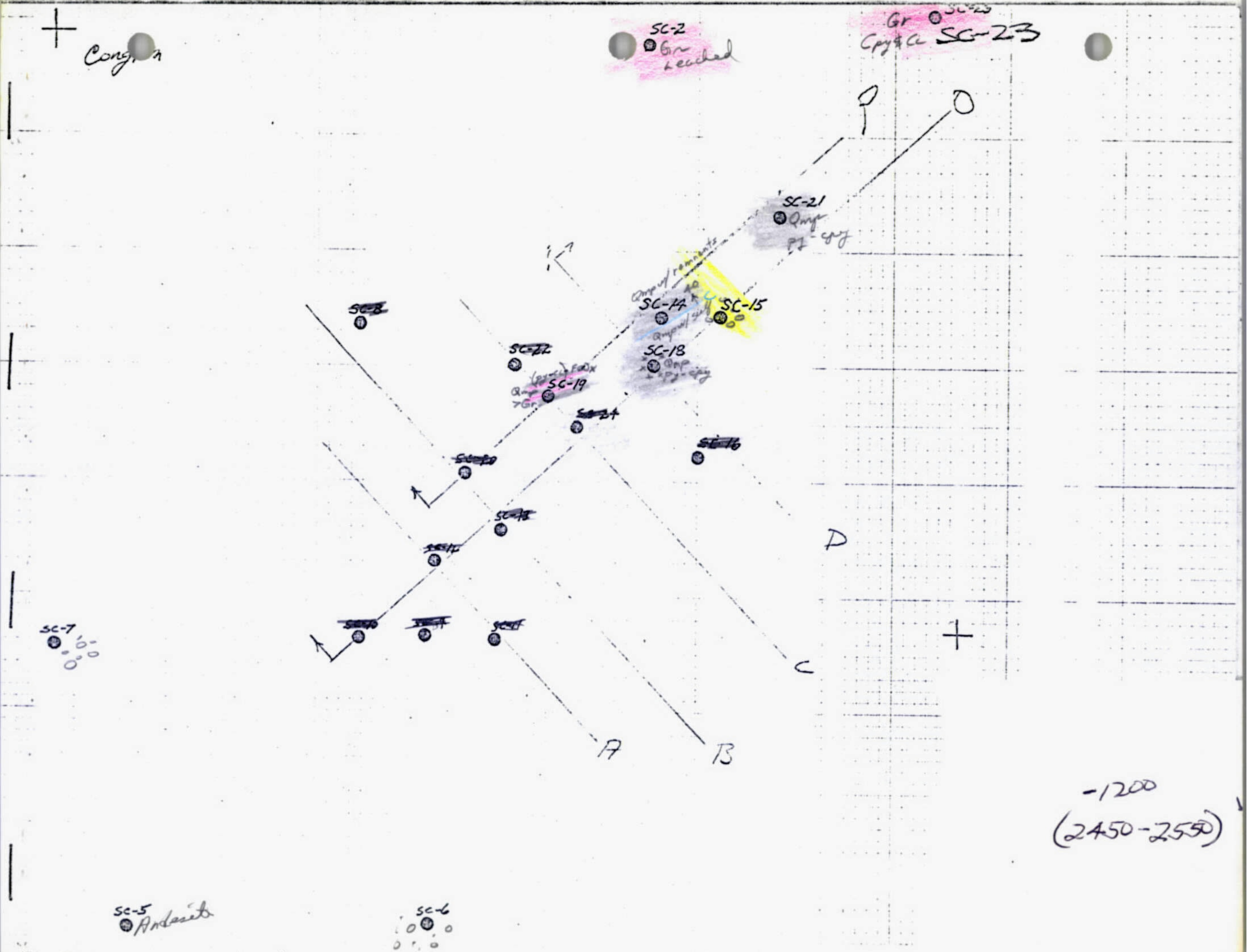


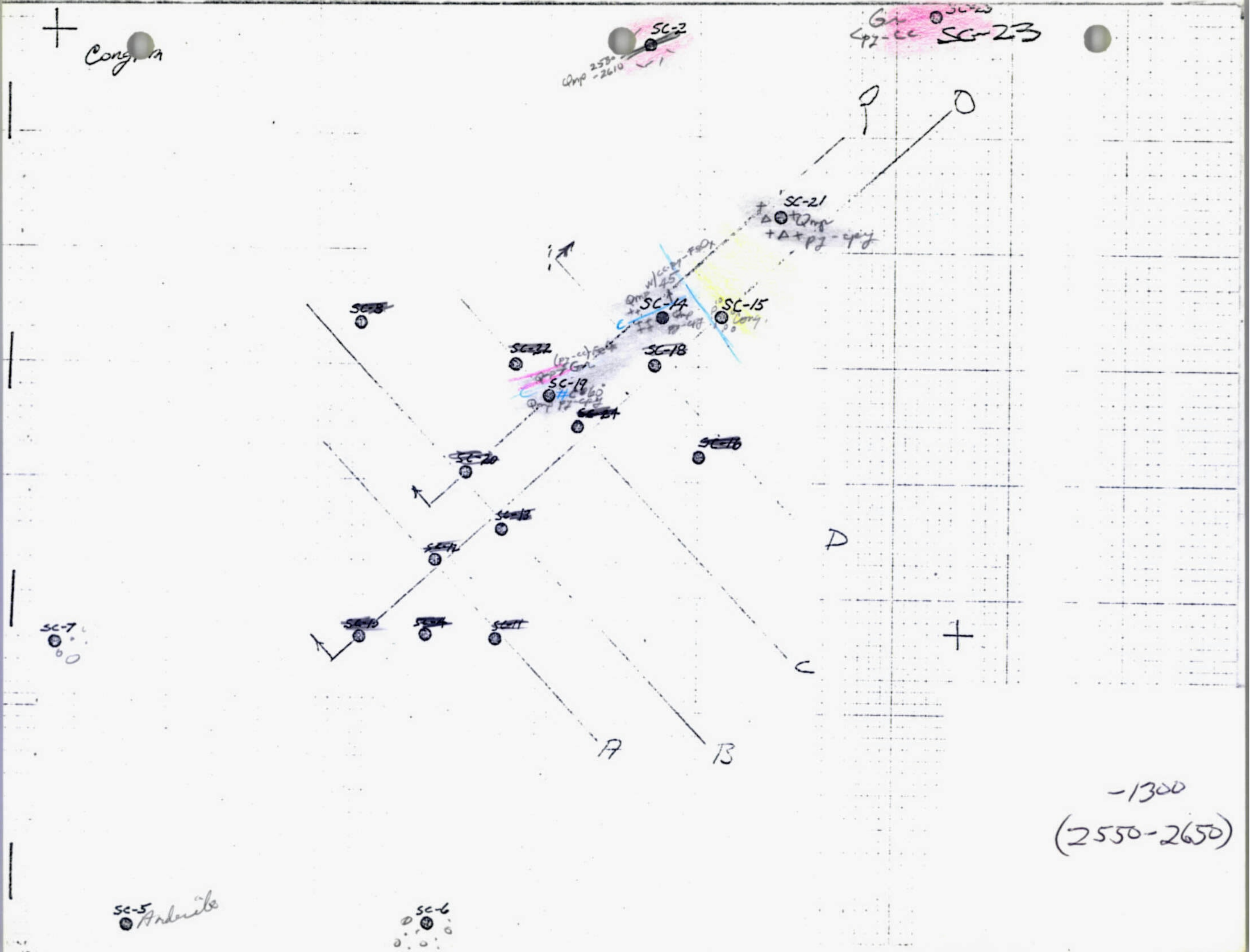
-900

(2150-2250)

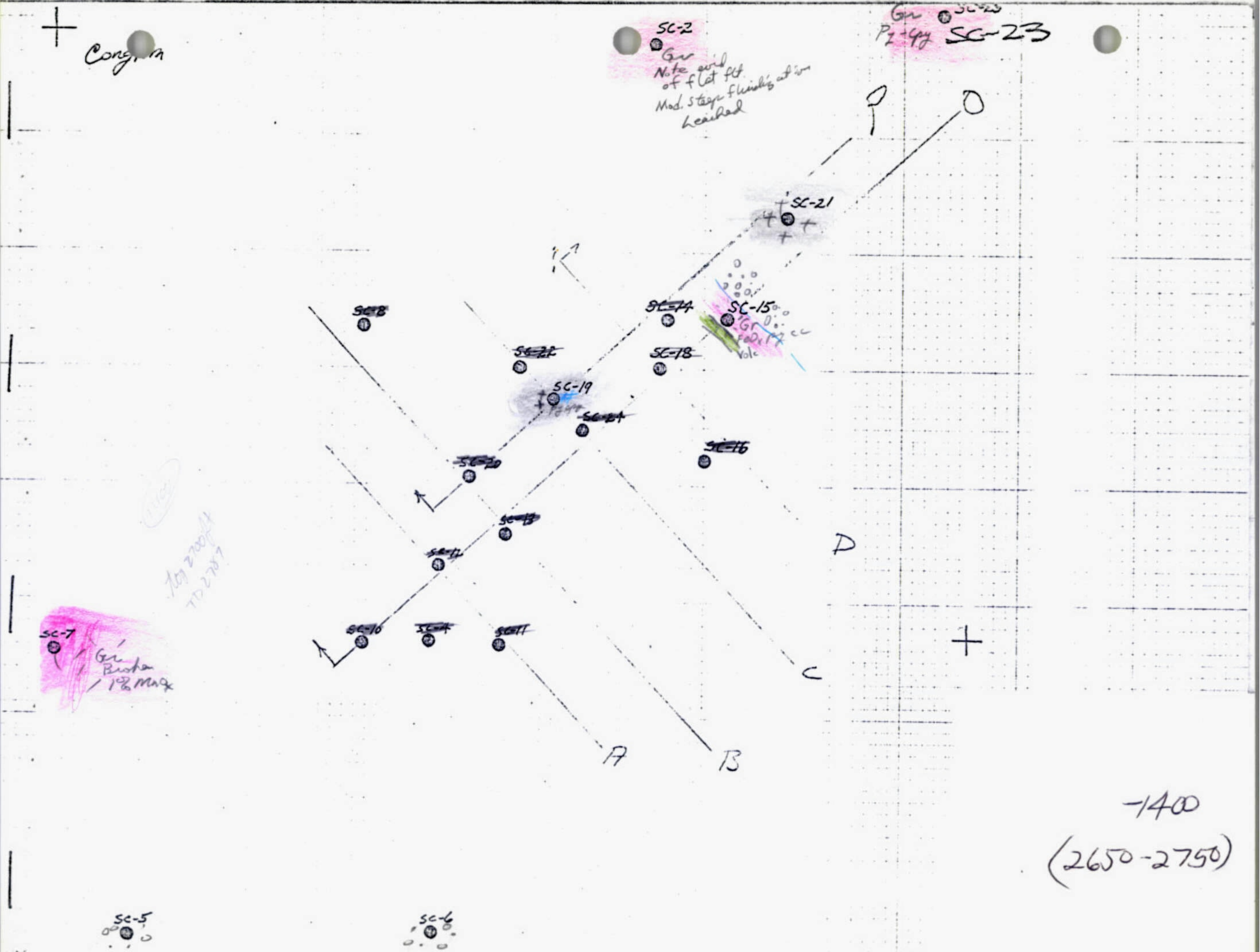
-1000
(2250-2350)

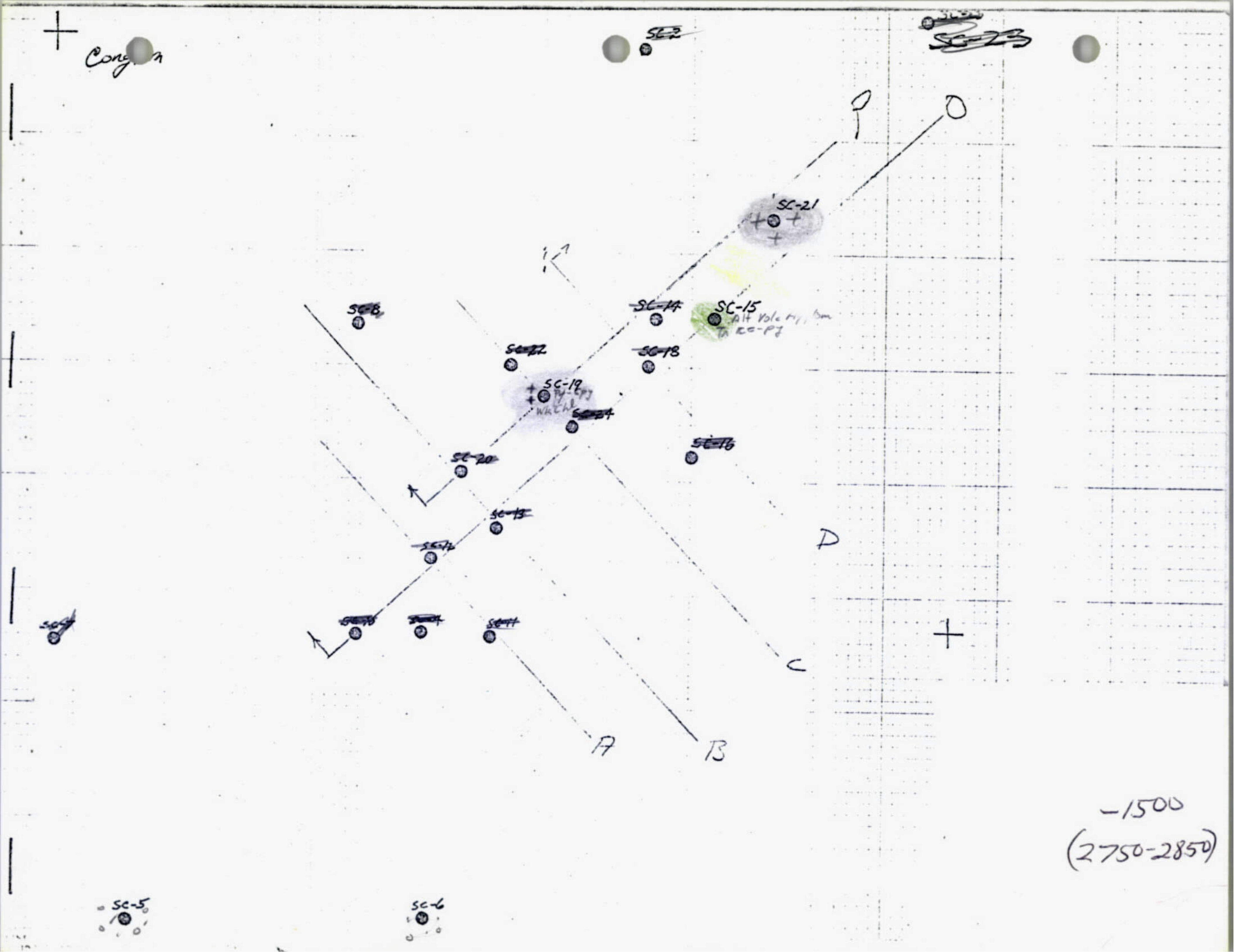

SC-2
Gr
Leached
Leached
-1
20-40
Leached
Gr
At 2435
0-10° Flt
w/ cc
in FW,
P
O
SC-21 Qmp
Cpy-Py-Trace
Qmp
Leached
w/ cc-py
SC-14
SC-15
SC-8
SC-22
SC-18
Qmp, Py-cpy
B Gr>Qmp>Db
Leached
SC-19
Qmp
.6
Cc-cpy-FeOx
Py-cc-FeOx
SC-24
25 Gr
Db Gr Py-cpy
SC-16
Leached
45
SC-20
fp
Leached
Py Trace
SC-13
SC-12
D
SC-7
SC-10
SC-11
C
A
B
-1100
(2350-2450)
SC-5 Red Speckled Andesite
SC-6

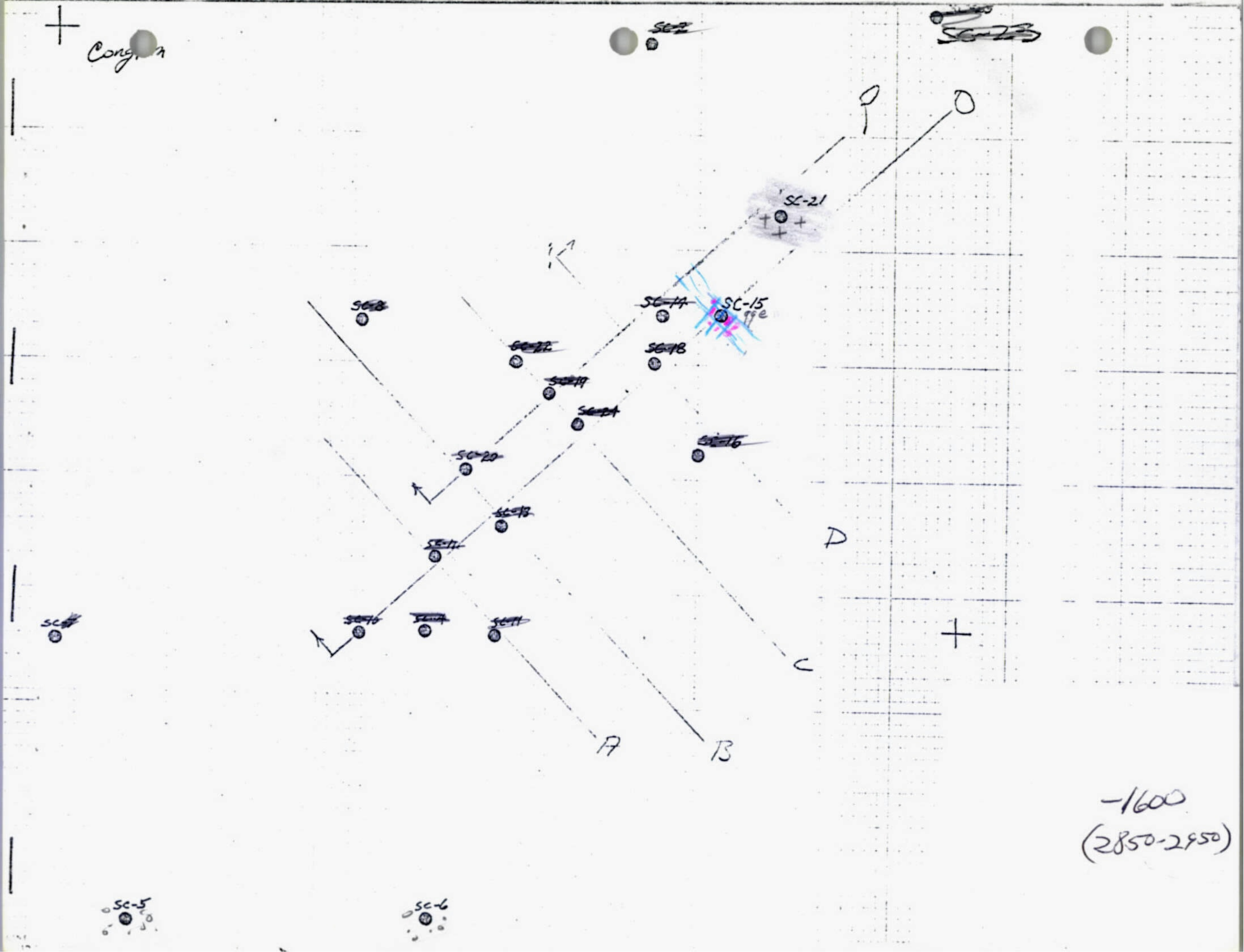

Cong…n
SC-2
Gr
Leached
Gr
SC-23
Cpy&Cc
SC-23
P
O
SC-21
Qmp
Py-cpy
Qmp w/ remnants
SC-14
Qmp w/ sulf
Qmp
SC-15
SC-18
Qmp
+ Py-cpy
~~SC-8~~
~~SC-22~~
(py-cc) FeOx
SC-19
Qmp
>Gr
~~SC-24~~
~~SC-16~~
~~SC-20~~
~~SC-13~~
~~SC-12~~
D
C
SC-7
A
B
-1200
(2450-2550)
SC-5
Andesite
SC-6



-1300
(2550-2650)

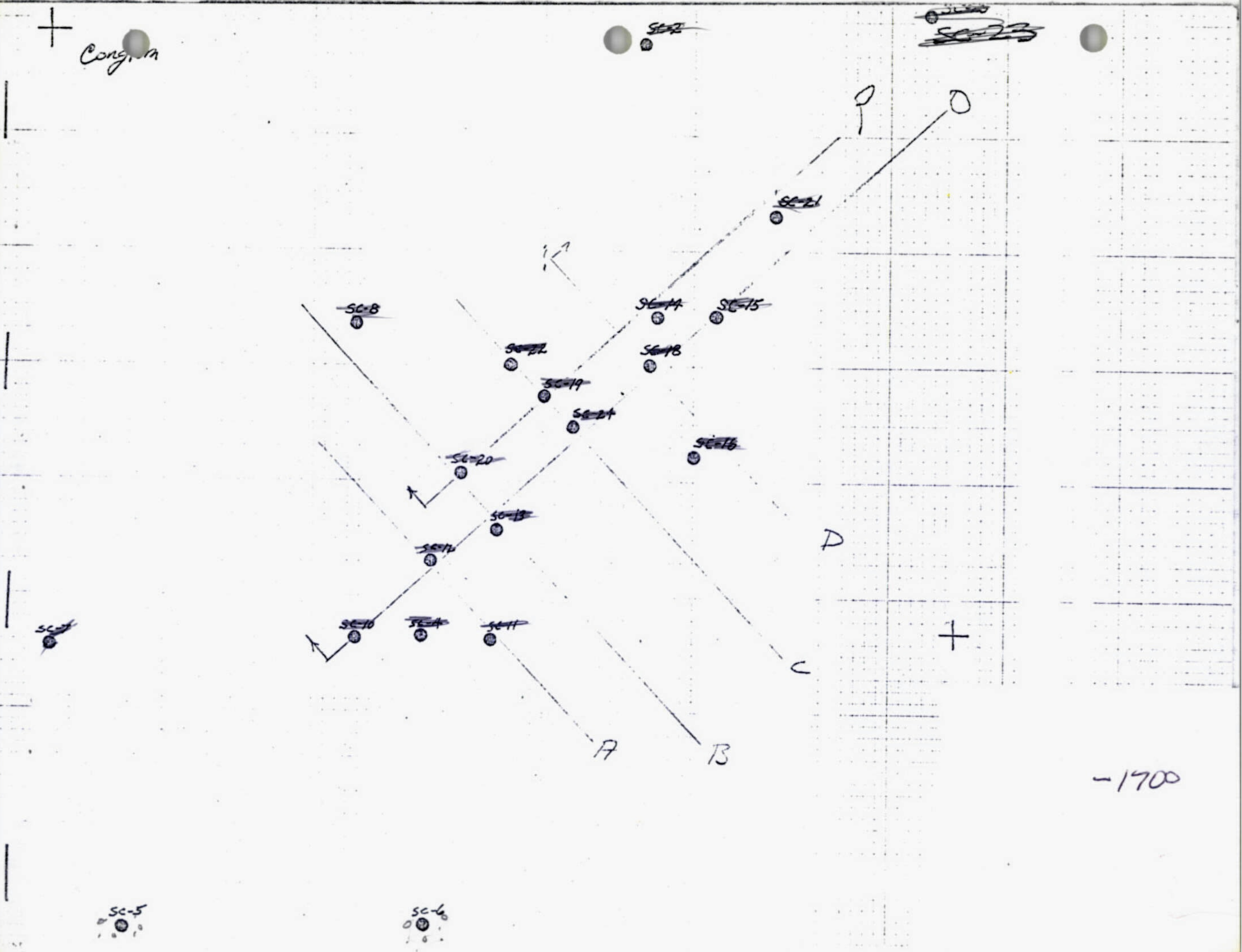

Cong[illegible]
SC-2
Gr
Note evid
of flat flt
Mod. steep fluid[illegible]ation
Leached
Gr
SC-23
Pz + Cpy
SC-23
P
O
SC-21
K
~~SC-8~~
~~SC-22~~
~~SC-14~~
SC-15
Gr
FeOx
cc
Volc
~~SC-18~~
SC-19
Py
~~SC-24~~
~~SC-16~~
~~SC-20~~
~~SC-13~~
~~SC-12~~
D
Tag 2700 ft
TD 2787
SC-7
Gr
Broken
1% Mag
~~SC-10~~
~~SC-4~~
~~SC-11~~
C
A
B
-1400
(2650-2750)
SC-5
SC-6


Cong n
~~SC-2~~
~~SC-23~~
P
O
SC-21
~~SC-14~~
SC-15
Alt Volc Hy, Bm
Tr ce-Py
~~SC-8~~
~~SC-22~~
~~SC-18~~
SC-19
Py-cpy
Wk Chl
~~SC-24~~
~~SC-16~~
~~SC-20~~
~~SC-13~~
~~SC-12~~
D
~~SC-10~~
~~SC-4~~
~~SC-11~~
~~SC-7~~
C
A
B
-1500
(2750-2850)
SC-5
SC-6

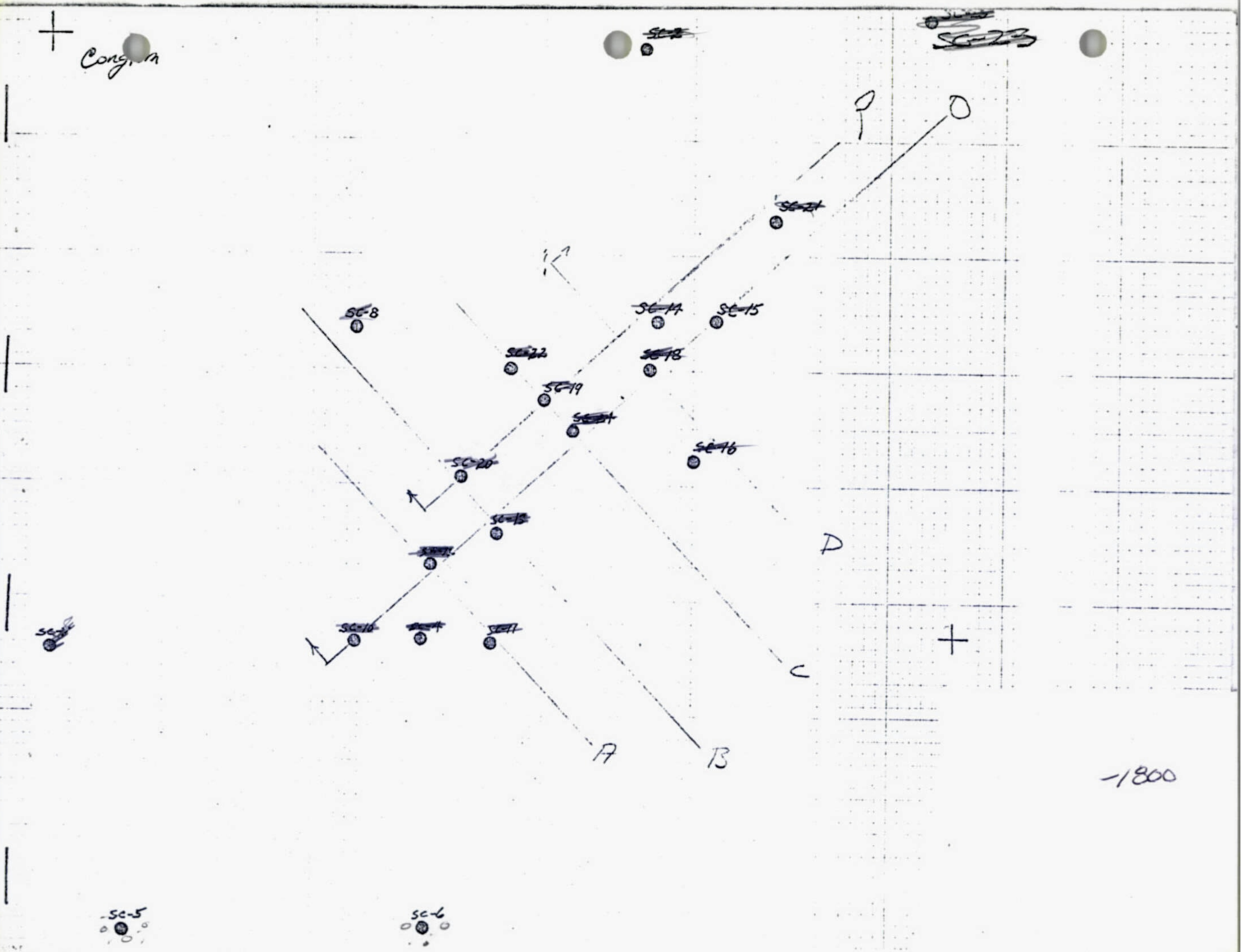


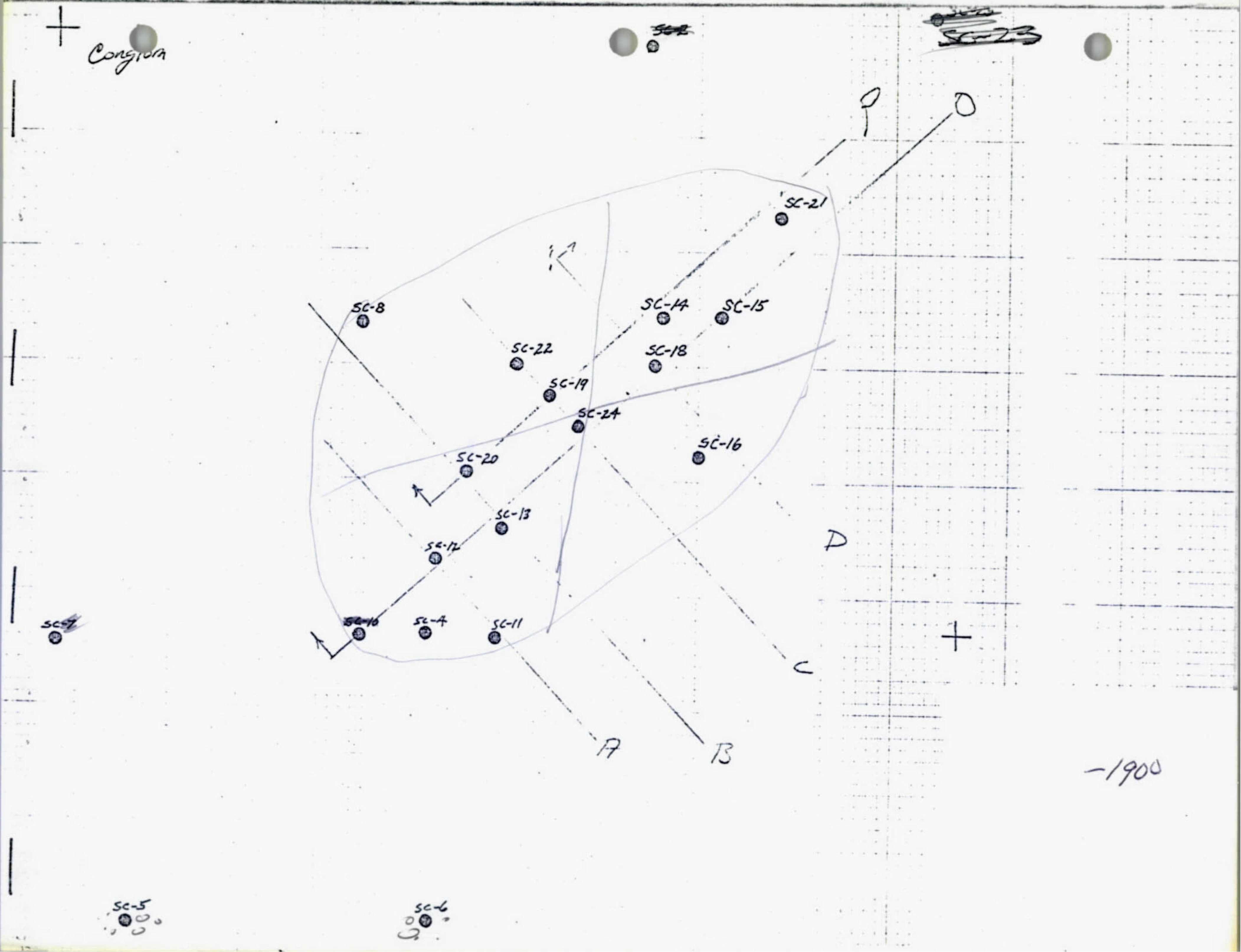
-1600
(2850-2950)

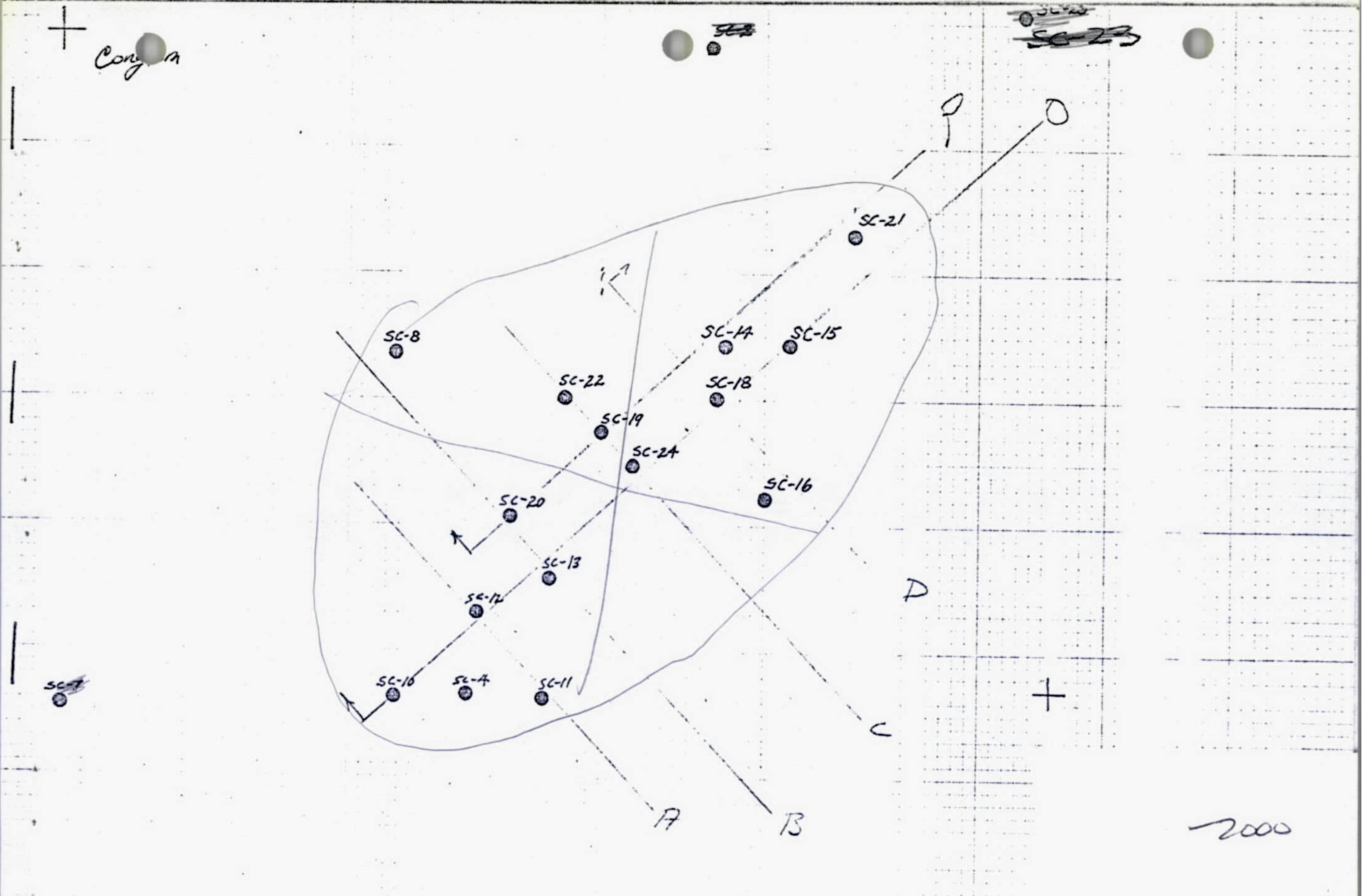
Congrm


SC-23
SC-2
P
O
SC-21
K
SC-8
SC-14
SC-15
SC-22
SC-18
SC-19
SC-24
SC-16
SC-20
SC-13
SC-12
D
SC-9
SC-10
SC-4
SC-11
C
A
B
SC-5
SC-6

-1700


Congram
SC-2
SC-23
SC-21
SC-8
SC-14
SC-15
SC-22
SC-18
SC-19
SC-24
SC-16
SC-20
SC-13
SC-10
SC-4
SC-17
SC-5
SC-6
A
B
C
D
-1800


Congiora
~~SC-2~~
~~SC-23~~
P
O
SC-21
SC-8
SC-14
SC-15
SC-22
SC-18
SC-19
SC-24
SC-16
SC-20
SC-13
SC-12
D
SC-7
SC-10
SC-4
SC-11
C
A
B
-1900
SC-5
SC-6



PLAN VIEW

At -2190 Gr Leached

At -2240 Trpy, cc in Gr > Qmp

SC-5

SC-6

PLAN VIEW

At -2900 Gr TiFeOx ±Py

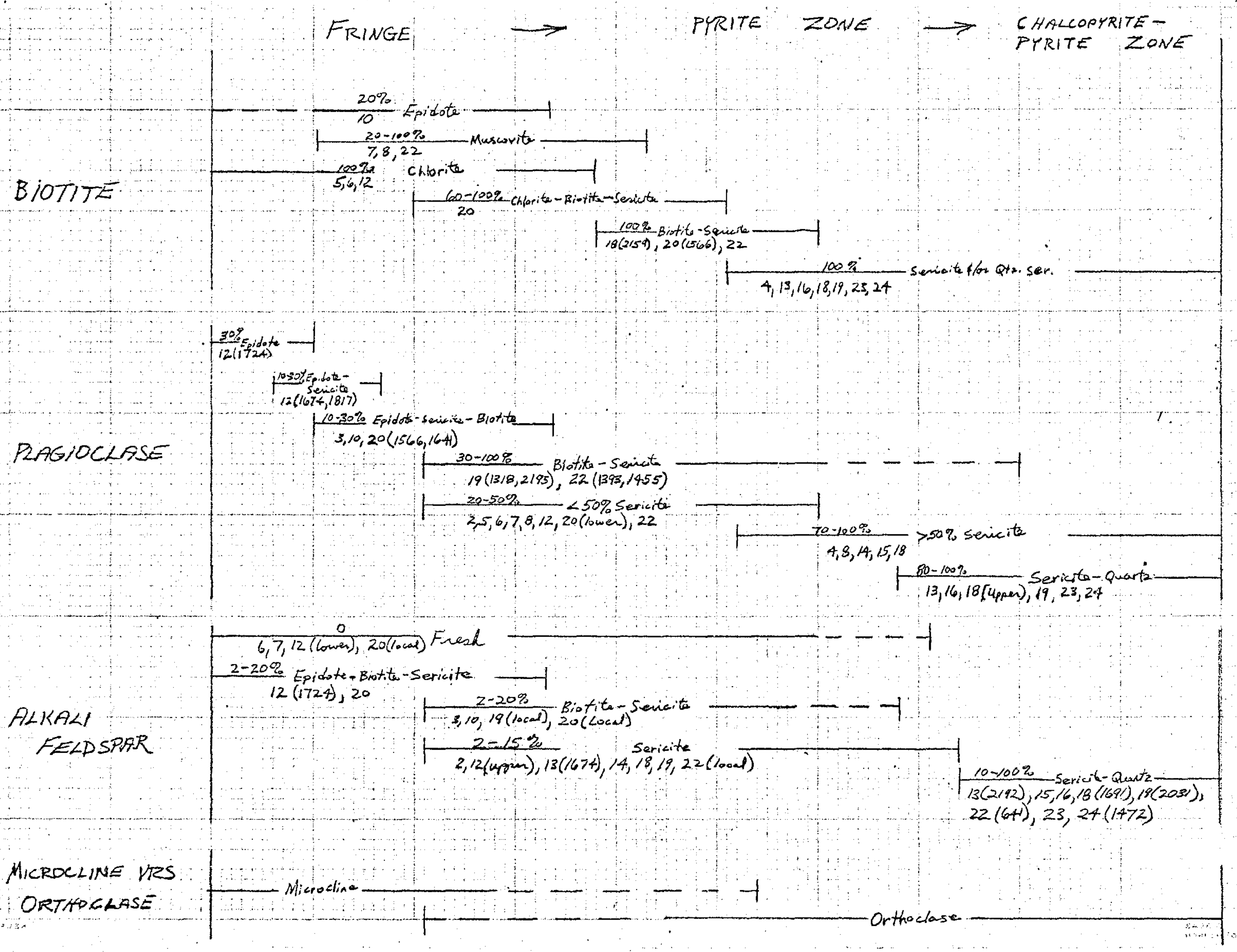
A -2970

T.D. in conglom at -3000 elev.

L-11-16

Jim,
This is a rough draft of the results of the thin section description of altered granite.
Herb

ALTERATION PRODUCTS OF ROCK FORMING MINERALS IN PRECAMBRIAN GRANITE



ALTERATION OF
pC GRANITE
SANTA CRUZ PROJECT
H. Kreis Feb. 19

Fluid Inclusion Data

Above the SC Zone

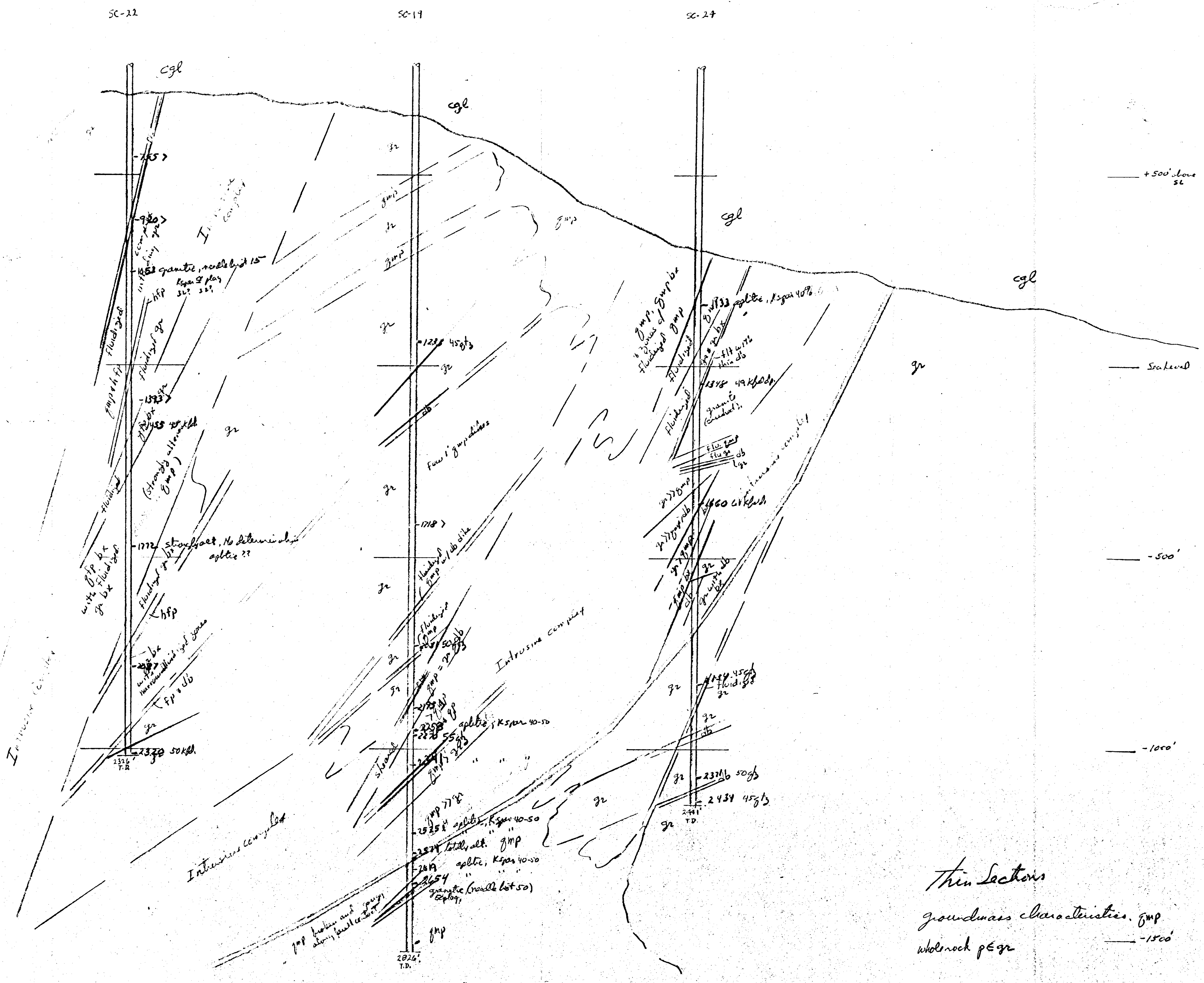
Hole No	Above Depth	% of Total			
		% Type I	% Type II	w/o Halite % Type III	% Type III w/ Halite
SC-4	1964	60	38	n s 2	—
-12	1910	60	20	S-K 17	3
-14	2522	60	10	K 24	6
-18	2247	No data			
-19	2600	35	20	K 41	4
-20	2160	60	30	n S-K 7	3
-24	1990.	10	30	K 45	15

[illegible] 5

Fluid Inclusion Data
Below the SC Zone

		% of Total			
Hole	Below Depth	% Type I	% Type II	without Halite % Type III	% Type III w/ Halite
SC-4	1966	73	20	7 P	—
-13	Surface	65	5	28 S	2
-14	2522	70	10?	20 S-P	Couldn't tell
-15	Surface	No Data			
-16	1720	No Data			
-18	2247	75	5	18 S	2
-19	2600	40	40	19 S	1
-20	2160	15	55	30 S-K	5
~~-21~~	~~Surface~~	~~15~~	(15) ~~10~~ 15	(31) ~~30~~ 40	~~5~~
-24	1990	20 ~~10~~	[illegible] [illegible]-15	~~[illegible]~~ 60 [illegible] K	5 ✓
21	2400	40	~~15~~	35 K	10 ✓
21	2444 + Below	60	10	28 S-K	2

40 30 30 H (min T H)



Thin Sections

groundmass characteristics. gmp

wholerock pЄgr

1" = 200'

Thin Section locations

Barry Watson (?)

Slide 3

S.B. Ignim. sill

Maybe a higher frequency of sanidine. Remnant shards. Good ignim text. Some rexlization, kaolinization, epidote.

Slide 2

Concentrator

Devitrified + recrystallized tuff — fragments of qtz + fs dot the field. Very wk superimposed sericitization + kaol

Slide 1

Concentrator

Crystal tuff — devit + rexl. — frags of foreign rks. Rk a mess. Incip. Fe-staining.

From Flux —

Slide ③ — Tuff devit + rexl. wi qtz veinlets superimposed in a uniform direction.

TS 36 — Good flow-banded volco wi strong superimp. metam — qtz + seric bands // banding.

Barry Watson?

SC #1

Mega

Porphyry rock showing good porphyry texture but with some signs of alteration (i.e. chloritization of femags).

Micro

Rock contains 40% phenocrysts, mostly twinned plagioclase, <2% qua occasional orthoclase, badly shot chlorite, zircon, and 3-4% magnetite-ilmenit and leucocene. Matrix has some quartz but is mostly feldspar. Rock is latite porphyry or monzonite porphyry (I prefer the latter because of the goodly percentage of phenocrysts).

Alt. Plagioclase shows two degrees of kaolinization — moderately weak and moderately strong, the former more common. Some of the strongly kaolinized phenocrysts may be orthoclase. A weak sprinkling of sericite is seen in most phenocrysts. The femag was either biotite or hornblen or both but was not present in quantity (<3%) and is now a chewed up chlorite. Ilmenite has generally turned to leucocene. Some epidote is here.

The matrix shows definite recrystallization of moderate degree. A textural streaking of equi-colored tiny crystals gives some parts of the matrix a lineation, but this appears to be an alteration feature, not a primary structure.

SC # 1A

Mega

Same porphyry rock as SC #1 but farther from critical contact area. Good porphyry texture. Groundmass shows a megascopic streaking in cut section suggesting incipient silicification.

Micro

Rock contains 35-40% phenocrysts, mostly twinned plagioclase but with occasional large K-spars. Large anhedral quartz crystals constitute up to 10% of the slide but occur principally (though not by any means exclusively) along wide parallel bands. This quartz may be in part introduced but is probably mostly sweated out of the matrix. There are no through-going quartz veinlets. Small quantities of botched up chlorite, magnetite, ilmenite and leucocene also exist. Zircon and epidote are present

The matrix has recrystallized with intensity slightly greater than SC #1. Recrystallization is more pronounced along bands showing considerable quartz. The lineation is a 2ndary feature.

Kaolinization of plagioclase and orthoclase phenocrysts is slightly more intense than in SC #1, although sericite is less commonly seen.

Rock is monzonite porphyry with a few primary quartz phenocryst. The amount of quartz sweated out of the matrix strongly suggests, however, the SC #1A and probably also SC #1 are more correctly quartz monzonite ~~porphyry~~ porphyry. (Quartz latite porphyry if one prefers the volcanic name.)

SC #2

35% phenocrysts, mostly twinned plagioclase, with some K-spar, sparse quartz, sparse chlorite. Magnetite-ilmenite appears almost completely destroyed with iron going primarily to fine-grained, fresh 2ndary biotite. Quartz is very sparse. Same rock as SC #1 and SC #1A but similar to SC #1 in that the composition appears to be latite or monzonite porphyry.

Matrix is recrystallized and appears to contain iron hydroxide with the feldspar. Lineation to rock is given by 2ndary biotite forming along parallel zones. Kaolinization is fairly strong and sericite is moderate. The rock is more intensely altered than SC #1 or 1A. A weak possible alignment of phenocryst is no different from 1 or 1A.

SC #3

Mega Looks decidedly different from 1, 1A or 2 in cut section.

Rock has apparent volcanic texture, has xenoliths, and presents a far fewer number of phenocrysts. This rock was very close to the contact.

Micro 15% phenocrysts, mostly untwinned plagioclase, K-spar, with very small amount of phenocrystic magnetite. One silty xenolith was seen.

The matrix is strongly recrystallized to plagioclase, orthoclase, some chlorite and or 2ndary biotite, and streaky quartz. Recrystallization has proceeded unevenly and a banding is seen where coarser matrix parallels finer matrix. 5-10% magnetite is locally finely disseminated through the matrix. Feldspar xenoliths show moderate clay alteration, weak sericitization, and a general lineation (alignment parallel).

Rock must be classified as porphyritic latite or quartz latite. Lack of phenocrysts, lack of twinned plagioclase, and presence of xenoliths make this rock very dissimilar to SC#1, 1A, and 2. To be the same rock would require total destruction of over half the phenocrysts, including total destruction of all twinned plagioclase. (Alteration of phenocrysts is not strong enough to mask twinning]. Also would require breakdown of magnetite crystals to finely disseminated magnetite.

SC#4

Mega Rock with apparent volcanic texture and few phenocrysts from ±20 feet from the critical contact.

Micro Maybe 20% phenocrysts, untwinned plagioclase, orthoclase, a couple of small remnant hornblendes(?), 2% magnetite with several more percentage finely disseminated through the matrix. One fairly large xenolith(?) is completely altered to quartz-sericite. Several other "masses" of clay-quartz-sericite may be remnant phenocrysts. Phenocryst show a general parallel alignment.

Matrix is recrystallized feldspar with some quartz. Thin black streaks seen in the cut section are streaked-out magnetite. Magnetite is also generally disseminated in the matrix. Considerable sericite is scattered through the matrix and also occurs in massive bands or lenses in the matrix.

This porphyritic latite or quartz latite ~~is~~ the same rock as SC #3, but with restoration of some of the possibly completely shot xenoliths (??) it would be texturally closer to SC#1, 1A and 2 than is SC#3. Still unexplained, however, is the lack of twinned plagioclase.

Like SC#3, this is a rather intensely altered rock.

SC #5

Mega Appears like a silicified, porphyritic, flow-banded volcanic rock in hand specimen.

Micro Maybe 10% of rock is phenocryst, mostly pretty well destroyed by recrystallization. Most feldspar is untwinned, but possible twinning was seen in two localities. Patches of massive sericite may represent former hornblende, or biotite or feldspar. Magnetit is altering to limonite with only cores of magnetite left.

The matrix is very fine-grained but closely streaked throughout with parallel bands of quartz. This matrix has a funny blotchy textu which I think is merely due to over-grinding of the slide. (?? No.)

This rock shows the most intense alteration yet, but is probably equatable with SC#3 + SC#4.

SC #6

Mega A strange, banded (distorted), apparent volcanic rock.

Micro About 15% phenocrysts recognizable. Most feldspars are pretty badly shot, no twinning seen. Sericite replaces one still sub-hedral phenocryst (biotite?) and occurs elsewhere as anhedral patches along with disseminated magnetite-limonite.

The matrix shows banded mobilization of quartz in some places, feldspar in others, and sericite formation yet elsewhere. The blotchy texture seen in SC#5 is here also, but obviously not a function of grinding. The coarser-grained patches show bands of recrystallized quartz in two directions — one perpendicular to the other. One direction is decidedly stronger and gives the rock its banded appearance. So banding is definitely a 2ndary feature. The finer portions of the matrix are for all practical purposes isotropic until highest power lens shows it to be feldspathic incipient recrystallization.

This rock — porphyritic latite or quartz latite — is again equatable with SC#5 + SC#4.

SC # 7

Mega Very similar in cut section to SC#6 except banding is well pronounced + "flows" around about 15% of well-defined phenocrysts.

Micro Similar is most respects to SC#6. Strong banding is 2ndary recrystallization + partial mobilization of quartz and feldspar. Magnetite-limonite and sericite are disseminated throughout. Feldspar phenocrysts are pretty well kaolinized.

Banding is 2ndary but could possibly be after a primary flow structure.

SC # 8

Up to 20% shot phenocrysts, mostly feldspar but some apparently after femags. Banding is 2ndary and quite contorted. Matrix is blotchy. Generally similar to SC # 7.

SC # 9

This is the banded limestone or marble from near the granitic intrusive on the east end of the Sycamore Canyon road.

Petrography a banded quartz-sericite mixture. No carbonate seen. Limonite rims small magnetite crystals and streaks parallel to banding. Some feldspar may be among the quartz

A totally 2ndary rock.

PAT 1

Handspecimen looks like a silty sediment. Banding might be an alteration feature parallel former bedding?

<u>Micro</u>

Former feldspathic-quartz silty sandstone, now well metamorphosed and grains show fusion with one-another. Quartz has been introduced (maybe sweated out of other areas of the sandstone) in the form of unidirectional veinlets.

PAT 2

Handspecimen looks like the same sediment, maybe somewhat more altered.

micro Probable former silty sandstone showing various phases of crystallization. Almost like a blotchy recrystallization texture in a fine-grained igneous matrix. Two directions of quartz veinlets are seen. Clumps of chlorite are growing, probably as accumulations of the silty portions of the original rock. & Fe oxide on fractures.

Alteration thus considerably more intense than in PAT 1.

PAT 3

Handspecimen looks like an intensely silicified rock. No texture visible.

micro Rock looks like a fused + partially crystallized sandstone. Silty fraction has gone to sericite. Fractures have Fe oxides. Quartz veining is nearly absent. If this rock is closer to the intrusive, it certainly shows a differential heating of the sandstone, for — except for the sericite which may or may not be significant — this specimen appears less altered ~~that~~ than PAT 2.

PAT 4

Handspecimen essentially siliceous, fine-grained, textureless.

micro
Sandstone showing ~~a~~ fusion, crystallization (growth of quartz) ~~[illegible]~~ to a somewhat lesser intensity than PAT 2 but more than PAT 1 or PAT 3. Sericite has gathered in clumps — is not so disseminated as it was in PAT 3. Quartz veinlets may be growing locally.

PAT 5

Rock looks like a flow-structured volcanic. Xenoliths were seen in cut section.

Igneous rock with ± 10% phenocrysts set in a recrystallizing quartz-feldspar-sericite matrix. Fragments are of sandstone. Phenocrysts are feldspars, sometimes twinned, usually well-formed and of fair size and kaolinised. The flow structure evident in hand specimen is vague but apparently due to recrystallizing coarser quartz (also sericite in some band) along a single direction.

So texture igneous overall, flow structure is but a 2ndary feature.

PAT 6

Obvious igneous porphyritic texture.

micro Phenocrysts (± 20% of rock) are generally feldspar, some twinn The phenocrysts appear to be incipiently recrystallizing. The matrix is recrystallizing and one quartz veinlet was seen. There is considerable sericite through the matrix + crystals of magnetite are present, though scarse

PAT 7

Handspecimen shows a chloritic streaking in a rock of questionable origin. Some patches look very fine-grained sedimentary, but other ~~vague~~ areas have vague possible igneous textures.

Intense alteration along fractures obscures identity. A few badly altered (kaolin, sericite, quartz) phenocrysts? suggest an original igneous texture, but some areas have no apparent phenocrysts unless they have been totally destroyed. Lots of quartz + sericite near fractures. Matrix appears incipiently recrystallized. Tiny crystals of magnetite are disseminated throughout the rock, making it possibly a dike of the volcanic type rock from the SC series. Fe oxide fills parallel fractures.

PAT 8

Good igneous porphyritic texture. Like SC #1 or 1A o 2.

Petrographically this is the monzonite or quartz monzonit of SC #1, 1A and 2. Phenocrysts are 50% of the rock and include feldspar (frequently twinned + kaolinized), magnetite, chlorite after femag. A little sericite is seen. There has been some incipient recrystallization of the matrix but it remains rather uniformly fine.

ASARCO

Southwestern Exploration Division

December 14, 1977

F.T.G.

TO: F. T. Graybeal

FROM: P. G. Vikre

Mafic Breccia
Santa Cruz Project

Below is a tentative outline for study of the mafic breccia encountered in holes SC-37, SC-39, and SC-48. Megascopic, and to an extent microscopic, observations will be integrated under A.

A. Petrology
  1. Description of clasts (may be in the form of a chart) - ok for details but give us a summary description as part of text.
    a. Rock type
    b. Relative abundance
    c. Size, shape, etc.
  2. Description of matrix
    a. 1st generation matrix
    b. 2nd generation matrix
    c. Varying matrix/clast
  3. Alteration
    a. Clasts
    b. Matrix
  4. Mineralization
    a. Assemblages in clasts — supported by assays of separate clast material, I assume.
    b. Assemblages in matrix
B. Structure
C. Proposed tectonic history - including significance of the mineralization.

APPENDIX Hole summaries

Peter G. Vikre
P. G. Vikre

PGV:lb

Peter
Looks OK to me. I think we discussed perhaps 1 week full time work (or equivalent) of your time might be sufficient and 2 weeks an upper limit. Be sure to get together w. Jim Sell to look at core before you start project

FTG
12/14/77

cc. JD Sell

ASARCO

Southwestern Exploration Division

June 21, 1976

TO: W. L. Kurtz

FROM: F. T. Graybeal

Structural Reinterpretation of
Santa Cruz Project -- The Lands
Pinal County, Arizona

Attached please find a report by J. D. Sell titled "A Structural and Related Mineral Reinterpretation of the Santa Cruz Horst Block". This study was initiated last Fall by Mr. Sell, H. G. Kreis, and R. B. Cummings with the objective being to clarify certain aspects of the Santa Cruz geology. Mr. Sell concludes that the primary geologic control in this area is a northeast-striking structural zone of Precambrian ancestry. He suggests this zone, originally vertically dipping, has been tilted and offset by northwest-striking faults. Several exploration targets peripheral to areas of past drilling are suggested, including one on the Griesbach property, just recently acquired by the Asarco-Freeport joint venture.

Mr. Sell has done an excellent job of compiling an incomplete data base, about which there is still disagreement. His conclusions should be of use during 1977 exploration of this area and also of use in our ongoing exploration of the Casa Grande region.

F. T. Graybeal

F. T. Graybeal

FTG:lb
Att.

cc: TCOsborne - w/att.
JDSell - w/o att.

JDS [illegible] → wk → JD Sell brings the geometry into sharp focus with clearcut illustrations involving bold interpretations —

It will very interesting to see how well this concept correlates with an updated Sacaton Study —

JHC

Incidentally, there may be a connection between the existance of a deep seated fluidized zone and the extreme movement in the vertical range required to account for the depth of oxidation.

over —

that is — the present depth (below sea level) of previously oxidized sulphides.

ASARCO

Southwestern Exploration Division

May 12, 1976

TO: F. T. Graybeal

FROM: J. D. Sell

Santa Cruz Project Studies
Pinal County, Arizona

Attached is my report: A Structural and Related Mineral Reinterpretation of the Santa Cruz Horst Block.

The study was undertaken with H. G. Kreis, Santa Cruz Project Geologist, and R. B. Cummings, Resident Geologist-Sacaton. Both contributed numerous ideas and comments and have reviewed the draft of this report.

James D. Sell

James D. Sell

JDS:lb
Att.

cc: HGKreis
RBCummings

A STRUCTURAL AND RELATED MINERAL REINTERPRETATION
OF THE SANTA CRUZ HORST BLOCK

Summary

Interpretation of the relogging of the core and rotary samples during the Santa Cruz Studies has suggested to Sell that in the horst block area the quartz monzonite porphyry intrusive was emplaced along an older structural zone.

The zone, here named the SC zone, is characterized by the abundance of thin diabase dikes cutting slices of Precambrian granite with thin breccia zones and faulting as subparallel planar structures. In Precambrian time, the zone of weakness was probably a near vertical feature but has since been involved in rotational, tilting movement. The axis of rotational movement was subparallel to the present strike trend of the zone. The SC zone presently strikes in a general N60°E direction and dips around 40° northwesterly. It is expressed between holes SC-18 on the northeast to SC-20 on the southwest, a distance of over 4000 feet. It is probably offset 2000 ft. to the south between holes SC-20 and SC-12 by the Westside fault which strikes N30°-35°W and dips 45° southwesterly. The SC zone is suggested to pass through hole SC-4 and continue further to the southwest.

In Laramide time the SC zone was the site of renewed movement along the faults, and a part of the tilting probably occurred at this time. Dikes of various porphyry rocks and thicker masses of quartz monzonite porphyry, as well as breccia masses, were emplaced along the zone and principally in the hanging wall of the Precambrian SC zone. The dikes and masses are again mainly subparallel to the planar fabric established during the Precambrian events. In the footwall of the SC zone, Precambrian granite is found high and to the west where it is quite massive, although cut by a few diabase dikes which generally have intrusive contacts. Easterly and at depth in the footwall of the SC zone is the Laramide quartz monzonite porphyry. The porphyry was in part guided into its emplacement by the SC zone and, although crushed and faulted at the boundary, is most often a massive unit below the SC zone.

The SC zone, on its northwesterly or hanging wall side, is the site for extensive faulting, brecciation, and fluidization of various Precambrian granite and Laramide quartz feldspar porphyry, hornblende porphyry, and various quartz monzonite porphyry units which generally show a preference for steeper contacts. The fluidized zones generally do not mix rock types and exhibit all degrees of fluidization and brecciation within the units. Diabase, in general, was not found with a fluidized texture, although in SC-22 a mixed zone of quartz monzonite porphyry and granite had a minor amount of "dark volcanic" and recognizable diabase inclusions.

The zone of massive fluidization and brecciation is noted in holes SC-14, 18, 19, 22, and 24. Outside the zone are numerous zones of narrow fluidization and "internally disintegrated" rock. These narrow zones are found both in the hanging wall granite and in the footwall granite and quartz monzonite porphyry.

The Santa Cruz horst is bounded on the east by the Eastside fault. This structure strikes N20°-25°W and dips 45° northeasterly. Little data is available east of the fault, but it appears to offset the SC zone and the extensive fluidized zone to the north for an unknown distance. As noted, the fluidized and brecciated zone, as exemplified in SC-18 and interpreted for SC-14, is cut by the Eastside fault. The northward offset may amount to around 2000-2500 feet of dominant strike-slip movement. The SC zone continues to the northeast between holes SC-21 and SC-23. No extensive fluidization features were noted in either SC-21 or SC-23, but the change from Precambrian granite on the north in SC-23 to Laramide monzonite on the south in SC-21 is the same type of change as found across the top part of SC-22 over to SC-24 (allowing for the difference in elevation of the monzonite mass).

Coincident with the extensive fluidized and brecciated zone is the occurrence of higher values of molybdenum contouring outward from hole SC-24 and a higher center of primary copper grades contouring outward from holes SC-18 and SC-24. Undoubtedly the original grade within this zone was responsible for the better development of a chalcocite blanket, which was subsequently modified and converted into the "copper oxide" blankets as presently known.

In the Santa Cruz horst area the massive quartz monzonite porphyry is known to extend up to an elevation of minus 420 feet below sea level on the footwall side of the SC zone. On the hanging wall side, dike-type units of similar quartz monzonite porphyry were first encountered at an elevation of minus 870 feet below sea level. Precambrian granite is known to extend to a depth of minus 1169 feet below sea level on the hanging wall side.

The various dikes and masses of hornblende porphyry, hornblende feldspar porphyry, quartz feldspar porphyry, grey quartz monzonite porphyry, black quartz monzonite porphyry, and various textures of quartz monzonite porphyry found in the hanging wall of the SC zone probably reflect a monzonitic source area at depth. The occurrence of massive quartz monzonite porphyry at a higher level in the footwall of the SC zone is probably the result of a) a higher level of intrusion of the monzonite mass along the weak zone exemplified by the diabase and faulting in the Precambrian granite, and b) some faulting along the contact which downdropped and tilted the hanging wall units both before and after the influx of the Laramide fluidization and brecciation event.

The area of fluidization, brecciation, and mineralization around holes SC-18 and SC-24 is regarded as a center of activity. A second center of mineralization is suggested in the vicinity of hole SC-4 where fluidization, better alteration, and higher molybdenum values are noted. Hole SC-23 to the northeast is regarded as a third area of contrasting alteration-mineralization-tectonic style.

Introduction

The location-plan map of the Santa Cruz project is shown in Figure 1 (modified from HGK Fig. 1). In September of last year, a relogging-reevaluation of the project drill results was initiated by Kreis, Cummings, and Sell. The main emphasis of study was the Santa Cruz horst block, the area of major drilling and significant results, centered around drill holes SC-22, -19, and -24.

Many thoughts were expressed and discussed by all involved. This report was written by Sell and has been reviewed by Kreis and Cummings. Neither Kreis nor Cummings agrees with portions of the text, and it was not feasible to clarify these differences at this time. Kreis·will incorporate his comments in a forthcoming comprehensive report, and Cummings will submit a separate memo comparing features of the Sacaton and Santa Cruz areas. The study ended with drill hole SC-24, and no review of the subsequent holes, presently being drilled, has been made.

Faulting

Logging and constraints have suggested a number of fault structures in the horst block area (Fig. 2). Basically interpreted is an older Precambrian fault trend, here named the SC zone, which strikes N60°E and presently dips 40° northwesterly. The SC zone horst block is cut, downdropped, and laterally translated by three major structures: 1) the westside fault, which strikes N30°-35°W and dips 45° southwesterly and offsets the SC zone some 2000 feet to the south mainly by strike-slip movement; 2) the eastside fault, which strikes N20°-25°W and dips 45° northeasterly, offsets the SC zone to the north an unknown distance but probably between 2000 and 2500 feet, also by strike-slip movement; and 3) the southside fault, which is interpreted to cut the westside and eastside structures, strikes N55°-60°E and dips steeply to the southeast. The southside fault may be a series of structures which cumulatively downdrop the south side of the horst block in excess of three thousand feet. A fourth fault structure was cut in hole SC-21 and is interpreted to terminate at the eastside fault while striking N60°E and dipping 50° southeasterly. This structure is based on one hole intercept and true strike direction is unknown.

Present drill hole data and three point resolutions do not permit the precise determination of the fault directions and dips. It is known that variations exist and the above figures reflect the general trends of the structures.

SC Zone

The SC zone is a totally complex structural-intrusive zone extending from Precambrian thru post-Laramide time.

A cross-section of the SC zone has been constructed through drill holes SC-22, -19, and -24. Figure 3 shows the SC structure as a fault (colored blue) with massive granite and quartz monzonite porphyry below on the footwall side. Minor crushing and shearing with gouge development are also noted along the fault structure and somewhat below. Several gently dipping diabase dikes and one steeper fluidized granite structure are also shown in the footwall block. This massive characteristic is sharply changed across the fault structure and in the hanging wall side of the fault a complex intrusive sequence of granite, diabase, and various porphyries, all highly fractured, brecciated, and fluidized to various degrees and involvement, is found to extend some distance away from the fault at the base of the sequence. In the upper part of drill hole SC-19 and the bottom of hole SC-22 are found "internally crushed" granite masses cut by diabase and quartz monzonite porphyry dikes dipping at moderate angles. In hole SC-22, the majority of the hole contains highly brecciated and fluidized units of granite and various porphyries. The top of the brecciated and fluidized group is marked by a strong fault containing gouge and breccia, and above the fault is massive, weakly shattered granite. The entire zone of brecciated and fluidized units is called the SC zone.

The events leading up to this complex picture are as follows: During Precambrian time, large masses of granite were emplaced in central Arizona generally in contact with Pinal Schist. The Santa Cruz area appears to be within the granitic mass and the earliest SC zone was characterized by shearing and breakage along the N60°E trend. Part of the zone of weakness was utilized by the emplacement of thin, planar, intrusive diabase dikes having chilled borders. Although no age dates are available from the Santa Cruz area, I believe the diabase is Precambrian in age as expressed by Balla (1972) in the Sacaton area. Further, I feel the diabase was initially injected as near vertical dikes and their present attitude reflects later tilting of the blocks.

Figures 4 and 5 are plan maps of the minus 500-foot elevation below sea level and minus 1000-foot elevation below sea level, respectively, in the area of study. On the northwest side of the SC structure, as noted in Figures 3, 4, and 5, thin diabase dikes were encountered in nearly each hole in the area. A profusion of slips, faults, and crushed zones is also apparent which appears to belong to the Precambrian fracture system and again mainly in the northwest or hanging wall of the SC structure. In the southeast or footwall of the SC structure, the Precambrian granite is essentially a massive, unbroken unit with two discrete diabase dike intercepts in hole SC-24. It is realized that the sparsity of drill intercepts into the footwall area of the SC zone does not permit a clarified picture, but there seems little doubt that the hanging wall side of the SC structure, as now known, was the site of multiple diabase dikes and much more abundant fracturing and faulting.

In Laramide time a mass of quartz monzonite porphyry was emplaced, and it appears to be guided by part of the older SC zone. As presently known in the southeast or footwall side, massive quartz monzonite porphyry was intruded to a fairly high level in the vicinity of holes SC-14, -16, and -18, and several discrete black quartz monzonite porphyry and black feldspar porphyry dikes were emplaced in the Precambrian granite further west. In the hanging wall side of the SC structure, numerous thin zones of quartz monzonite porphyry with a number of textural variations were emplaced in the sheared granitic terrain. Also in the hanging wall side, extensive brecciation and fluidization of Precambrian granite and Laramide quartz monzonite porphyry were involved. The fluidization exhibits all degrees of intensities and involvement, but in general is restricted to single units and, although granite and quartz monzonite porphyry may alternate in relatively thin apparently planar slices and each is fluidized, the fluidization generally did not mix rock types. Although the diabase is assigned to the Precambrian and the fluidization as a Laramide event, diabase was rarely found to exhibit fluidization features except very locally along contacts. Post-fluidization fracturing and faulting are common features and occur within the expanded fluidized SC zone. Apparently late hornblende porphyry, quartz feldspar porphyry, and various darker quartz monzonite porphyries were emplaced late in the fluidization sequence. Much of the fluidized and late diking appear to favor steeper structural zones than the diabase and more planar quartz monzonite porphyry zones and may represent continued rotational adjustment along the SC zone.

In the footwall side of the SC structure, rare fluidization was noted. A fluidized quartz monzonite porphyry dike was noted in drill hole SC-4 while a small fluidized structure of Precambrian granite was found in hole SC-24.

Figure 6 separates the non-brecciated, brecciated, and fluidized granite and porphyries. Drill hole SC-22 was terminated between the two intrusive complex groups, and no data is available in other holes to confirm the depth configuration of the intrusive complex. Figure 6 also indicates the probable continuing tilting and rotational movement of the Santa Cruz Horst block with the passage of time. Assuming a near vertical zone during the emplacement of the diabase, then each succeeding event was accompanied by rotational movement, so that the diabase presently has a flatter attitude than does the monzonite, followed by the fluiding event and culminating in the late hornblende feldspar porphyry dikes which cut the fluidized zones at a generally steeper angle.

Mineralization

Mineralization within the Santa Cruz system as presently known can be divided into four groups: 1) primary sulfides of pyrite and chalcopyrite; 2) a chalcocite zone, often partially leached; 3) a first remnant chalcocite with pyrite zone, often highly leached; and 4) the "oxide copper" zone of chrysocolla, brochantite, and atacamite.

Figure 7 is the cross-section of holes SC-22, -19, and -24 with the above four zones as intercepted. Hole SC-22 did not intercept any oxide copper but found a remnant leached chalcocite-pyrite zone and, further in depth, a leached chalcocite zone before terminating in partially leached primary pyrite-chalcopyrite. Hole SC-19 intercepted three distinct oxide copper zones, then a highly leached zone with sparse remnant chalcocite containing an oxide copper band at its base, then a leached chalcocite zone terminating at a fault (the SC fault) where unleached pyrite-chalcopyrite was encountered to the terminated depth. Hole SC-24 also intercepted three oxide copper zones, then penetrated the SC fault, after which the hole went into highly leached remnant chalcocite-pyrite, followed by a distinct chalcocite zone which bottomed in partially leached and chalcocite-enriched primary values, and terminated in primary pyrite-chalcopyrite values.

Interpretation of this information would suggest a moderate dip to the top of the primary pyrite-chalcopyrite values, which are interpreted to be subparallel to the top of the chalcocite zone drawn between holes SC-22 and -19. Likewise, the line connecting the top of the first remnant chalcocite-pyrite zone is compatible to the lower two surfaces. In Figure 7, the dip assigned to hole SC-24 is determined by association and other control described below.

If the top of the chalcocite zone between holes SC-19 and SC-22 is taken to have formed at a near horizontal surface, then the present surface has been rotated to the increased slope. Note that if the surface is rotated back to near horizontal, then the late stage features found in hole SC-22 assume a near vertical emplacement trend.

The oxide copper zones roughly fall at the same elevation but, as shown in Figure 7, appear to be somewhat irregular and are assigned a flattish dip and probably reflect redistribution to the present bedrock surface. Intra-spaced drilling of the oxide deposit will resolve this problem more fully.

Figure 8 is a plan map showing interpreted structural contours on the top of the oxide copper zone as penetrated in the present drilling. As contoured, the top of the zone is a rather sharp ridge which slopes away in three directions, and which appears to reflect the rock surface contours. A further modification is along the Eastside fault where volcanics and granite appear to be along the fault surface and have acted as a trap or sponge for the oxide copper values.

The top of the first remnant chalcocite with pyrite can also be contoured and is shown on Figure 9. The contouring is separated into sectors based on the faulting and offsets, as well as hanging and footwall sectors of the SC zone. In the main area of the hanging wall sector, four control points are available and contouring suggests a slight bowing of the surface subparallel to the SC fault trace and dipping around 20° to the southeast. In the footwall of the SC fault two points are available, but hole SC-24 is in fault contact with the first remnant chalcocite-pyrite zone and hence the true thickness is unknown. The contours are drawn in the footwall based on the 250-foot thickness in hole SC-13. However, as suggested in the hanging wall block, the thickness increases from west to east across the block, and if this is true in the footwall block then any increase in thickness would move the contours to the south, as shown by the plus (+) marks, and the final configuration would be subparallel on both sides of the SC fault. Note that there is over 100 feet of displacement across the fault, with the hanging wall down in relation to the footwall. This is also reflected in the cross-section of Figure 7.

Only one point is available in the block containing hole SC-4, but does exhibit the lateral strike-slip offset of contours from the adjacent blocks.

The top of the chalcocite zone contours is shown in Figure 10. On the hanging wall side of the SC fault, three points afford some control and reflect a 25° southeast dipping surface subparallel to the SC fault. On the footwall side, only one clear data point is available, with constraints placed by the use of three additional points. The construction suggests the same subparallel strike direction, but the surface probably dips much shallower at around 10° to the southeast. Pyrite was noted in the quartz monzonite porphyry at the bottom of hole SC-16. The depth does not conform to the contouring and is presently anomalous. The pyrite could reflect a part of the remnant chalcocite-pyrite zone but would again be at an elevation higher than the contourable data, or more probably it reflects a non-leached and non-enriched area. Possibly other complicating fault structures are present and the would clarify the data.

Again, hole SC-4 is a single control point but emphasizes the offset feature.

Figure 11 lists the elevation of the primary sulfides with comments in each hole of the Santa Cruz study area. As the various structures offset the top of the surface and few holes have contacts represented by the base of the chalcocite zone for reference, the data is not contoured. It should be noted, however, that holes SC-14, -18, and -19 all encountered unleached sulfides immediately below the SC fault. Also, hole SC-15 encountered primary sulfide at and in the basal structures of the Eastside fault (dipping easterly), while hole SC-21 entered primary sulfides below an interpreted south dipping fault.

Centers of Intrusive Activity and Mineralization

As exemplified on the plan maps of Figures 4 and 5, and the cross-section of Figures 3 and 6, the area containing holes SC-14, -18, -19, -22, and -24 is one of extensive brecciation and fluidization of Precambrian and Laramide units. Eastward the intrusive complex zone is cut and displaced by the Eastside fault, to the south it terminates against the SC fault, westward it apparently becomes narrower and less complicated, while to the north it terminates in a high angled fault zone against Precambrian granite. A center for the extensive fluidization would appear to be around the holes SC-14, -18, and -19 area and displaced on the east side.

A massive quartz monzonite porphyry-granite contact occurs on the footwall side of the SC fault and had little fluidization and brecciation associated with the contact, as shown by the logging of the basal portions of holes SC-19 and SC-24.

Interpretation of this feature suggests that the fluidization is a later event than the emplacement of the quartz monzonite porphyry and, although the fluidization source undoubtedly utilized the nearby granite-quartz monzonite porphyry contact on the northerly side of the porphyry mass, it is a manifestation of a deeper, later monzonite source and not a contact phenomenon.

Scattered molybdenum values have been obtained from both the rotary and core drilling. Figure 12 plots the molybdenum values in units above the SC fault. A partial closure, with a high of plus 150 ppm, can be drawn in the vicinity of holes SC-18, -19, -22, and -24, the same area as the extensive brecciation and fluidization features. Another tighter closure of plus 100 ppm is suggested for the hole SC-4 area. A possible easterly axis is suggested for the larger closure.

In the footwall of the SC fault, Figure 13, a closure is suggestive in the holes SC-18 and -24 area with less than 100 ppm. Very low values are recorded in hole SC-4 area. Across the Eastside fault in hole SC-21, the progressive increase in molybdenum values at depth suggests either a new center or an offset continuation of the holes SC-18 and -24 closure. A more northeasterly axial trend is suggested subparallel to the SC structural zone.

Also shown on Figure 13 are the copper values found in the primary zone intercepted in the drill holes. These data, mainly in the footwall block of the SC fault, indicate the highest copper values are in the general high molybdenum area.

Another type of mineral center is suggested in the overall distribution of the copper oxides. (Based on descriptive footage, may not be as clear based on weighted copper assay.) Figure 8 shows that holes SC-20 and -24 have chrysocolla as the oxide mineral, whereas hole SC-18 has predominantly chrysocolla with brochantite, while SC-19 has chrysocolla with antlerite. Further outside this grouping of holes, on the east, SC-14 and -16 show brochantite greater than antlerite, while to the southwest SC-13 shows antlerite predominantly over brochantite and chrysocolla.

Chrysocolla is also the mineral type in the area of SC-4.

The high copper oxide values (plus 1%) in holes SC-16 and -18 occur in volcanic agglomerate mixed with granite breccia. A volcanic agglomerate dike is noted lower in hole SC-18 and was highly altered and also contained plus 1% copper oxide values. Similar volcanic agglomerate and granite breccia were apparently intercepted in the rotary hole SC-15, and there the copper values were predominantly chalcocite.

The role of the highly altered volcanic agglomerate as a site mineralization is open to question, but one thought is that the volcanic agglomerate was essentially emplaced along the Eastside fault line and available to the early enrichment cycle of migrated chalcocite. The chalcocite was later downdropped to the present level on the east, and the chalcocite on the upthrown side was subsequently oxidized in place to form the oxide values as now known.

Exploration Targets

The excellent alteration, leached capping, and chalcocite zone found in hole SC-23, a mile and one quarter northeast of hole SC-14, is a distinct and separate entity from the Santa Cruz horst area. The flat fault complications cannot be resolved with the single data point, and the thin interval of chalcopyrite intercepted just prior to the termination of the hole is a tantalizing feature. Additional drilling in this area should have the greatest priority.

The concept of a Precambrian zone of weakness, which was the loci of an extensive zone of brecciation and fluidization as well as the major zone of mineralization in the Laramide, can be used as a guide. As developed, a substantial portion of the zone in the horst area of SC-14 and SC-18 is probably offset along the Eastside fault and the offset is projected to pass north of hole SC-21 and south of hole SC-23. A hole or holes located north of SC-21 would probe for this fluidized zone in Target Area A. Positive results would clarify the mineral projection across a large block of presently noncontrolled ground.

The chalcocite in the Eastside fault zone volcanic agglomerate-granite breccia of hole SC-15 and the southside downdropping of the block south of SC-21 suggest that a relatively thick chalcocite enriched area may be preserved east and south of the two holes and between the extension of the Southside fault, as in Target Area B.

The preservation of chalcocite in the footwall of the SC zone in the area of hole SC-24 suggests a relatively thin and probably local amount of chalcocite would be preserved in a zone subparallel to the SC zone on the footwall side in Target Area C.

On the hanging wall side, a substantial zone of oxide copper is probably preserved between hole SC-19 and the Eastside fault. The southern extent of the oxide zone is questionable south of holes SC-24 and SC-18 toward hole SC-16. A hole placed in the triangle out of the reach of either the Eastside or Southside faults would claify the picture in Target Area D.

A deep primary zone is suggested to underlie the intensive fluidized zone exemplified in holes SC-18 and -24. Fluid inclusions suggest these two holes have excellent characteristics for containing ore grade copper as chalcopyrite near the boiling interface. Reviewing Figures 3 and 6, it is probable that the loci of the fluidized central vent undoubtedly lies below the SC fault as shown, and at some point ruptured the zone and then partially used the zone as a structural control to expand upward, as the drilling has shown. The constraint placed by hole SC-14, which penetrated the SC fault and into massive quartz monzonite porphyry, suggests the test hole should be placed north of a line connecting holes SC-14 and SC-22 and possibly as much as 500 feet north in Target Area E. Valueable information on this problem would have been gained by deepening hole SC-22 into and through the lower intrusive complex.

The Southside fault and its probably continued step-down system appears to be a strong basin controlling system. Present thought is that it is deep (plus 2500 to 3000 feet) to the bedrock units at a short distance south of hole SC-16. The rock type is unknown, but it is likely Precambrian granite near the south contact of the main mass of quartz monzonite porphyry. As more information is gleaned as to the characteristic of the northern contact, it may be justified in probing for and along the south contact. (Apparently hole SC-25, drilled after the preliminary draft of this report, intercepted unaltered Precambrian granite at a much shallower depth southwest of SC-16 than would have been suggested by the foregoing interpretation Probing the south contact would be a much shallower target area.)

James D. Sell
May 1976

J D Sell
~~Ginny~~ 6/21/76

On all copies of J D Sell report refer to Figure 1

a.) hole SC-3 at bottom left side of page should be SC-5

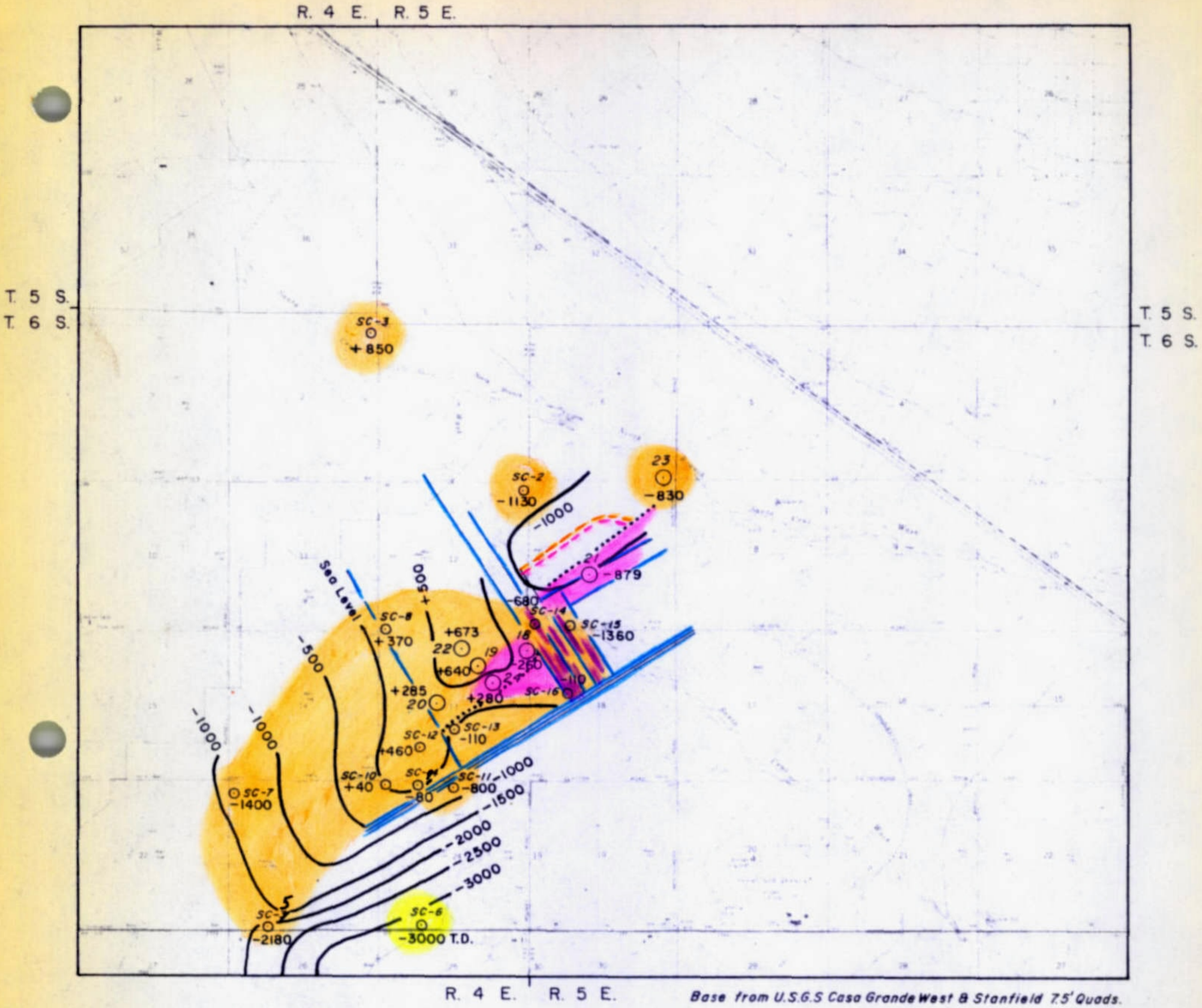
b.) hole SC-14 between SC-10 and SC-11 should be SC-4

I think a little eraser work should suffice. Please as soon as possible

FTG

4 copies changed 6/21/76 (FTG
NY
FILE
HGK) and changes called to RB Cummings.

—FIGURE·I—



Base from U.S.G.S Casa Grande West & Stanfield 7.5' Quads.

—EXPLANATION—

Initial Rock Type Encountered In Hole

🟧 Precambrian granite

🟪 Laramide porphyry

🟪 Volcanics

🟨 Hole bottomed in conglomerate

-500 Elevation contours, top of bedrock

······· Subsurface projection of SC fault (footwall)

═ Fault trace contours

north

TO ACCOMPANY Santa Cruz Project Studies Report

DATED May 12, 1976

BY J. D. Sell

PLAN MAP

SANTA CRUZ PROJECT

(ASARCO-FREEPORT JOINT VENTURE)

Pinal County, Arizona

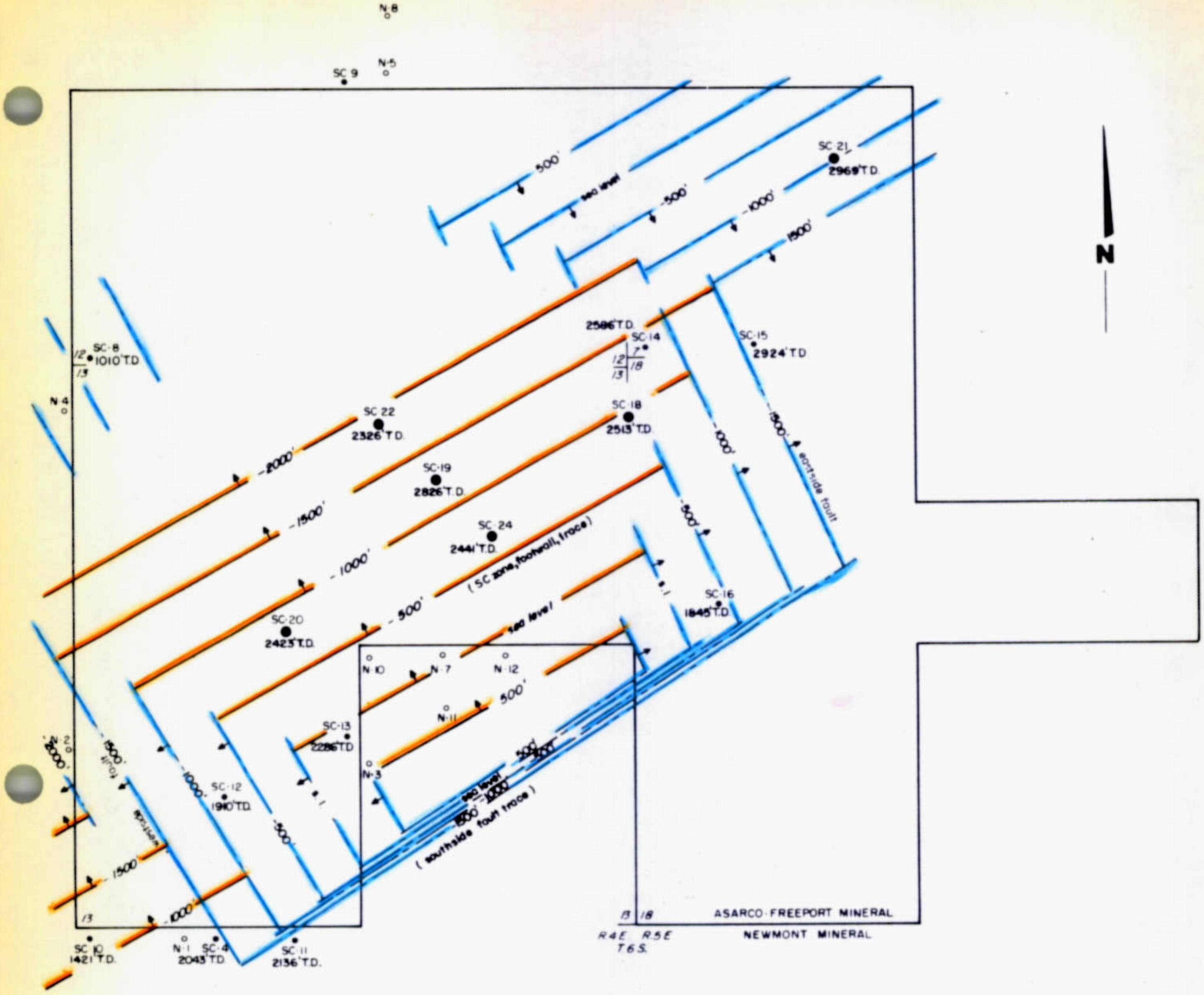
SCALE 1"=1mile

J.D.S.

May 1976

mn 2936 MVK

— FIGURE · 2 —



EXPLANATION

- ● Recent ASARCO drill holes
- • Previous ASARCO drill holes
- ○ Newmont drill holes
- 🟧 SC zone (footwall)
- 🟦 Faults

NOTE: Using 1300' as surface collar elevation on deep hole control

NOTE: Cgl units below+300' level probably involved in faulting except south of southside fault.

TO ACCOMPANY Santa Cruz
Project Studies Report
DATED May 13, 1976
BY J. D. Sell

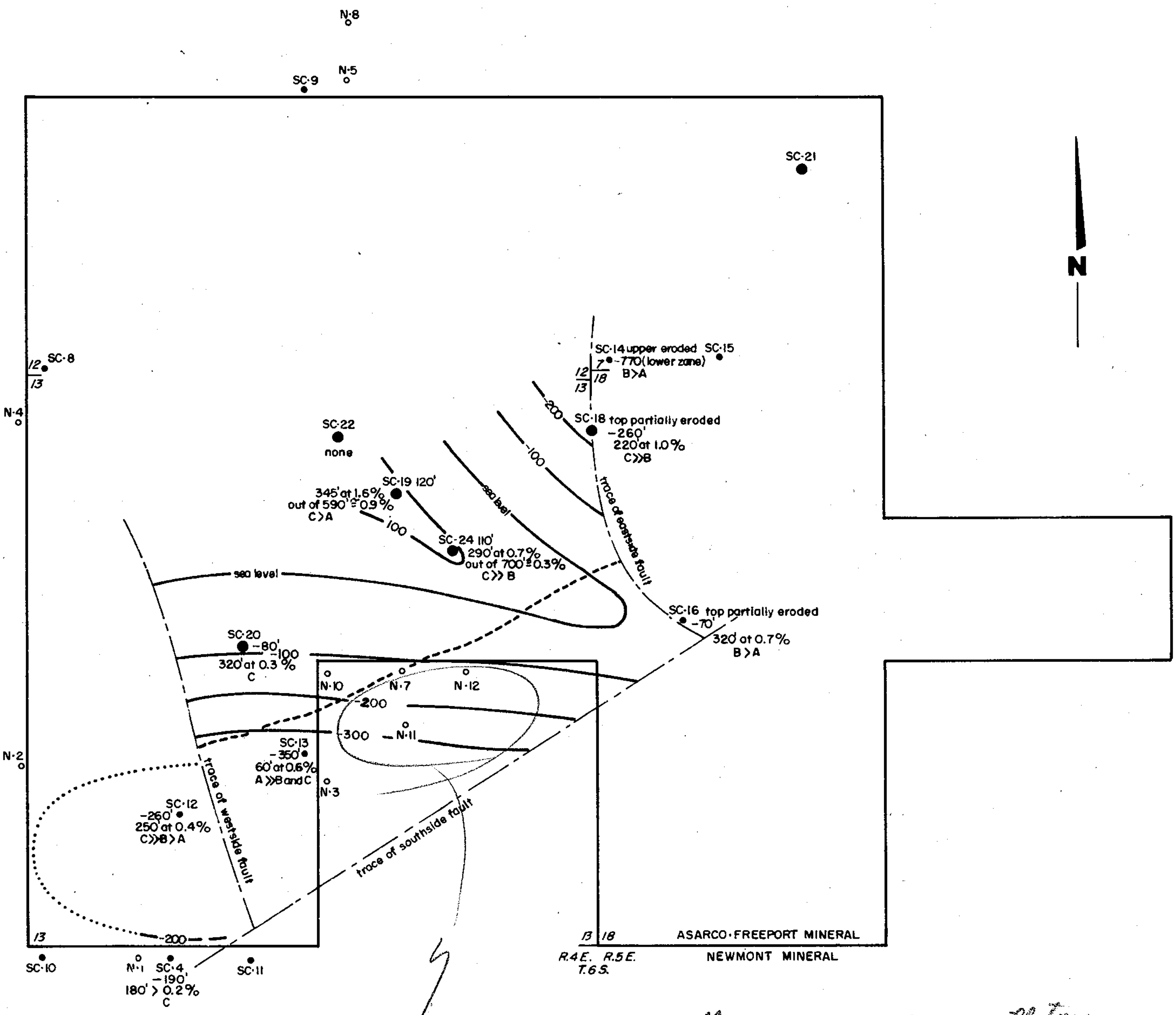
ASARCO
FAULT TRACE & SC ZONE TRACE
SANTA CRUZ PROJECT
PINAL CO., ARIZONA

0 1000 2000
FEET

J.D. Sell
May, 1976

mn 2937 dam

—FIGURE·8—



Oct 1976, Hanna-Getty announce 250 mill tons of +1% copper in this area. Depth of 1600-3200 feet. Subsequent verbal (WES) suggests abundant atacamite as oxide form.
They believe this is the root zone of Sacaton.
John Kinnison "working" for Dave Lowell! consultant to H-G. (Nov. 4, 1976)

EXPLANATION

- ● Recent ASARCO drill holes
- • Previous ASARCO drill holes
- o Newmont drill holes
- – – – Fault
- - - - - SC trace
- ——— Structural contour

NOTE : Thickness, grade and mineral type noted near drill hole
A = Atacomite
B = Brochantite
C = Chrysocolla
> = Greater than
>> = Much greater than

TO ACCOMPANY Santa Cruz Project Studies Report
DATED May 12, 1976
BY J. D. Sell

ASARCO

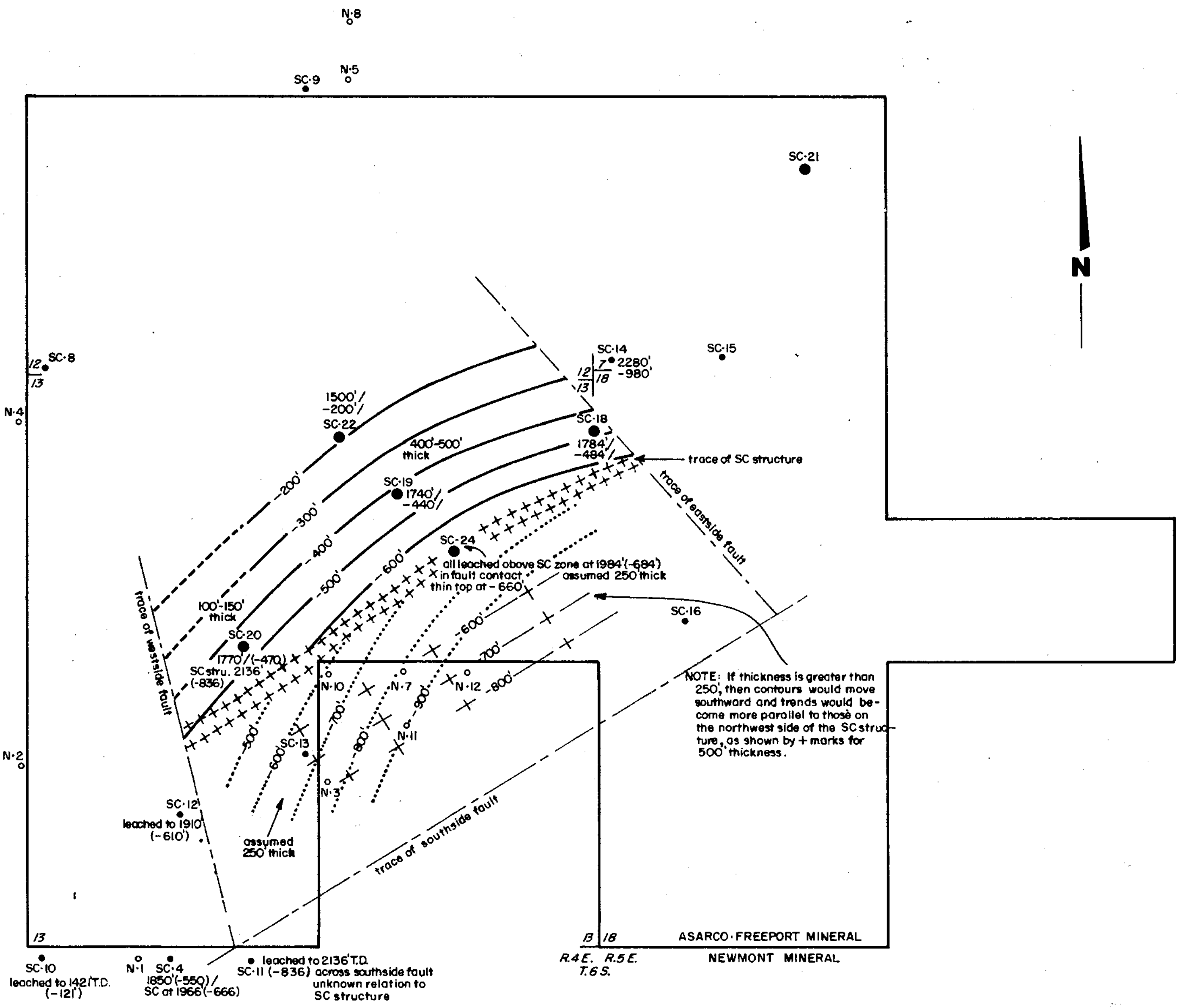
STRUCTURAL CONTOURS
TOP OF "OXIDE" COPPER
SANTA CRUZ PROJECT
PINAL CO., ARIZONA

0 1000 2000
FEET

J.D.Sell May, 1976

mn 2943 dam

FIGURE·9



EXPLANATION

● Recent ASARCO drill holes

• Previous ASARCO drill holes

○ Newmont drill holes

++++ Trace of SC structure

—— First remnant Cc above SC structure

·········· First remnant Cc below SC structure

Note : contours dip 20° to southeast

---- Fault

TO ACCOMPANY Santa Cruz
Project Studies Report
DATED May 12, 1976
BY J. D. Sell

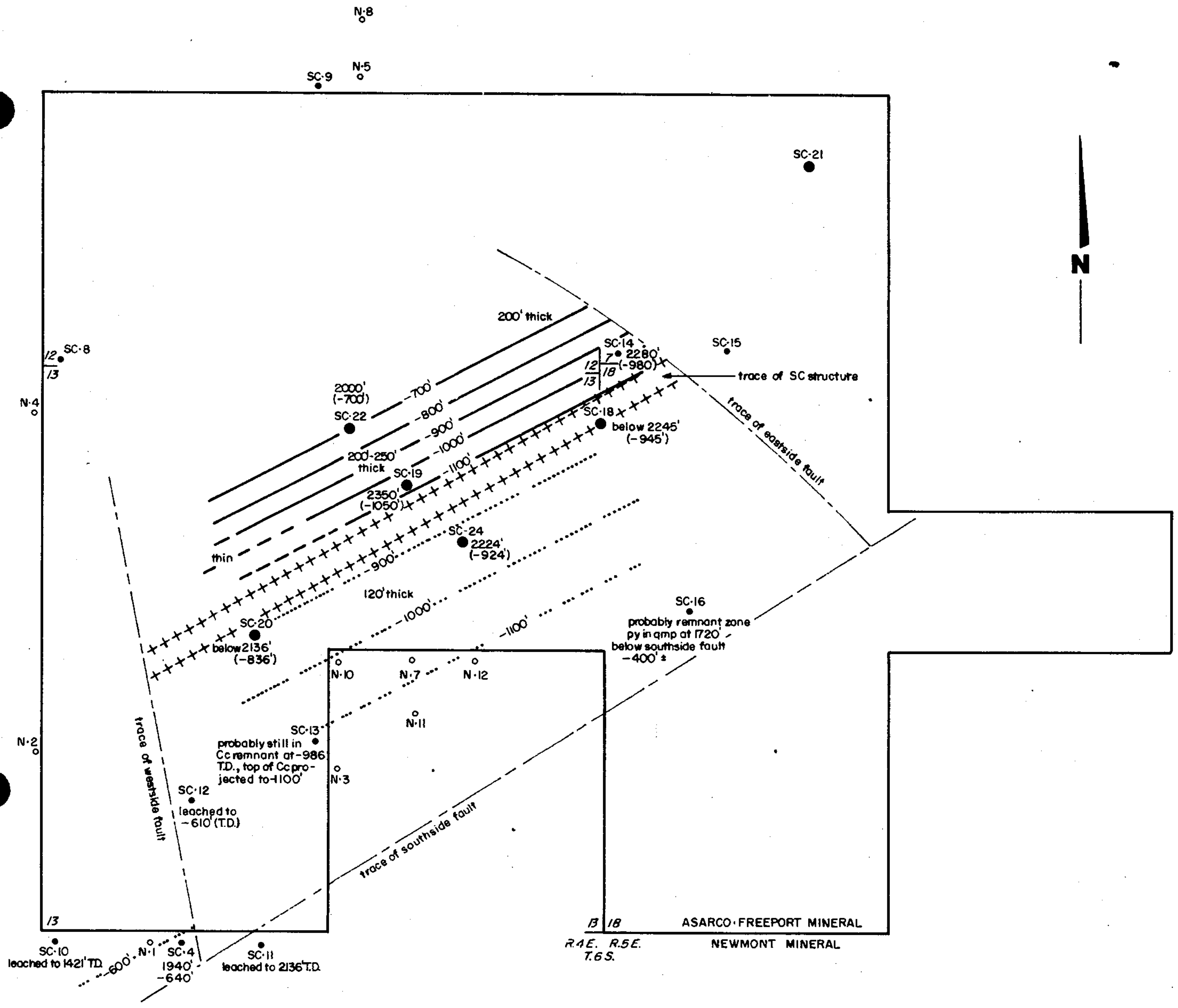
ASARCO

STRUCTURAL CONTOURS

SANTA CRUZ PROJECT
PINAL CO., ARIZONA

0 1000 2000
FEET

J.D.Sell May,1976



EXPLANATION

● Recent ASARCO drill holes

• Previous ASARCO drill holes

○ Newmont drill holes

++++ Trace of SC structure

—— Top of Cc zone above SC structure

········ Top of Cc zone below SC structure

– – – – Fault

NOTE: Cc contours dip 25°± to southeast above SC structure and 10° to southeast below SC structure

TO ACCOMPANY Santa Cruz Project Studies Report
DATED May 12, 1976
BY J. D. Sell

ASARCO

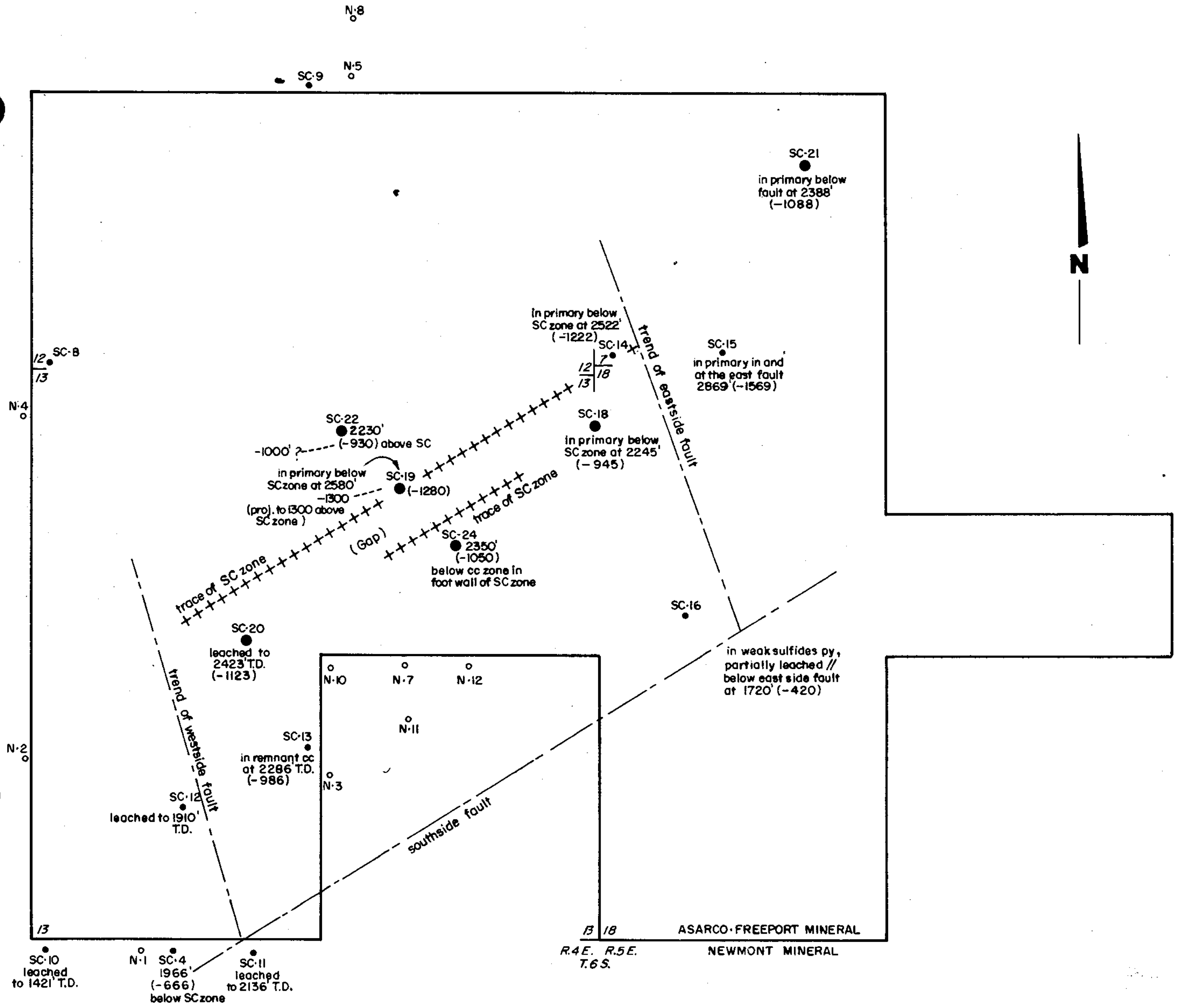
STRUCTURAL CONTOURS

SANTA CRUZ PROJECT
PINAL CO., ARIZONA

0 1000 2000
FEET

J.D.Sell May, 1976

mn 2945 dam



EXPLANATION

● Recent ASARCO drill holes

• Previous ASARCO drill holes

○ Newmont drill holes

TO ACCOMPANY Santa Cruz
Project Studies Report
DATED Aug 12, 1976
BY J. D. Sell

ASARCO

ELEVATION OF PRIMARY SULFIDES

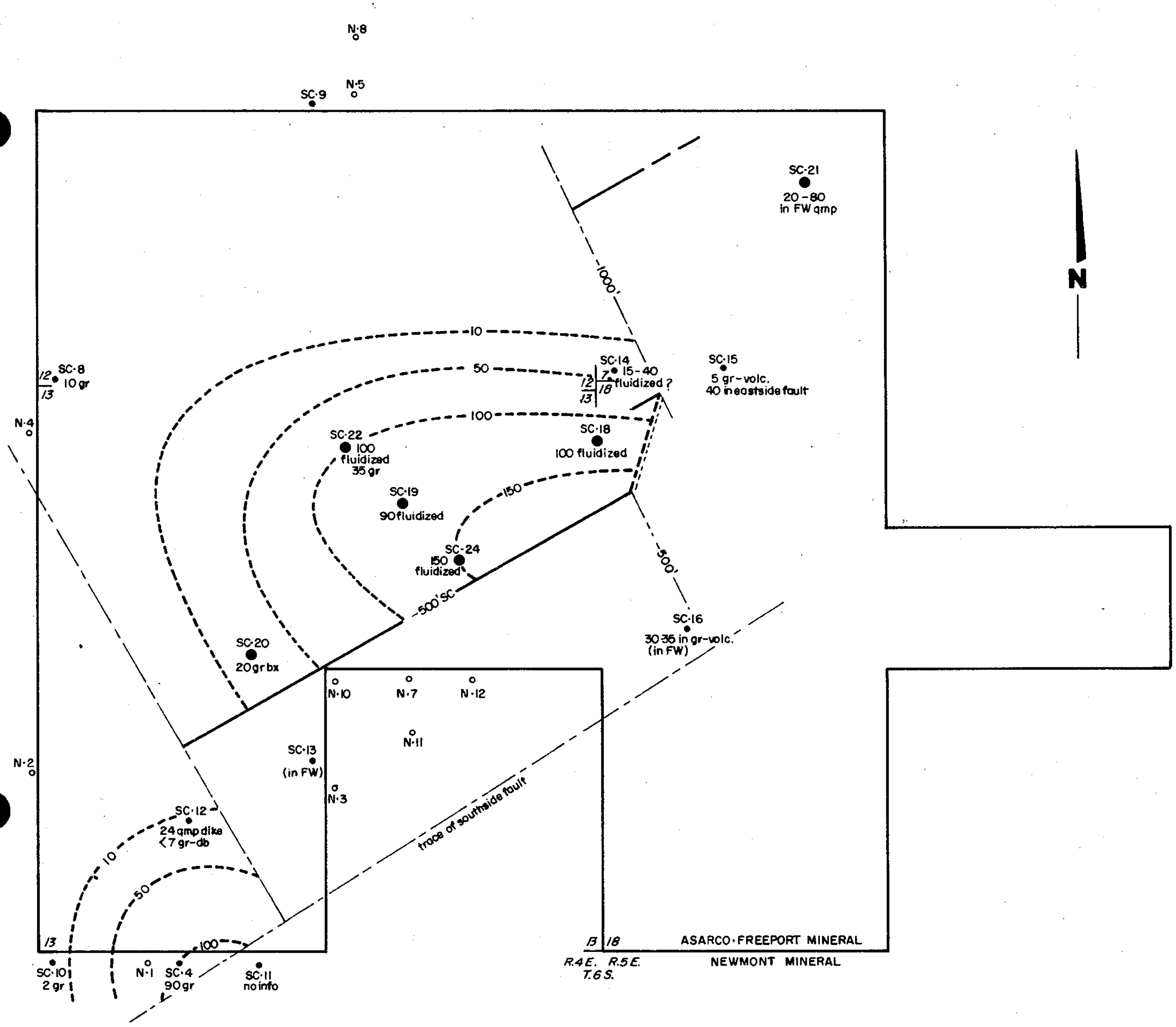
SANTA CRUZ PROJECT
PINAL CO., ARIZONA

0 1000 2000
FEET

J.D.Sell May,1976

mn 2946 dam

—FIGURE·12—



EXPLANATION

● Recent ASARCO drill holes

• Previous ASARCO drill holes

○ Newmont drill holes

- - - - Mo distribution contours (ppm as presently known)

—— SC structure trace (-500'elev.)

— - — Fault trace at -500'elev.

TO ACCOMPANY Santa Cruz
Project Studies Report
DATED May 12, 1976
BY J. D. Sell

ASARCO

Mo DISTRIBUTION IN UNITS ABOVE SC STRUCTURE

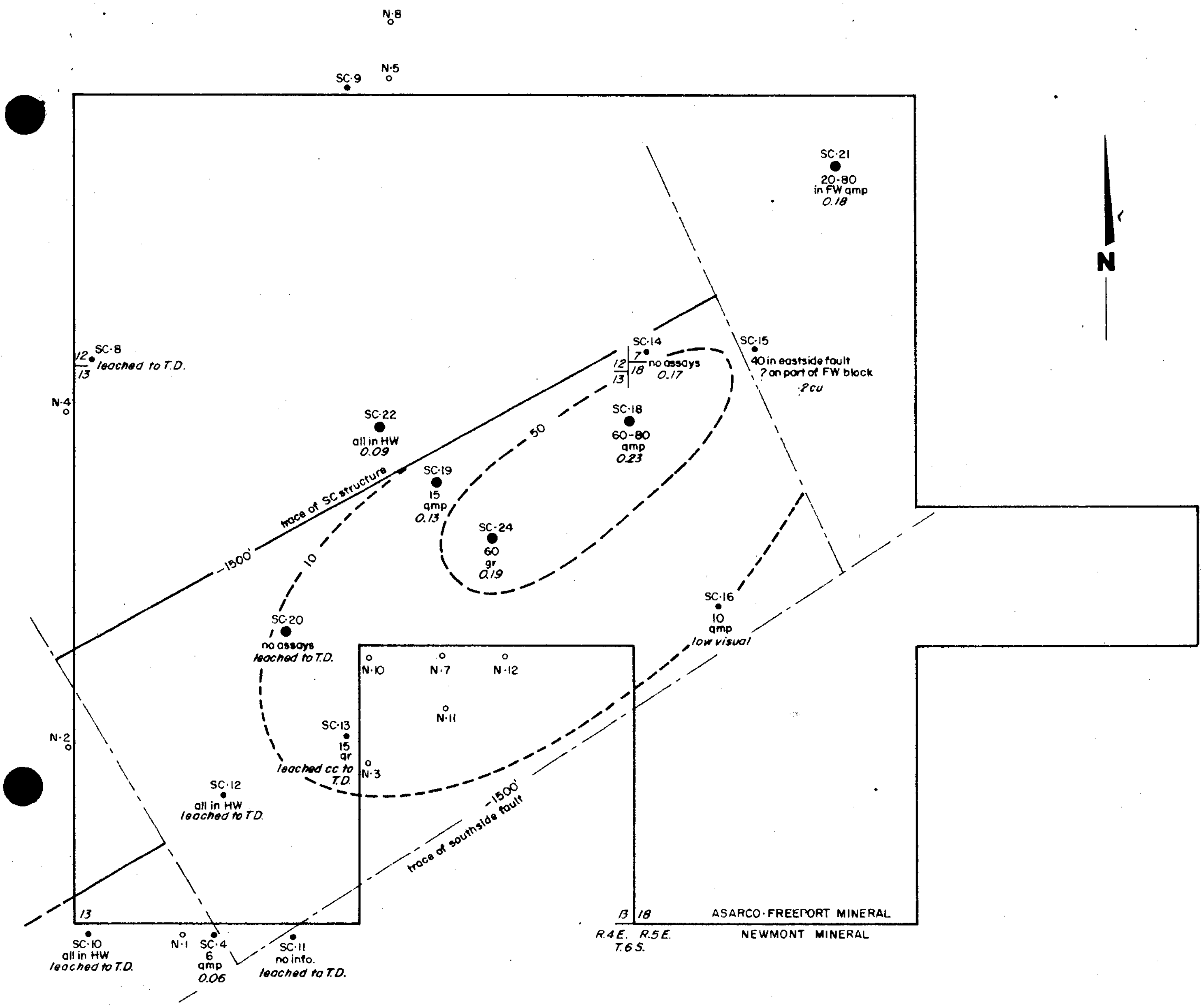
SANTA CRUZ PROJECT
PINAL CO., ARIZONA

0 1000 2000
FEET

J.D. Sell May, 1976

mn 2947 dam

—FIGURE·13—



EXPLANATION

● Recent ASARCO drill holes

• Previous ASARCO drill holes

○ Newmont drill holes

- - - - Mo distribution contours (ppm presently known)

—— Trace of SC structure at -1500' elev.

-·-·— Fault trace at -1500' elev.

0.19 Primary copper value

TO ACCOMPANY Santa Cruz
Project Studies Report
DATED May 18, 1976
BY J.D. Sell

ASARCO

Mo DISTRIBUTION IN UNITS BELOW SC STRUCTURE

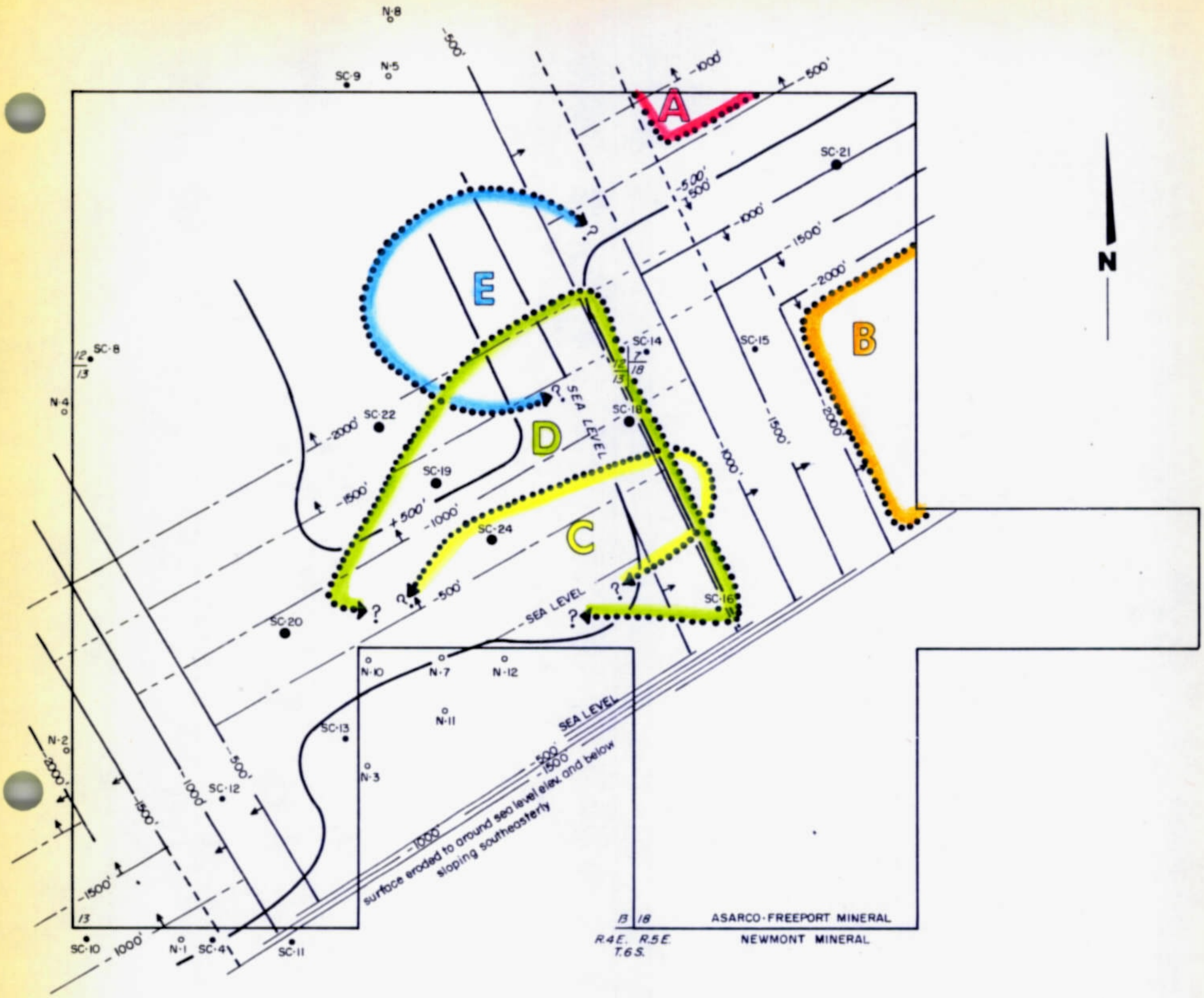
SANTA CRUZ PROJECT

PINAL CO., ARIZONA

0 1000 2000
FEET

J.D. Sell May, 1976

mn 2948 dam



EXPLANATION

●	Recent ASARCO drill holes
•	Previous ASARCO drill holes
○	Newmont drill holes
———	Bedrock subsurface contours
— - —	SC fault contours, at base
———	Downdropping fault contours
••••••••	Exploration target areas
A	Target area for fluidized SC zone offset.
B	Target area for downdropped and preserved chalcocite blanket. (bedrock surface probably between -1500' and -2000' elev.) Zone may be 500' thick at 1.0%
C	Target area for chalcocite zone as in SC-24 100' at 0.7% (partially leached) between -800' & -1100' elev. in foot wall of SC fault.
D	Target area for oxide copped between 200' and -600' elev. with grades of 1.0%. May have leached zones within interval.
E	Deep target area for fluidization vent area and primary values at interface below -1500', probably -2000' elev.

TO ACCOMPANY Santa Cruz Project Studies Report
DATED May 12, 1976
BY J. D. Sell

ASARCO

EXPLORATION TARGETS IN HORST BLOCK AREA

SANTA CRUZ PROJECT

PINAL CO., ARIZONA

0 1000 2000
FEET

J.D.Sell May,1976

mn 2949 dam

—FIGURE·4—

EXPLANATION

🟨	CONGLOMERATE
🟪	VOLCANIC AGGLOMERATE
▨	QUARTZ MONZONITE PORPHYRY bx /or fluidized
▭	QUARTZ MONZONITE PORPHYRY massive
🟩	DIABASE
▨	PRECAMBRIAN GRANITE bx/and or fluidized
🟧	PRECAMBRIAN GRANITE massive
●	RECENT ASARCO DRILL HOLES
•	PREVIOUS ASARCO DRILL HOLES
○	NEWMONT DRILL HOLES

ASARCO

PLAN MAP OF -500 FEET BELOW SEA LEVEL (OR 1800 FEET BELOW COLLAR)

SANTA CRUZ PROJECT
PINAL CO., ARIZONA

J.D.Sell

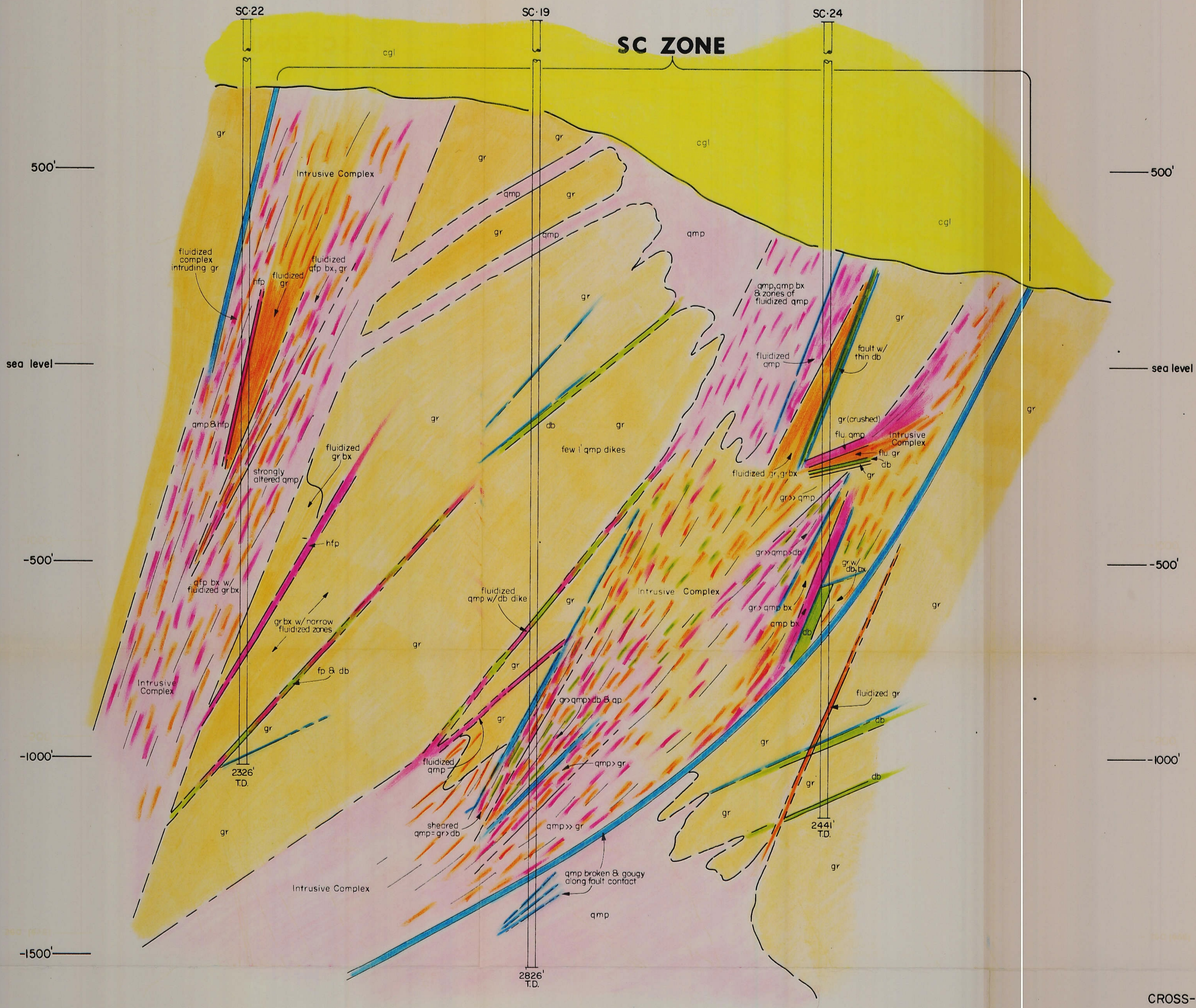
0 500 1000
FEET

May,1976

TO ACCOMPANY Santa Cruz
Project Studies Report
DATED May 18, 1976
BY J. D. Sell

mn 2939 dam

— FIGURE 3 —



EXPLANATION

🟧	Precambrian granite
🟩	Precambrian diabase
▨	Laramide porphyries
🟨	Conglomerate
— —	Fault

ASARCO

CROSS-SECTION THROUGH HOLES
SC-22, SC-19, & SC-24
LOOKING EASTERLY

SANTA CRUZ PROJECT
PINAL CO., ARIZONA

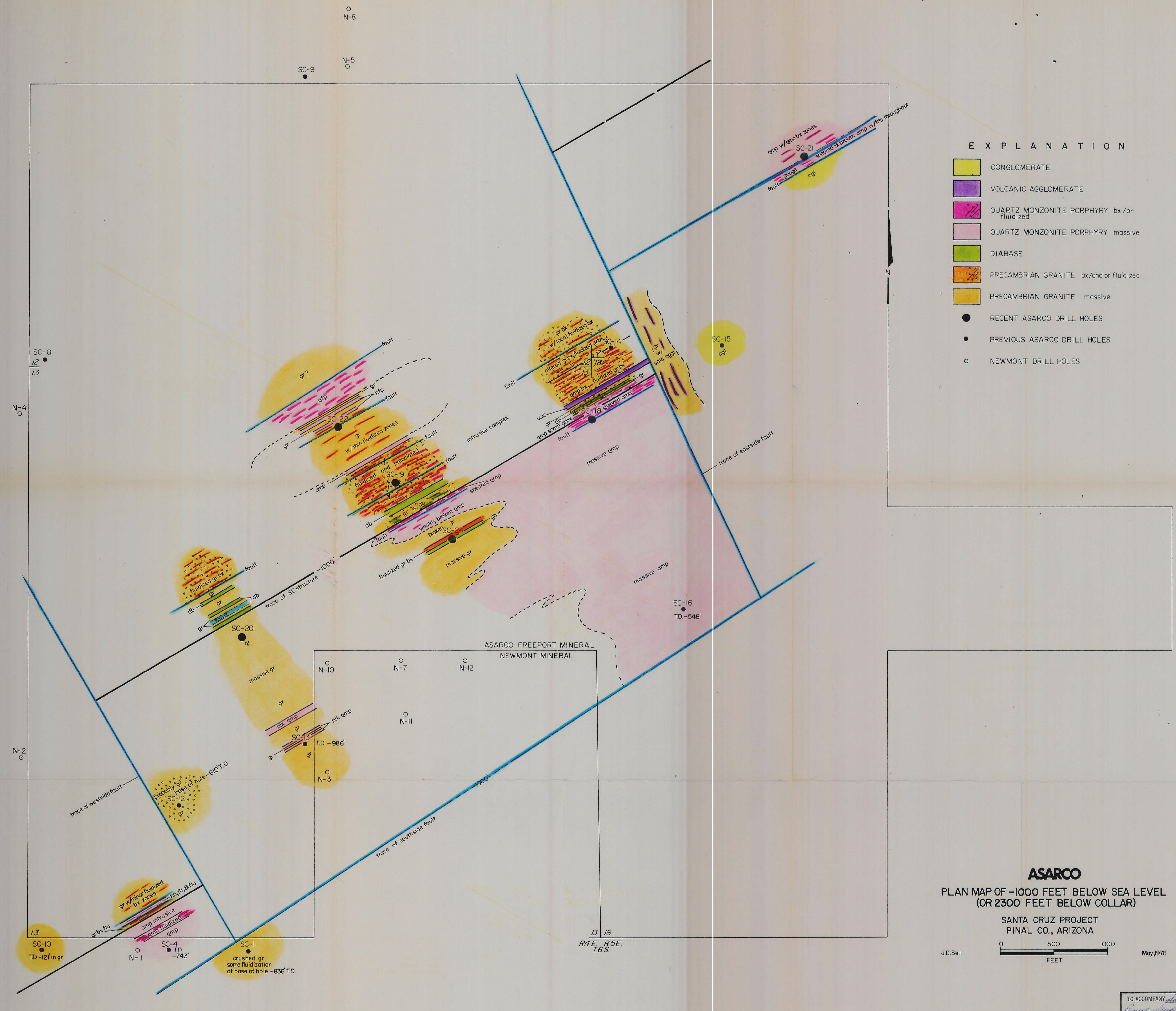
0 200 400
FEET

J.D.Sell May,1976

TO ACCOMPANY Santa Cruz
Project Studies Report
DATED May 18, 1976
BY J. D. Sell

mn 2938 dam

FIGURE 5



ASARCO

PLAN MAP OF -1000 FEET BELOW SEA LEVEL
(OR 2300 FEET BELOW COLLAR)

SANTA CRUZ PROJECT
PINAL CO., ARIZONA

0 500 1000
FEET

J.D.Sell

May, 1976

TO ACCOMPANY Santa Cruz Project Studies Report
DATED May 13, 1976
BY J.D. Sell

mn 2940 dam

– FIGURE 6 –

EXPLANATION

🟨 bx — Precambrian granite
🟧 fluidized — Precambrian granite
▨ bx — Laramide porphyries
🟪 fluidized — Laramide porphyries
— - — Fault

ASARCO

CROSS-SECTION THROUGH HOLES
SC-22, SC-19, & SC-24
LOOKING EASTERLY

SANTA CRUZ PROJECT
PINAL CO., ARIZONA

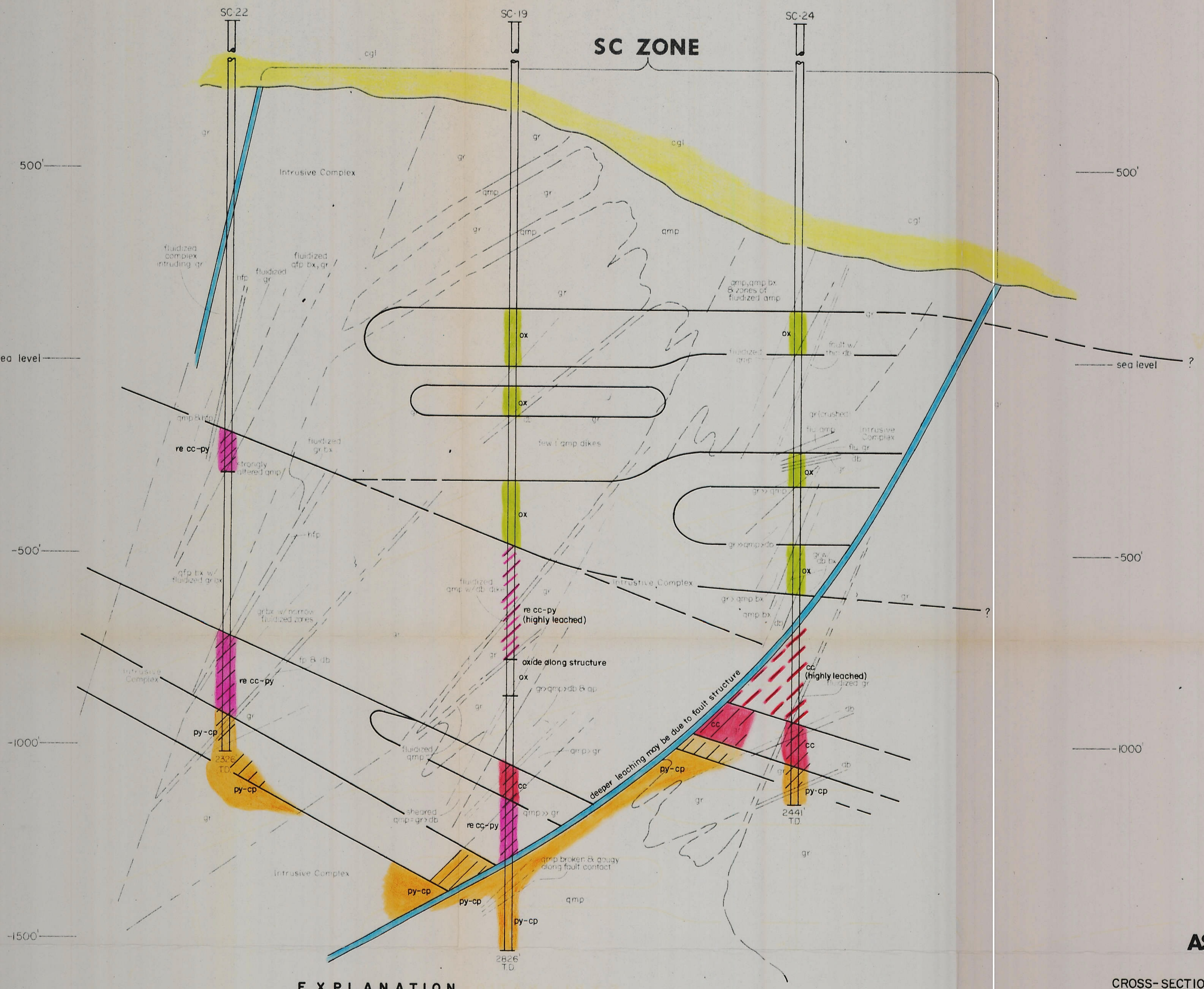
0 200 400
FEET

J.D. Sell

May, 1976

TO ACCOMPANY Santa Cruz
Studies Report
DATED May 12, 1976
BY J. D. Sell

mn 2941 dam



E X P L A N A T I O N

- 🟩 "Oxides"
- 🟪 Remnant Cc–py
- 🟥 Cc
- 🟧 py–cp
- ▨ partially leached area

ASARCO

CROSS-SECTION THROUGH HOLES
SC-22, SC-19, & SC-24
LOOKING EASTERLY

SANTA CRUZ PROJECT
PINAL CO., ARIZONA

0 200 400
FEET

J.D.Sell May,1976

TO ACCOMPANY Santa Cruz
Project Studies Report
DATED May 18, 1976
BY J. D. Sell

mn 2942 dam

Ack Copy JDS

AMERICAN SMELTING AND REFINING COMPANY
Tucson Arizona

May 14, 1964

J.H.C!
JUL 23 1964

RECEIVED
MAY 5 1975
S. W. U. S. EXPL. DIV.

MEMORANDUM TO MR. J. H. COURTRIGHT

Sacaton-Santa Cruz Prospects
Preliminary Geologic Map

The preliminary geologic map (att.) of the subject area shows some formational groups not previously used in Company correspondence; the following comments describe their salient features.

Pre-Ore Rocks

Pre-Cambrian Basement:

Pinal Schist. Partly typical of the quartz-sericite schist defined as Pinal in other areas. Also here includes banded injection gneiss, granite gneiss, and aplite.

Granite. There are two types undivided on the map. One is "typical" coarse-grained granite with biotite similar to the Mineral Butte granite at Blackwater (Report, A. G. Blucher). A second type is coarse-grained, but with less biotite and with large pink feldspar phenocrysts.

Pre-Cambrian and Paleozoic sediments:

The Apache group of shale and quartzite (Younger pre-Cambrian) is mapped undivided.

Paleozoic sediments represent Bolsa quartzite and Devonian-Carboniferous limestone. Not separated during mapping.

Laramide intrusives:

The Laramide intrusive complex contains many more varieties than are shown; these have been grouped into four units, each of which comprises varieties similar in composition and relative age.

Diorite. The earliest intrusive and/or border phase of Laramide granite is rich in biotite and locally contains magnetite.

Coolidge granite. Defined by Blucher (Report, Blackwater and Sacaton). Equigranular biotite granite which is very uniform in character. The granitic rocks along the west edge of the map which extend from Highway 84 north to the Palo Verde mountains may be pre-Cambrian, but they are most similar to Coolidge in appearance. A better correlation of these granites will be made when mapping is complete.

Micro-granite. This rock is like the Coolidge granite but is fine-grained. Included in the category for mapping purposes are pegmatite, aplite, and alaskite--all in small bodies.

Porphyries. A variety of porphyritic rocks ranging from mafic to acid, with and without quartz, occur as dikes in the mountain ranges. The only larger mass occurs beneath cover in the Sacaton Cu deposit, where it is altered to sericite and clay. There, a monzonite and a dacite have been recognized. The monzonite, in the weakly altered fringe area, is seen to contain much biotite.

Post-Ore Rocks

(1) Volcanics.

The volcanic terrain south and west of Casa Grande is divided into three units:

Sediments. Conglomerate and grit derived from granite and apache group. These rocks are tilted as much as 50°.

Older volcanics. Above the sediments (not always present) are flows of basalt, andesite and latite. These rocks are faulted and tilted.

Basalt. The exposed basalt flows are widely scattered erosional remnants resting on the older volcanics.

(2) Valley conglomerates.

The conglomerates which fill the Casa Grande valley are divisible into three units:

Sacaton conglomerate. This unit is known only near the Sacaton Cu deposit. There are no outcrops of similar type. Its character, as determined by drill cores, is that of an unsorted fanglomerate made of granite and schist/gneiss boulders and grit. The Sacaton conglomerate was deposited against steep relief cut on the Sacaton altered zone, and then displaced along the Basement fault to its present position. Induration is significant and the formation is hard and compact.

Burgess Peak conglomerate. A small hill--Burgess Peak--arises just NW of Casa Grande and is composed of a hard granite-boulder fanglomerate with hematite cement. Our three holes on the Gila prospect penetrated similar conglomerates, and water well drillers' logs indicate that this formation probably extends southeast along the ridge which appears to separate the water basins east and west of Casa Grande. The formation is variable in hardness, but is generally well indurated, although less so than the Sacaton conglomerate.

Gas line conglomerate. The Gas line conglomerate is named for a small outcrop of conglomerate along the El Paso gas line east of Sacaton and drill hole penetrations of the formation in the same area. The formation appears to be younger than known faults and is derived from the granitic rocks of the Sacaton mountains. It is poorly consolidated and consists of fanglomerate and sandy stream deposits. A thick clay layer is present east of the Sacaton deposit, which appears to trend south and taper-out across its width of about 2 miles. The Gas line is the aquifer north of Casa Grande. Where it is adjacent to the Sacaton deposit it is dry. The aquifer gravels in the deep basin west of Casa Grande are probably equivalent in age, but they will no doubt contain boulders derived in part from the mountains south and west thereof. The outline of the Gas line basin at Sacaton is shown in green on the map.

(3) Andesite.

Dikes of andesite are post-ore but older than the valley conglomerate.

(4) Quaternary.

Alluvium made of poorly consolidated silt and sand is spread out across the Casa Grande valley, reaching a thickness of about 200 feet near the Santa Cruz River.

Dissected alluvial fans flank Table Top mountain, and are made largely of volcanic rubble.

John E Kinnison
JOHN E. KINNISON

JEK/jk
cc: JRWojcik w/att.
JEKinnison w/att.
File w/att.
3 extras w/att.

Bill, the Cg in the pit contains mainly schist and p€gr clasts. No Three Pks Monzonite has been seen.

AMERICAN SMELTING AND REFINING COMPANY
TUCSON ARIZONA

June 4, 1975

Memorandum to: W. L. Kurtz

From: G. J. Stathis

Petrographic Thin Section
Examination of Drill Core from the
Santa Cruz Project;
Pinal County, Arizona

Sixty-eight petrographic thin sections were examined of drill core from the Santa Cruz Project. Purpose of this examination was to study nature and intensity of the alteration mineralogy which, perhaps, would aid in predicting in what direction or part of the Santa Cruz Project area better primary copper mineralization might be expected at depth.

Results of the petrographic examination are summarized on Table I. Under the rock classification column, two varieties of Precambrian granite were recognized; e.g., a microcline variety and an orthoclase variety. One or the other of the K-feldspar varieties occurs at the exclusion of the other. Other than that, the two granites appear to be very similar mega and microscopically.

Both a biotite-rich and a quartz-rich monzonite porphyry (Laramide) have been noted microscopically. The porphyries appear to be similar microscopically. The classification "biotite monzonite porphyry" was used when the quartz phenocryst volume content was down to 5 percent or less. This is usually accompanied by a corresponding increase in the biotite phenocryst content. Megascopically there appears to be a real textural and color difference between the two Laramide monzonite porphyries. H. Kries has used the textural designation "aplitic" and "aphanitic" porphyry to differentiate between the two porphyries. The aplitic porphyry is lighter in color and more siliceous looking. The aphanitic porphyry is darker and perhaps this is due to a slight increase in groundmass biotite.

Table II is an attempt to compare the two Laramide porphyry rocks and see if the megascopic and microscopic classifications are directly comparable; e.g., is the biotite monzonite porphyry the same as the aphanitic porphyry; if not, is the difference influenced by alteration (increase of). Results show that the two classification schemes are not always directly comparable, that is bmp does not always = aphanitic, nor qmp = aplitic. The discrepancies do not appear to be caused by alteration.

TABLE I

SUMMARY OF PETROGRAPHIC THIN SECTION EXAMINATION
SANTA CRUZ PROJECT, PINAL CO., ARIZONA

Drill Hole #	Thin Section Depth (in feet)	Rock Classification	Degree of Alteration	Alteration Mineralogy (approximate order of abundance)
2	2591	andesite	moderate to strong	kaolinite, chlorite
2	2661	granite (microcline)	weak	sericite, kaolinite
2	2705	granite (microcline)	weak	sericite, kaolinite
4	1608	granite (orthoclase)	weak to moderate	sericite
4	1892	biotite porphyry	strong	biotite, orthoclase, kaolinite, epidote
4	1895	brecciated porphyry?	moderate to strong	sericite
4	1912	basaltic andesite	moderate to strong	epidote, sericite, chlorite, tremolite
4	1984	monzonite porphyry (qtz)	weak to moderate	kaolinite, chlorite, tremolite
4	2038	monzonite porphyry (qtz)	weak	chlorite, epidote
5	2662	basaltic andesite	weak	iddingsite, carbonate
5	3135	granite (orthoclase)	fresh to weak	sericite
5	3559	basic dike	moderate to strong	sericite, chlorite
5	3600	granite (microcline)	weak	sericite
6	3951	brecciated granite (microcline)	moderate	sericite, kaolinite
6	4259	brecciated granite (microcline)	weak	sericite
6	4298	brecciated granite (microcline)	?	heavy iron staining
7	2785	granite (microcline)	weak	sericite
8	873	porphyry	moderate	sericite, chlorite, epidote
8	899	granite (microcline)	weak to moderate	sericite, hydromica
10	1417	granite (microcline)	fresh	———
11	1580	breccia or conglomerate?	———	———
11	2124	brecciated granite (microcline)	weak to moderate	chlorite, biotite, sericite
12	1415	granite (microcline)	moderate	sericite
12	1578	monzonite porphyry (quartz)	moderate	hydromica
12	1585	monzonite porphyry (biotite)	moderate to strong	kaolinite, sericite
12	1603	monzonite porphyry (biotite)	weak	sericite
12	1633	monzonite porphyry (quartz)	moderate to strong	kaolinite, quartz, sericite
12	1654	monzonite porphyry (quartz)	moderate to strong	biotite, kaolinite
12	1674	granite (microcline)	weak	chlorite
12	1699	diabase	strong	biotite, epidote
12	1724	granite (microcline)	weak	sericite, chlorite
12	1731	diabase	strong	biotite, epidote
12	1778	diabase or gabbro	moderate to strong	chlorite, epidote
12	1817	granite (microcline)	weak	sericite
12	1855	granite (microcline)	moderate	kaolinite, sericite
12	1901	granite (microcline)	weak	sericite

TABLE I — Continued

Drill Hole #	Thin Section Depth (in feet)	Rock Classification	Degree of Alteration	Alteration Mineralogy (approximate order of abundance)
13	1674	granite (orthoclase)	strong	orthoclase, sericite, clay veinlets
13	2155	granite (orthoclase)	weak to moderate	sericite
13	2192	granite??	very strong	sericite, quartz
13	2250	diabase	strong	biotite, sericite, kaolinite
13	2251	monzonite porphyry (quartz)	strong	biotite, kaolinite, sericite
14	2320	monzonite porphyry (quartz)	strong	biotite, sericite, kaolinite
14	2472	monzonite porphyry (biotite)	weak to moderate	sericite, biotite, kaolinite
14	2580	monzonite porphyry (quartz)	weak	chlorite, carbonate
15	2818	basaltic glass	—	—
15	2921	brecciated granite (orthoclase)	—	—
16	1420	basaltic glass	—	—
16	1511	brecciated basaltic glass	—	—
16	1512	brecciated basaltic glass/monzonite porphyry (quartz) fragments	—	—
16	1516	basaltic glass	—	—
16	1841	monzonite porphyry (quartz)	moderate	biotite, kaolinite, sericite, quartz
18	2159	recrystallized granite	moderate	quartz, biotite
18	2272	monzonite porphyry (biotite)	fresh	—
18	2340	monzonite porphyry (biotite)	moderate	sericite, kaolinite, carbonate
18	2434	monzonite porphyry (quartz)	moderate to strong?	sericite, carbonate, quartz, hydromica, chlorite
19	1233	granite (orthoclase)	weak to moderate	sericite, kaolinite, quartz, chlorite
19	1318	brecciated granite (orthoclase)	moderate	kaolinite, biotite, sericite
19	2031	granite (orthoclase)	moderate	sericite, kaolinite
19	2258	monzonite porphyry (quartz)	weak to moderate	kaolinite, sericite
19	2525	monzonite porphyry (quartz)	moderate to strong	biotite, kaolinite, sericite
19	2619	monzonite porphyry (quartz)	moderate to strong?	biotite, kaolinite, sericite
20	1533	granite (microcline)	weak	sericite, chlorite
20	1566	brecciated granite (microcline)	weak to moderate	sericite, quartz, epidote, hydromica
20	1703	granite (microcline)	weak	sericite, hydromica
21	2400	monzonite porphyry (biotite)	moderate	kaolinite, quartz, chlorite, biotite
21	2444	monzonite porphyry (biotite)	moderate	kaolinite, chlorite, biotite, sericite
21	2543	monzonite porphyry (biotite)	moderate to strong	sericite, kaolinite, chlorite, biotite
21	2592	monzonite porphyry (biotite)	fresh	—

TABLE II

COMPARISON OF MONZONITE PORPHYRY ROCKS FROM SANTA CRUZ PROJECT, PINAL CO., ARIZONA

SC Drill Hole Number	Thin Section Depth (in feet)	Megascopic Classification	Microscopic Classif.*	Degree of Alteration**
4	1984	aplitic	qmp	W-M
4	2038	aphanitic	qmp	W
12	1578	aplitic	qmp	M
12	1585	aphanitic(?)	bmp	M-S
12	1603	aphanitic	bmp	W
12	1633	aphanitic(?)	qmp	M-S
12	1654	aphanitic	qmp	M-S
13	2251	aphanitic	qmp	S
14	2320	aphanitic	qmp	S
14	2472	aphanitic	bmp	W-M
14	2580	aplitic	qmp	W
16	1841	aplitic	qmp	M
18	2272	aplitic	bmp	F
18	2340	aplitic	bmp	M
18	2434	aplitic	qmp	M-S?
19	2258	aphanitic	qmp	W-M
19	2525	aphanitic	qmp	M-S
19	2619	aphanitic	qmp	M-S?
21	2400	aplitic	bmp	M
21	2444	aphanitic	bmp	M
21	2543	aplitic	bmp	M-S
21	2592	aplitic	bmp	F

* qmp = quartz monzonite porphyry
bmp = biotite monzonite porphyry

** F = fresh
W = weak
M = moderate
S = strong

Under the heading "Degree of Alteration" found in Table I, the designation weak, moderate, or strong alteration is based on degree of replacement of primary minerals, especially plagioclase and biotite, and not to progressive destruction of the primary texture in the rock. Obviously, under conditions of strong alteration, the primary texture will be affected (destroyed). It was readily noted that the two main rock units (granite and monzonite porphyry) show a basic difference in their comparative mineralogies as alteration intensity increases. The mineralogic changes for the two rocks is summarized as follows:

a) Granite

1. Weak Alteration
   Plagioclase - 1/3 to 1/2 of its volume altered to sericite with trace kaolinite.
   Biotite - minor chloritization and partial oxidation.

2. Moderate Alteration
   Plagioclase - complete sericitization or 1/2 sericite & 1/2 kaolinite by volume.
   Biotite - mostly altered to hydromicas with minor chlorite and epidote.

3. Strong Alteration
   Texture destroyed. Recrystallization of sericite after plagioclase and local replacement by quartz.
   Secondary orthoclase. Some orthoclase, kaolinite, and quartz veining.

b) Monzonite Porphyry

1. Weak Alteration
   Plagioclase phenocrysts - mostly fresh, trace epidote.
   Biotite phenocrysts - 1/3 to 1/2 chloritized.

2. Moderate Alteration
   Plagioclase phenocrysts - mostly altered to kaolinite, locally 2/3rds sericitized. Epidote clots.
   Biotite phenocrysts - chloritized or locally partly altered to hydromica.
   Biotite groundmass - partly chloritized or partly altered to hydromica. Some development of secondary biotite and minor biotite veining.
   Quartz phenocrysts - resorbed by groundmass.

3. Strong Alteration
   Plagioclase phenocrysts - completely kaolinized or completely sericitized.
   Quartz phenocrysts - strongly resorbed (corroded).
   Groundmass - strong biotization of groundmass and corresponding increase in sericite as well. Biotite content exceeds sericite.

Results of the petrographic study are shown on Plates 1 & 2. Plate 1 summarizes the situation based on drill hole information available up to April 1, 1975 and shows the petrographic classification of alteration intensity noted at the bottom of 14 drill holes. Drill hole 13 had, by far, the strongest alteration noted in thin section. It is concluded that the SW1/4 of the map area is of no interest. The indications are that the best primary copper mineralization potential would be approximately in the central portion of the E1/2 of the map area. Plate 2 shows distribution of holes that bottomed in Precambrian granite versus those bottomed in Laramide porphyry.

Only 16 of the 68 thin sections showed evidence of disseminated sulfide (pyrite, chalcopyrite) mineralization and only 4 of these thin sections were estimated to have more than 2 percent sulfide by volume. None of the 4 sections had more than 4 percent sulfide by volume.

In conclusion, once again it is important to note the difference in alteration (especially in the moderate thru strong intensity range) between the two major mineralized units at Santa Cruz. The Precambrian granite has a phyllic alteration assemblage and the Laramide monzonite porphyry a potassic alteration assemblage. Under extreme or strong alteration conditions, there is a coexistence of sericite and secondary orthoclase in the granite and sericite and secondary biotite in the monzonite porphyry.

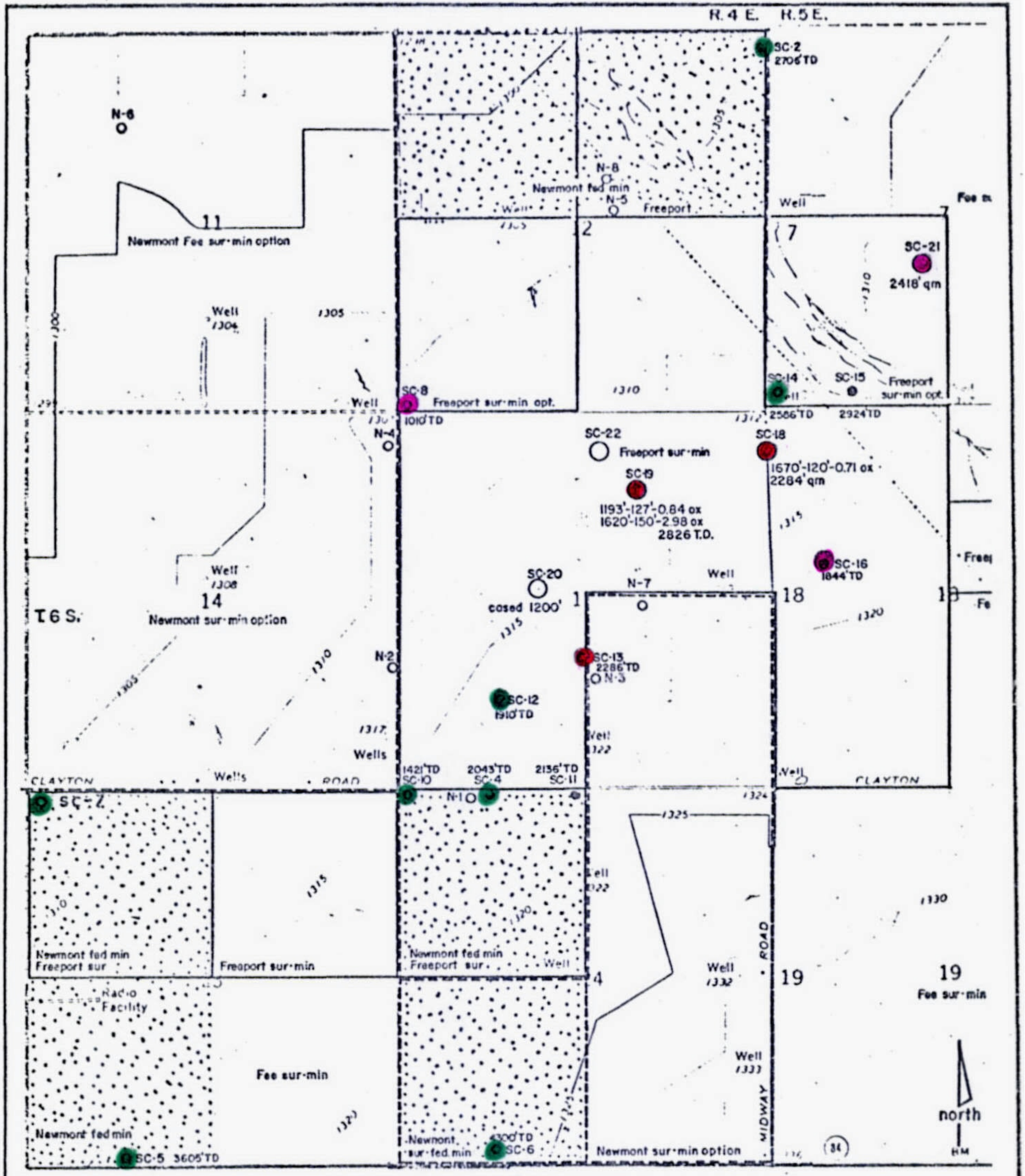
I believe that the difference in alteration between the two rock units is a reflecting bulk rock chemistry variation (microscopically, at least, this variation does not appear to be that great between the two rock types) rather than spatial position within a sulfide system, a la the classic Kalamazoo model. The few diabase dikes examined in thin section all show very strong development of pervasive secondary biotite accompanied by considerable disseminated epidote. Apparently, these altered diabase dikes can occur anywhere within the granite section.

The occurrence of potassic alteration (mostly secondary biotite) in the monzonite porphyry should not be regarded as being in the core zone (consequently "barren" by implication) of the sulfide system (Kalamazoo model). In reality, the potassically altered monzonite porphyry noted at Santa Cruz may equate in position to the upper phyllic zone level of alteration of the Kalamazoo model.

George
G. J. Stathis

GJS:lb
Attachs.

cc: JHCourtright, HGKreis



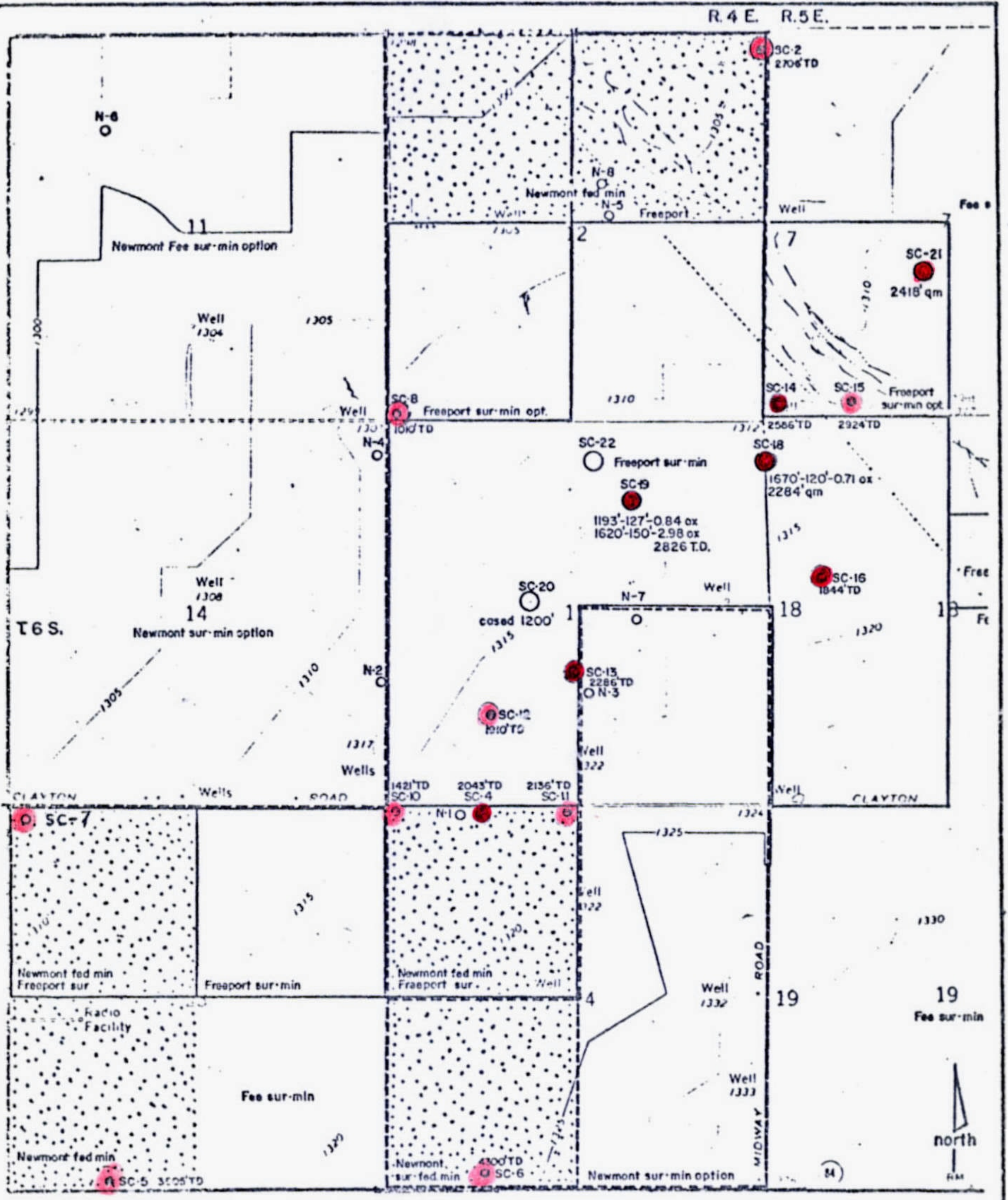
● Weak Alteration

● Moderate Alteration

● Strong Alteration

AMERICAN SMELTING AND REFINING COMPANY

area SANTA CRUZ PROJECT	data by GJS	state Arizona	township-range	revisions - date
		county Pinal	map number	PLATE 1
title ALTERATION	drawn by GJS	2000 0 2000 4000ft		
mining district Casa Grande	date April 75			



● LARAMIDE PORPHYRY (qtz. monzonite & biotite monzonite)

● PRECAMBRIAN GRANITE(mostly microcline gr. Some orthoclase granite)

AMERICAN SMELTING AND REFINING COMPANY

area SANTA CRUZ PROJECT	data by GJS	state Arizona	township-range	revisions - date
		county Pinal	map number	PLATE 2
title IGNEOUS ROCK TYPE (bottom of drill hole)	drawn by GJS	2000 0 2000 4000ft		
mining district Casa Grande	date April 75			

TO ~~W.L. KURTZ~~ JDJ

FROM H. KREIS

W. L. K.
SEP 15 1975

SUBJECT Thin Sections - Santa Cruz DATE 9/15/75

MESSAGE

Thin sections have been prepared for SC-23 and SC-24. There is only one section for SC-22 and three more will be prepared as soon as the core can be sampled. The sections will be reviewed and the results presented as an update to Stathis' report of 6-4-75. This will be a useful supplement to the visual logging alteration studies as summarized for each ~~log~~ hole in Appendix I of my report, Aug. 8, '75.

SIGNED Hank DATE / /

Rediform® 4S 472
Poly Pak (50 sets) 4P472

SEND PARTS 1 AND 3 WITH CARBON INTACT - PART 3 WILL BE RETURNED WITH REPLY

SANTA CRUZ PROJECT
MID-1975 PROGRESS REPORT

TO: W. L. Kurtz
FROM: H. G. Kreis

ASARCO
Tucson Office
August 8, 1975

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

SUMMARY AND CONCLUSIONS

Recent core drill holes SC-18, -19, -24, and a previous rotary hole, SC-16, have encountered a copper oxide deposit in the Santa Cruz horst block (Figures 1 and 2). Core hole SC-23, a step-out hole between Santa Cruz and Sacaton, drilled through a chalcocite blanket of unknown lateral extent. Significant geologic intercepts including internal leached capping are:

Hole	Depth	Interval	Cu Grade	Cu Form
SC-18	1670[a]-1790	120'	0.71%	CuOx
SC-19	1193 -1770	577'	1.10%	CuOx
SC-24	1550 -1820	270'	0.68%[b](Est.)	CuOx
SC-16	1560 -1650[c]	90'	1.45%(Est.)	CuOx
SC-23	2430[d]-2650	220'	1.27%	Chalcocite

[a] Above is 70' @ 1.81% Cu in volcanic agglomerate (1560-1630).

[b] Assayed except for 80' estimated at 0.05% Cu.

[c] No assays of cuttings of CuOx from 1650-1770 in SC-16.

[d] Overlain by 220' at 0.41% Cu (CuOx and chalcocite).

No reserve calculations have been made at this time. However, the grades and thicknesses of the copper oxide intercepts and their projected extent are compatible with the tonnages and grades upon which the Santa Cruz project was reinitiated (subject to modification by the competition's acquisition of the Collins' property).

The Santa Cruz copper oxide deposit is interpreted to be an oxidized chalcocite enrichment blanket faulted off on the northeast and southeast sides. SC-23, a step-out hole between Santa Cruz and Sacaton drilled through an intact but fault thinned chalcocite enrichment blanket of unknown extent.

The Santa Cruz copper oxide deposit and the chalcocite blanket in SC-23 are part of a large buried sulfide system. The extent of the system is only partially defined with the Santa Cruz horst on the southwest, SC-2 just to the north, and the Sacaton barren basement complex on the northeast. The southeast side is completely open. The Santa Cruz sulfide system is believed to be 12,000 to 20,000' long and at least 2,500' wide.

Geologic studies to date suggest a low total sulfide system (2-3% average by volume) hosted by Precambrian granite with small Laramide quartz monzonite porphyry intrusives. The stronger primary copper mineralization appears to have been distributed within 2000' of a large quartz monzonite porphyry mass (intercepted in SC-14, -16, -18, -19, and -21). In the portions of the sulfide system explored to date, the highest primary grades are interpreted to have been about 0.5-0.6% copper prior to oxidation and leaching.

Multiple cyclic enrichment has produced and destroyed chalcocite enrichment blankets. In SC-23 and at Sacaton these enrichment blankets remain. Chalcocite blankets in the Santa Cruz horst block, containing a high chalcocite to pyrite ratio, were oxidized without significant leaching to form copper oxide deposits. The enrichment blankets have been offset by horst-graben faulting and more recent low angle (flat) faulting. Sacaton appears to have been faulted from an unknown position within the Santa Cruz sulfide system.

The results of the 1974-75 drilling program are encouraging and more drilling is needed in the Santa Cruz horst block between SC-16, -18, and -19; in the SC-23 area; between SC-23 and Sacaton; and in the area south and east of SC-16 (Sections 17 and 19) as outlined in Figure 1. Testing of the latter three areas would require additional land acquisition. Exploration in these three areas is enhanced by the potential for chalcocite mineralization rather than copper oxide mineralization.

38,364' of drilling was done in the 1964-1965 Santa Cruz drilling program and 18,484' in the recent 1974-1975 program, for a total of 56,848'. Although very little is known about Newmont's exploration program, it is guesstimated at 15,000' of rotary-core drilling.

INTRODUCTION

The discovery of the Santa Cruz sulfide system was made by Asarco in September-October 1964 while exploring for the Sacaton "roots" along Sacaton's southwest trend. The exploration program drilled SC-1 through SC-17 from mid-1964 to mid-1965. In mid-1965 Asarco's land position was dropped.

During late 1970 and early 1971 Asarco attempted to reestablish its land position following a favorable geologic report by Bruce Kilpatrick (October 5, 1970). No land was acquired during the following years. In July 1974 Asarco and Freeport Exploration Company entered into a joint exploration agreement. During October 1974 Freeport purchased North American Acceptance Corporation land in and about the area of previous drilling in Section 13 (T6S R5E). Asarco commenced drilling in October 1974 and continued to the end of June 1975. Holes SC-18 through SC-24 were drilled during this time.

Ore grade and potentially economic copper intercepts have been encountered in four holes of the recent drilling program. Geologic interpretation of the past and recent drilling results has resulted in a reasonable understanding of the former primary mineralization, enrichment cycles, copper oxide deposit formation, and offsetting fault structures. The purpose of this report is to highlight the results of the recent drilling program and the geologic interpretation resulting from studies since October 1974.

DRILLING RESULTS

The 1964-1965 drilling program consisted of 17 holes totalling 38,364' of rotary and core drilling (Santa Cruz Summary Report, J. Wojcik, May 1966). During the recent program seven holes and one wedged hole (SC-21W) were completed, for a total drilling footage of 18,484' (10,083' of rotary drilling and 8,401' of core drilling). The footages of the recent program are detailed in the following table.

TOTAL RECENT DRILLING

Drill Hole	Rotary	Core	Total
SC-18	1,505'	1,008'	2,513'(T.D.)
SC-19	1,205	1,621	2,826 (T.D.)
SC-20	1,206	1,217	2,423 (T.D.)
SC-21	2,364	605	2,969 (T.D.)
SC-21W	-0-	315	315 (2,417'T.D.)
SC-22	600	1,726	2,326 (T.D.)
SC-23	2,150	521	2,671 (T.D.)
SC-24	1,053	1,388	2,441 (T.D.)
Total	10,083'	8,401'	18,484'

Norm Whaley's calculations (work sheets dated July 30, 1975) show Joy cored 5,240' at an average cost of $15.92/ft. and Longyear cored 3,162' at an average cost of $21.87/ft. (mud and lost casing costs included in both figures). On a comparison basis, the costs would be $16/ft. for Joy versus an estimated $19 to $19.50/ft. for Longyear, adjusting for depth, core size, number of rigs, mud experimentation, wedging, and minimum footage bid (Asarco supervision and overhead not included). From Whaley's calculations, it can be found that Joy drilled at an average rate of 27 ft./calendar day and Longyear averaged 41 ft./calendar day, adjusted for wedging time only. Hunter-Shelton rotary drilled at an average cost of $6.79/ft. and CXM Drilling averaged $11.09/ft. (not adjusted for comparison).

The results of the individual holes are summarized in the following table and Figures 3 through 9. Graphic summary logs of the detailed logging sheets are in Appendix I. Factual and interpretive points of interest for each hole are noted in the following paragraphs.

SELECTED COPPER INTERCEPTS
(Geologic Cutoff Grades, Approx. 0.3% Cu)

Hole	From	To	Interval	Copper	Copper Minerals
SC-18	1670'	1790'	120'	0.71%	Chrysocolla
SC-19	1193	1320	127	0.84	Chrysocolla & Atacamite
	1620	1770	150	2.98	Atacamite
SC-23	2430	2650	220	1.27	Chalcocite & Chalcopyrite
SC-24	1180	1280	100	0.51	Chrysocolla
	1550	1660	110	1.10	Chrysocolla & Atacamite
	1740	1820	80	0.73	Chrysocolla
	2220	2420	200	0.58	Chalcocite

Note: SC-13, -14, and -16 of the 1964-1965 drilling program contained significant copper intercepts of questionable grade (rotary cuttings) and some intercepts were not assayed.

SC-18: Drill hole SC-18 (Figure 3) went from conglomerate into bedrock across a fault at a depth of 1,560'. This fault is interpreted to have removed about a 900' thickness of capping containing an estimated 100-150' thick blanket of copper oxides averaging 0.5-0.8% total copper.

From 1,560 to 1,630' was 70' at 1.81% copper (chrysocolla) hosted in altered volcanic agglomerate. The nature of the host rock and its limited distribution within enrichment blankets suggests that the thickness and definitely the grade should be discounted for projections over 100' distant from SC-18.

An anomalous abundance of breccia (mostly in granite) and high former total sulfides yield at depth to typically low grade (0.2% Cu), moderately weakly altered quartz monzonite porphyry (aplitic groundmass). SC-18 penetrated quartz monzonite porphyry with primary sulfides at a depth above copper oxide and chalcocite enrichment blankets that project from SC-19 to SC-14 and are seen in SC-24 as a 50% leached chalcocite blanket.

SC-19: Drill hole SC-19 intercepted 690 feet-percent copper enrichment in the form of copper oxides and minor chalcocite (Figure 4). The feet percent copper in SC-19 is greater than nearly all the holes at Sacaton, but the economic potential is less because the zones of copper are widely separated by leached capping. The hole bottomed in low grade, weakly altered quartz monzonite porphyry (aplitic groundmass). The suggested interpretation of the former primary grades and the supergene redistribution of copper values are shown in Figure 10. In general copper intercepts in SC-19 correlate nearly horizontally with intercepts in SC-24, SC-18, SC-16, and SC-14.

SC-20: The geology of SC-20 (Figure 5) is divided into two distinct domains that are separated by a fault at 2,150'. Above the fault the former total sulfides averaged about 1% by volume in moderately strongly altered granite and about 5% in strongly altered granite breccia intervals. From about 1,700 to 2,050' was indigenous hematite after chalcocite and pyrite. Below the fault at 2,150' the granite is weakly altered with low (3/4%) former total sulfides. The hole bottomed in leached capping (50 feet of rods lost in hole at a depth of 1,300').

SC-21 and SC-21W: The suggested interpretation of the geology of SC-21 and SC-21W (Figure 6) is shown in Figure 11. Remnant enriched sulfides are intermixed with limonites beneath thoroughly leached capping and separated by faulting from the top of the primary sulfides. The hole bottomed in typically low grade copper, weakly altered quartz monzonite porphyry (aplitic groundmass). An apparent increase in molybdenite with depth (see log in Appendix I) is noteworthy and could reflect a change in the geology below the bottom of SC-21.

SC-22: SC-22 (Figure 7) penetrated only local trace amounts of CuOx and two zones of weak chalcocite enrichment that have experienced about 60% leaching. It appears that the pyrite to copper sulfide ratio, both in the former primary sulfides and in the enrichment zones, remained very high. Reconstruction of the two enrichment horizons prior to leaching at 1,510' to 1,600' and 2,080' to 2,240' suggests 90' at 0.5% and 160' at 0.3% total copper, respectively. The last 80' of SC-22 encountered weakly oxidized, unenriched primary sulfides. No zone of stable enrichment was penetrated by the depth of 2,326', the bottom of the hole.

SC-23: Drill hole SC-23 (Figure 8) has encountered the strongest, most pervasive sericite alteration of all the Santa Cruz drill holes to date (exclusive of strong alteration associated with breccia). Plagioclase and biotite are totally replaced, and K-feldspar is weakly to moderately replaced.

In general there was much more drill core evidence of flat faulting in SC-23 than in any of the holes in the Santa Cruz horst block. The chalcocite enrichment zone in SC-23 was bottomed by a 0-20° dipping fault. Prior to enrichment the last 250' of SC-23 appears to have had a primary grade of 0.5% copper.

SC-24: Drill hole SC-24 (Figure 9) found the conglomerate-bedrock contact 350' lower than projected from SC-22 and SC-19 suggesting a fault between SC-19 and SC-24. As previously discussed, the copper oxide intercepts in SC-24 correlate with intercepts in SC-19, -16, and -18.

SC-24 encountered a chalcocite enrichment blanket that was 50% leached; from 2,220' to 2,420' was a 200' thickness of 0.58% copper as chalcocite with no copper oxides. The enriched grade prior to leaching is estimated at slightly greater than 1% copper. The top of this blanket correlates with the top of significant chalcocite enrichment in SC-13 which occurred at a depth of 2,250' (SC-13 bottomed at 2,286').

SC-24 bottomed in moderately altered granite with weakly oxidized pyrite and chalcopyrite.

SANTA CRUZ SULFIDE SYSTEM

The Santa Cruz copper deposit is a horst block of part of a large buried sulfide system. The extent of the system is only partially defined with the Santa Cruz horst on the west, SC-2 just to the north, and the Sacaton barren basement complex on the east.

Geologic studies to date suggest a low total sulfide system (2-3% average by volume) hosted by Precambrian granite with small Laramide quartz monzonite porphyry intrusives. The stronger primary copper mineralization appears to have been distributed within 2,000' of a large quartz monzonite porphyry mass. In the portions of the sulfide system explored to date, the highest primary grades are estimated to have been about 0.5-0.6% copper. Figure 12 shows the interpreted vertical and horizontal zoning of alteration and primary mineralization as related to the apparent quartz monzonite intrusive at depth.

Multiple cyclic enrichment has produced and destroyed chalcocite enrichment blankets. In SC-23 and at Sacaton these enrichment blankets remain. Chalcocite blankets in the Santa Cruz horst block, however, contained a high chalcocite to pyrite ratio and were oxidized without significant leaching to form copper oxide deposits. The enrichment blankets have been offset by horst-graben faulting. More recent low angle (flat) faulting is seen in SC-23 and at Sacaton.

The factual and interpretive geology of the Santa Cruz sulfide system is detailed in outline form in Appendix II. Figure 13 depicts a simplified interpretive version of the copper enrichment history of the Santa Cruz horst block.

APPENDIX I

Explanation for Detailed Log Summary

The summary logs are generalizations of detailed descriptions made for every ten feet of core. Explanation of the headings follows (see explanation accompanying detailed logs for a more complete explanation):

Fracturing of core -- fracturing and breakage of core which appears to be post oxidation (post sulfide if in sulfide zone).

Faults -- fault evidence in core that is potentially significant to interpretation.

Rock type --

- Gr - granite
- Qmp - biotite quartz monzonite porphyry ("a" is aplitic and "b" is aphanitic appearing in hand sample)
- Db - diabase
- Bx - breccia (unclassified)
- Bx_1- rock fragments without rotation commonly set in up to 10-20% matrix material
- Bx_2- mobile or rotated rock fragments, often subrounded and set in 20-50% matrix material
- Cong - conglomerate

Crushing -- weak (W), 20% crushed; moderate (M), 50% crushed; and strong (S), 80% crushed. Premineral structure.

Molybdenum -- mostly from composite assaying by American Analytical and Research Laboratories (AARL) and expressed parts per million.

Copper -- percent total copper determined by AARL. Averages of 10' assays and some composite assays.

Total sulfides -- volume percent estimate of all sulfide minerals (ore and gangue; prior to oxidation if in capping).

Sulfide control -- relative abundance of fracture, vein, and breccia controlled sulfides compared to disseminated sulfides (disseminated sulfides do not include those disseminated sulfides that are obviously fracture associated).

Limonites -- relative abundance of indigenous limonite to total limonite content indicated by weak, moderate (transported equals indigenous), and strong. Volume percent hematite to total limonite (hematite, goethite, and jarosite). Local occurrence of jarosite similarly noted.

Quartz veins -- relative abundance. A weak designation equates to about one thin quartz vein every foot or two.

Alteration -- expressed as an arbitrary number based on relative (weak, moderate, and strong) replacement of rock forming minerals by alteration products (generally sericite and kaolinite) in hand sample. The numbers equate to the alteration of rock forming minerals in granite and quartz monzonite porphyry approximately as follows:

APPENDIX I - Continued

	No.	Alt. of Biotite	Alt. of Plagioclase	Alt. of K-feldspar
For Granite:	1	Fresh	Fresh-W	Fresh
	2	W	W	Fresh
	3	W	M	Fresh
	4	M	M	Fresh
	5	S	MS	Fresh
	6	S	S	Fresh
	7	S	S	WM
	8	S	S	MS
For Qmp:				
	1	Fresh	W-Fresh	Fresh
	2	Fresh	W-Fresh	Fresh
	3	Fresh	W	Fresh
	4	Fresh-W	M	Fresh
	5	W	S	Fresh
	6	M	S	Fresh
	7	S	S	Fresh
	8	S	S	WM

APPENDIX II

Santa Cruz Sulfide System
Factual and Interpretive Results to Date

I. Location (Also see plan map, Figure 1)
   - A. NE corner of T6S R4E and NW corner T6S R5E (GSRBM)
   - B. Pinal Co., Ariz., 6 miles NW of Casa Grande
   - C. Under 600' to 2,100' and possibly to 5,000' of post mineral conglomerate cover
   - D. North edge of Casa Grande basin

II. Size
   - A. Length
      - 1. 12,000' and possibly to 20,000'
      - 2. West end
         - a. SC-20, -12, and -4
      - 3. East end
         - a. Probably 2,000-10,000' east of SC-23
      - 4. Trend, NE-SW
   - B. Width
      - 1. 2,500' minimum
      - 2. North side
         - a. 1.500-2,000' southeast of SC-2
      - 3. South side
         - a. Probably at least 2,000' south of SC-16
   - C. Vertical Extent
      - 1. Greater than 2,000'

III. Attitude
   - A. Unknown

IV. Host Rocks
   - A. Precambrian granite (Gr)
   - B. Laramide quartz monzonite porphyry (Qmp)
      - 1. Dike-like bodies intruded into Gr
      - 2. Intermixes with Gr breccia
      - 3. Large intrusive possibility
         - a. SC-14, -16, -18, -19, and -21 bottomed in Qmp
         - b. SC-21 penetrated 800' of texturally uniform Qmp
         - c. SW part of Sacaton
   - C. Diabase
      - 1. Very minor host rock
      - 2. Thin widely spaced dikes
   - D. Breccia
      - 1. Occurs in Gr, Qmp, and mixtures of the two
      - 2. Probably pre to post sulfide in age

V. Primary Mineralization
   - A. Pyrite, chalcopyrite, and trace molybdenite
   - B. Volume percent total sulfides (conservative estimates)
      - 1. Commonly 1-2% in non-brecciated rock
      - 2. 2-5% in breccia
      - 3. 1/2 - 1% in Qmp at depth

- C. Sulfide ratios
  - 1. 10 py:1 cpy in fringe areas to 1:1 in areas of best primary copper grades
  - 2. Enriched zones 10 py:1 cc to 2 py:1 cc (present copper oxide zones)
- D. Grades
  - 1. Interpretation and SC-23 suggest former average primary grades up to 0.5-0.6% copper
  - 2. Molybdenum up to 240 ppm (SC-23)
  - 3. Molybdenum very closely associated with higher chalcopyrite grades
- E. Thickness
  - 1. Greater than 0.3% copper estimated to be 500-700' thick measured normal to the Gr-Qmp (Qmp at depth) contact
- F. Continuity
  - 1. Inferred to be reasonable judging from plus 200 feet percent-copper in SC-16, -18, -19, -24 area and evidence of previous former sulfides in capping
- G. Structural control
  - 1. Generally fracture and breccia control greater than disseminations
  - 2. Local abundant disseminated control
- H. Locus of mineralization
  - 1. Chalcopyrite (+0.3% copper) appears to have been deposited within 2,000' of an apparent large Qmp intrusive at depth
- I. Source of mineralization
  - 1. Hydrothermal solutions associated with Qmp
- J. Associated mineralization
  - 1. Sparse quartz veins
  - 2. Calcite in Qmp at depth
  - 3. Local minor specularite
  - 4. Alteration products

VI. Alteration (supergene minor compared to hypogene)

- A. Granite
  - 1. Sericite and kaolinite produced
    - a. Plagioclase and biotite fresh to totally replaced
    - b. K-feldspar generally fresh to partially replaced
  - 2. No secondary K-feldspar
  - 3. Local secondary biotite
    - a. Most commonly observed near Qmp and Db dikes
  - 4. SC-23 most strongly altered
  - 5. Least altered in bottom of SC-20, mid SC-12, and certain peripheral holes
- B. Quartz monzonite porphyry (Qmp)
  - 1. Kaolinite, sericite, biotite, chlorite
    - a. Plagioclase and biotite fresh to totally replaced
    - b. K-feldspar generally fresh
  - 2. Least altered in bottoms of SC-15, -16, -18, -19, and -21
- C. Breccias
  - 1. More strongly altered
  - 2. Quartz-sericite (and kaolinite?) matrix

- D. Diabase
  - 1. Biotite, chlorite, sericite, kaolinite, and epidote
- E. Volcanic Agglomerate
  - 1. Totally altered (supergene?)
    - a. Clay minerals
- F. Thin section study
  - 1. See report by Stathis, June 4, 1975

VII. Supergene Environment
- A. Multiple cycle leaching and enrichment of Santa Cruz horst
  - 1. Probably 1 or 2 more cycles than experienced at Sacaton
  - 2. Produced copper oxide blankets
- B. Copper oxide deposits of Santa Cruz horst
  - 1. Description
    - a. Chrysocolla and atacamite mineralogy
    - b. Blanket-like shape with near horizontal attitude
    - c. Individual units 70 to 150' thick (SC-16 indicates a potential for local continuous thicknesses up to 200-300')
    - d. Extent -- see Figure 1
    - e. Average grades 0.5%-1.11% and up to 3%
    - f. Continuity
      - 1) Moderately variable grades, thicknesses, and horizons
      - 2) Continuity found in feet percent copper from hole to hole and along projections of certain CuOx horizons
    - g. Generally lower limonite content
  - 2. Formation
    - a. High chalcocite to pyrite ratio prior to oxidation
    - b. Multiple cycle enrichment
    - c. Copper immobilized and removed from cycles of further enrichment by formation of CuOx minerals
    - d. Locally "captivated" in reactive rocks (Db, Qmp, Volc. agglom)
- C. Chalcocite enrichment
  - 1. Santa Cruz horst block
    - a. SC-13 bottomed in chalcocite
    - b. Other than possibly in SC-13 area, a stable enrichment zone associated with last stage of oxidation has not been intersected in drill holes
    - c. SC-24 drilled 200' at 0.58% Cu as chalcocite enrichment but was 50% leached out
    - d. Potential between SC-13 and SC-24
    - e. CuOx deposits have depleted the amount of copper available for enrichment
  - 2. SC-23 area
    - a. Unoxidized, stable chalcocite enrichment
    - b. Thickness - 220' with flat fault at bottom
    - c. Stage of enrichment cycle(s) comparable to Sacaton rather than the Santa Cruz horst block
  - 3. Untested potential areas
    - a. Down faulted blocks east and southeast of the Santa Cruz horst block
    - b. Between Sacaton and SC-23 (subject to several unpredictable structural effects)

D. Leached capping
  1. Pervasive oxidation to depths up to 1,500-1,900' below the erosional bedrock-conglomerate contact
  2. Grade 0.01 to 0.06% copper not including local CuOx and chalcocite remnants
  3. Goethite-hematite capping
    a. Mixture with 40-60% to locally 80% hematite
    b. Local minor goethite-jarosite mixtures
  4. Transported limonite generally exceeds, sometimes equals, indigenous limonite
  5. Locally abundant indigenous limonite
  6. Iron transportation appears less than a foot
  7. Local minor chalcocite-pyrite remnants commonly occur as high as 750 feet above the primary sulfides

E. Supergene alteration
  1. Effects appear minor compared to hypogene alteration
  2. Kaolinite seams

VIII. Structure
  A. Rock preparation
    1. Granite
      a. Crushing
        1) 10-100%
        2) Commonly 40-60%
      b. Breccia
    2. Quartz monzonite porphyry
      a. Crushing
        1) Dikes same as or less than Gr
        2) Qmp at depth - tight hairline fractures more than crushing
      b. Breccia
    3. Fracturing
      a. 60-80° dips most abundant
      b. 20-40° dips second most abundant
  B. Faulting
    1. High angle, horst-graben type
      a. Form three sides of Santa Cruz horst
      b. Between SC-19 and -24 and elsewhere in Santa Cruz horst
    2. Low angle, 0-30° dip
      a. Conclusive evidence under Sacaton
      b. Moderate evidence under Desert Carmel
      c. Weak evidence under Santa Cruz horst
      d. Post dates horst-graben faulting
    3. Sacaton appears to be faulted from the Santa Cruz sulfide system
  C. Regional trend
    1. Globe-Miami, Superior, Poston Butte, Sacaton, Ajo trend
      a. NE-SW direction

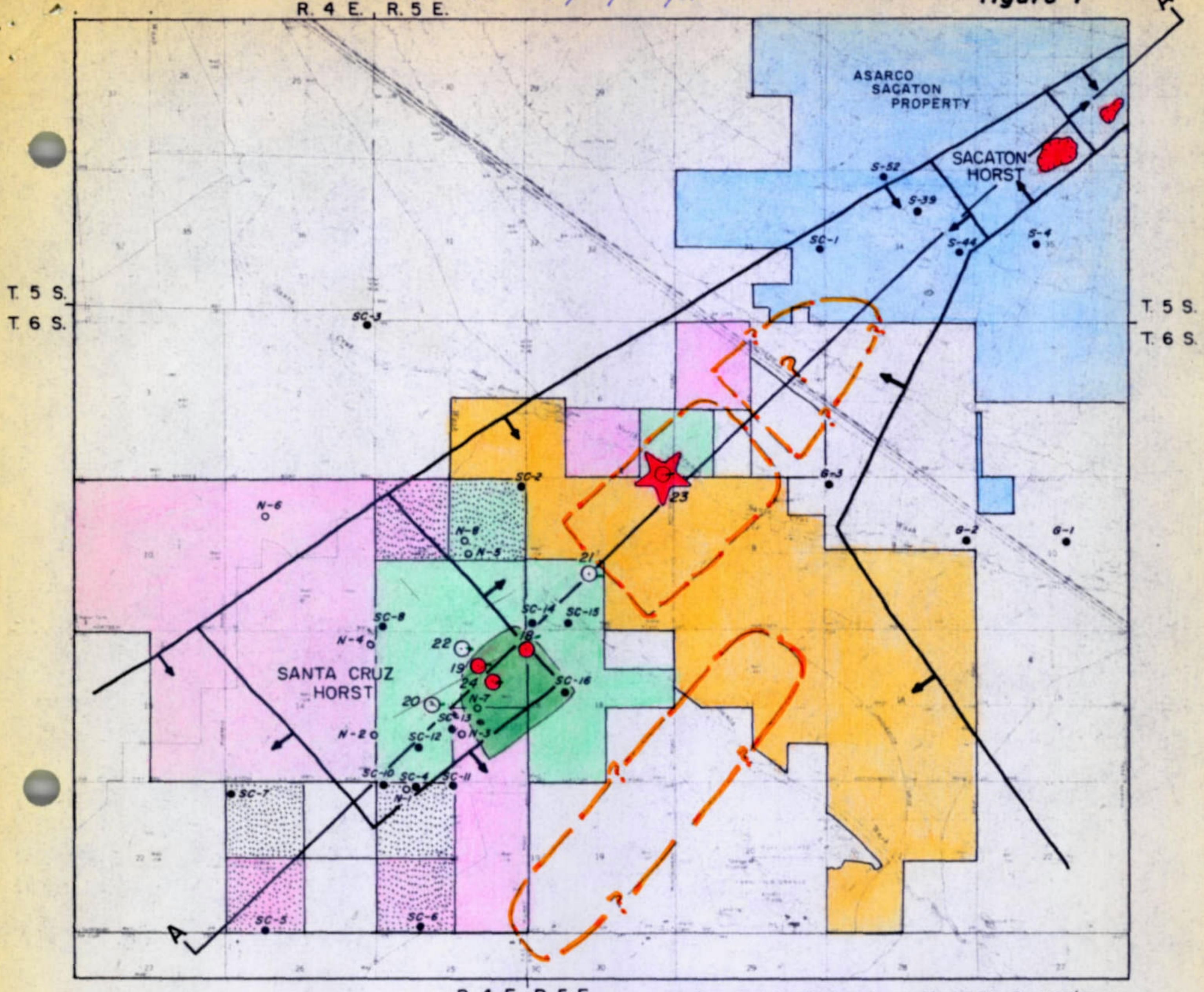
- D. Sacaton trend
  - 1. NE-SW
  - 2. Trough-like graben structure
    - a. 35,000' estimated length
    - b. Seen between SC-1 and G-3 and continues to the northeast across Highway I-10
    - c. Weak mineralization northeast of Sacaton
    - d. Width -- generally 2,000-6,000'
    - e. Fault on NW side of trench continues SW past Santa Cruz
    - f. Not known if Santa Cruz is part of this trench
    - g. Structurally similar to Cactus-Carlotta (Miami, Arizona)

IX. Geophysical Expression

- A. Gravity survey
  - 1. No indication of sulfide system
  - 2. Delineates Santa Cruz horst
  - 3. Delineates Casa Grande basin
- B. Aeromagnetic survey
  - 1. No indication of sulfide system
  - 2. Reflects offset rock types produced by basin-range faulting
  - 3. Magnetic gradient band
    - a. NE-SW through Santa Cruz
      - 1) Bedrock high on northwest side and deep conglomerate on southeast side
      - 2) Believed to be reflection of regional fault structures
- C. I.P.
  - 1. No meaningful response predicted
    - a. 2,000-2,500' depth to top of sulfides
    - b. 640-1,000' minimum thickness of conglomerate
    - c. Low average total sulfides, 2-4% by volume

To Accompany Aug 8, 1975 HGK report

figure 1



Base from U.S.G.S Casa Grande West & Stanfield 7.5' Quads.

EXPLANATION

- 🟩 ASARCO FREEPORT
- ▨ Newmont Federal Lode Claims
- 🟪 NEWMONT
- ▨ Newmont Federal Lode Claims
- 🟧 NAAC
- ● PREVIOUS ASARCO DRILL HOLES
- ⊙ RECENT ASARCO DRILL HOLES
- ○ NEWMONT DRILL HOLES
- GENERAL AREAS TO EXPLORE for Potential Enrichment (Cu Ox &/or Cc)
- 🟩 COPPER OXIDE MINERALIZATION Estimated Area of + 200 ft.-% Copper
- 🟥 CHALCOCITE MINERALIZATION
- Predicted Sea Level Contour of Horst-Graben Faults. Arrow on Down Dropped Side.

north

● SIGNIFICANT INTERCEPTS

SC-18	1670'-120'-0.71 ox	(2513' T.D.)
SC-19	1193'-127'-0.84 ox 1620'-150'-2.98 ox	(2826' T.D)
SC-20	(2423' T.D.)	
SC-21	(2969' T.D.)	
SC-22	(2326' T.D)	
SC-23	2430'-220'-1.27 sulf	(2671' T.D.)
SC-24	1180'-100'-0.51 ox 1550' ~~1150'~~-110'-1.10 ox 2220'-200'-0.58 cc	(2441')

ASSAY DATA KEY

depth-length-% Cu
1670'-120'-0.71

PLAN MAP

SANTA CRUZ PROJECT

(ASARCO-FREEPORT JOINT VENTURE)

Pinal County, Arizona

SCALE 1" = 1 mile

H.G.K. July-1975

MVK-2878

figure 2

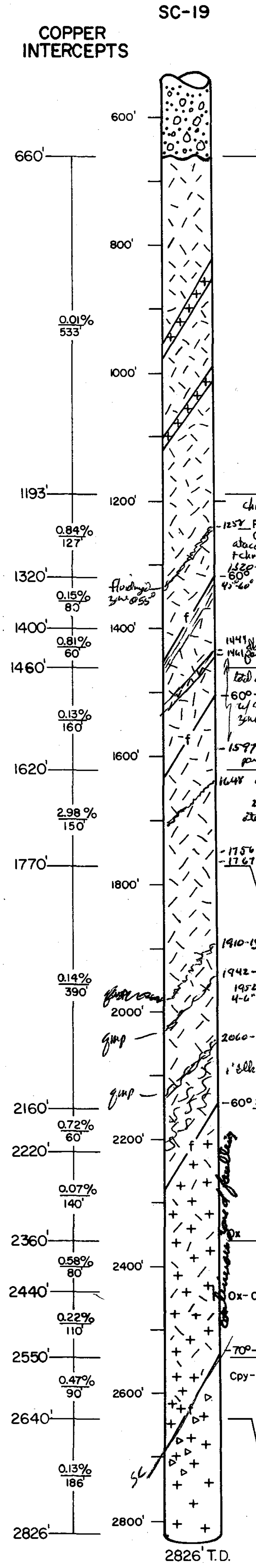
CROSS SECTION A-A'

LOOKING NORTHWESTERLY

SANTA CRUZ PROJECT
PINAL COUNTY, ARIZONA
ASARCO-FREEPORT JT. VEN.
H. KREIS ASARCO INC.
JULY 1975
ALR 2880

DRILL HOLE SC-19

2826' T.D., 1313' Collar Elevation
Rotary: 0-1250' Hunter-Shelton Drilling
12-6-74 to 12-12-74
Core: NX 1205'-2436' Joy Drilling
BX 2436'-2826' Joy Drilling
12-21-74 to 2-28-75



660' ok

Conglomerate

Granite with local minor quartz monzonite porphyry. Goethite-hematite leached capping. No visable copper minerals. 1-2%(?) former total sulfides. Moderately strong alteration.

1193'

chrysocolla
-1257 ROTARY CORE
atacamite + chrysocolla,
1320-25'
-60° w/crushing to 1358'
45°-60°
flooding zone @ 55°

on steep + 90° fract & all fract/broken pieces.

Granite-Chrysocolla and atacamite intervals separated by leached capping. CuOx of lower interval in high angle fractures.

0.5% former sulf.

1.25% former total sulfides. Goethite-hematite capping.

← probably a pre sulfide fault. contains 2-3% diss & fract. bio zone; plag qtz-ser, ab k f.

Moderate alteration.

0.5% d>f, mostly oxidized except top interval w/ strongly transported ~~chalc~~ chrysocolla - some leached, on steep + 75° fracture.

1441 lower angle? 45°
1441 fault at base

Note: small db (<1') @ 1284' & 1304' have ± 30-40° dip contacts

1460'

total assay
-60°-80° w/ crushed zones

pieces of qmp @ 1545' & 1563'
1½% at top, 2-3% bottom former sulfides cc enriched

Granite.Leached goethite-hematite capping. 1.75% former total sulfides. Moderate alteration.

f > d. basal portion has leached chrysocolla.

-1597 base of crushed & faulted zone
partly crushed
1-1½%, f, T=I some leached chrysocolla, wk atacamite below 1626.

1620'

1648 60-70° faulted/crushed zone.

2-4% up to 10% disseminated & veinlets atacamite

Granite, Atacamite with minor chrysocolla at top and bottom of interval. About 1% former sulfides, mostly disseminated. } no real structural break here

-1756 zone of biotite (secondary)? 5-10% w/ chrysocolla & atacamite. 4% sulf d>f
-1767

Indigenous hematite after chalcocite. Moderate alteration.

Very weakly broken, strong rock

Variable bio alt → clay ser., variable mod plag → clay ser. variable wk K-sp. variable [illegible] sulf → 3% ave 1½-2% T≥5. 1848 - 6" db. No oxide copper

1770'

1910-13' fluidized zone @ 70°

1942-49 @ 50° intrusive contact, sctd black qmp

1952-59 4-6" squirts of fine db

Granite with local thin quartz monzonite porphyry dikes. Leached goethite-hematite capping. Few minor chalcocite-pyrite remnants.

2020-2050 - remnant cc mainly py.

1.75% former total sulfides. Moderate alteration.

qmp
2060-2064 blk qmp, intrusive contact @ relative flat ±30° & crosscutting at +55°. qtz. mineral sulf + alt (qtz) & dissem. remnant cc w/ py.

one 1" mg por squirt
1' blk qmp @ 2090-91 @ relative low angle ± 30-35°?
increased crushing, bx zones, @ + 60° increased transported.
qmp
several mg por dikes one in bx. lower one w/ speck or two of chrysocolla.
-60° 2156-2160 Fault gouge pieces @ 60-70°.

2160'

Alternating quartz monzonite porphyry & granite. Chrysocolla for 60' followed by leached goethite-hematite capping. Variable (0.75-2%) former total sulfide. Moderate alteration.

Ox

2360'

Ox-Cc-Py

Quartz monzonite porphyry mixed with a lesser amount of granite. Chalcocite and pyrite decrease with depth as oxidation and leaching increases. 2.75% former total sulfides. Moderately strong alteration.

70°-90°

Cpy-Py

2550'

Quartz monzonite porphyry. Faulted, appears steeply dipping. Evidence of pre and post sulfide movement. 1-2% total sulfides, pyrite and chalcopyrite. Moderate alteration.

2640'

Quartz monzonite porphyry. 0.75% total sulfides, pyrite and chalcopyrite, (3-5 py : 1 cpy). Weakly altered. Very weak fracturing and crushing. 1.50% calcite.

EXPLANATION

- Conglomerate
- Breccia
- Volcanic agglomerate
- Quartz monzonite porphyry
- Diabase (only thicker dikes shown)
- Granite
- Fault

Alteration - Based on degree of replacement plagioclase, K-feldspar and biotite by primarilly sericite and kaolinite. Secondary biotite and chlorite in quartz monzonite porphyry, diabase and locally in granite.

Total Sulfides - Visual volume percent estimates.

figure 4

ASARCO
SC-19
GEOLOGIC LOG SANTA CRUZ PROJECT
ASARCO-FREEPORT J.V. PINAL CO., ARIZONA

1" = 200'

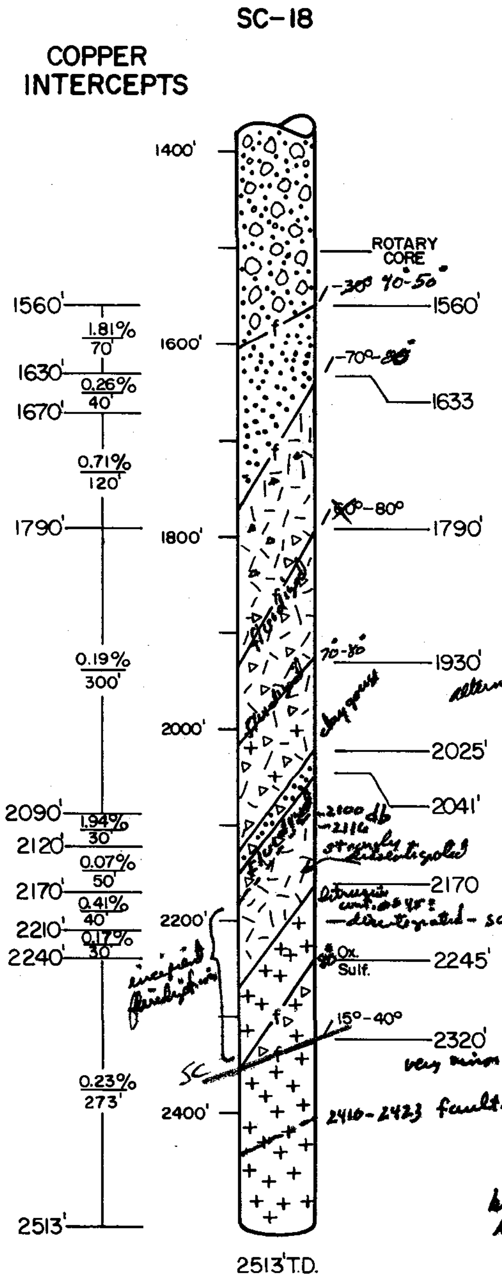
H. KREIS JULY, 1975

P.7
figure 4
SC-19

mn 2876B dam

DRILL HOLE SC-18

2513' T.D., 1313' Collar Elevation
Rotary: 0-1505' Hunter-Shelton Drilling
11-25-74 to 12-5-74
Core: NX 1505'-2513' Joy Drilling
3-1-75 to 4-2-75



Conglomerate
rather clean cg in partially muddy matrix. few por. ?vdc? may be a bx, starting @ 1460.

Volcanic agglomerate. Totally altered. Chrysocolla. abundant internal slips. Fault contacts. Probable past sulfide age.

bx leached to 1674. minor leached chrysc. steeply dipping structure
Granite. Chrysocolla and minor atacamite. Moderate alteration. strong alteration control of fractures + diss-fracture mineral. qtz-sericite-ac kaolinite 2% former total sulfides. Upper and lower contacts faulted. w/ brochantite-atacamite to 2070. Diss diminished below. some pink orthoclase below w/ weaker qtz-ser. Leached chrysc to bottom.

fluidized features, very steep dip top + bottom.
Granite breccia. No oxide. Leached goethite-hematite capping. diss + matrix control. Minor local chalcocite-pyrite remnants. 3% former total sulfides. Moderately strong alteration.

alteration "60%"
Granite and quartz monzonite porphyry breccia. Leached goethite-hematite. 3% diss + vein fractures former total sulfides. Moderately strong alteration. steep structure + veinlets, some fluidiz.

Volcanic agglomerate breccia. Chrysocolla. + CuOx w/ variation. intruding older fluidized zone.

Granite breccia ~~and granite~~ fluidized. minor sericite + capping in upper part. Below. Local CuOx and chalcocite in leached capping. 2% former total sulfides. Moderately strong alteration. 2100-2116 db w/ bx on walls. nearly complete biotization of mafics.

strongly [illegible]
intrusive cont. @ 45°; -disintegrated - some fluidized in fractures
"60%"
Quartz monzonite porphyry. Chrysocolla in goethite-hematite capping. @ 45-50° 0.75% former total sulfides. Moderately weak alteration. decreasing w/ depth.
2244-48. Gouge, minor fluidiz. text. 1% sulfides, broken in zones.

Quartz monzonite porphyry breccia. 0.75% total sulfides, pyrite and weak bx some w/ sulfides chalcopyrite. Moderately weak alteration. some specularite.
very minor bx text, some fluidization hint.

2410-2423 fault-broken, has steep slips but overall may be low angled.

Quartz monzonite porphyry. 0.50% total sulfide, pyrite and chalcopyrite. Moderately weak alteration. 1% calcite.
broken only, increased intensity w/ depth to T.D. generally high angled +60° breakage.

EXPLANATION

- ▨ Conglomerate
- ▨ Breccia
- ▨ Volcanic agglomerate
- ▨ Quartz monzonite porphyry
- ▨ Diabase (only thicker dikes shown)
- ▨ Granite
- ▨ Fault

Alteration – Based on degree of replacement plagioclase, K-feldspar and biotite by primarilly sericite and kaolinite. Secondary biotite and chlorite in quartz monzonite porphyry, diabase and locally in granite.

Total Sulfides – Visual volume percent estimates.

figure 3

ASARCO
SC-18
GEOLOGIC LOG
SANTA CRUZ PROJECT
ASARCO-FREEPORT J.V.
PINAL CO., ARIZONA

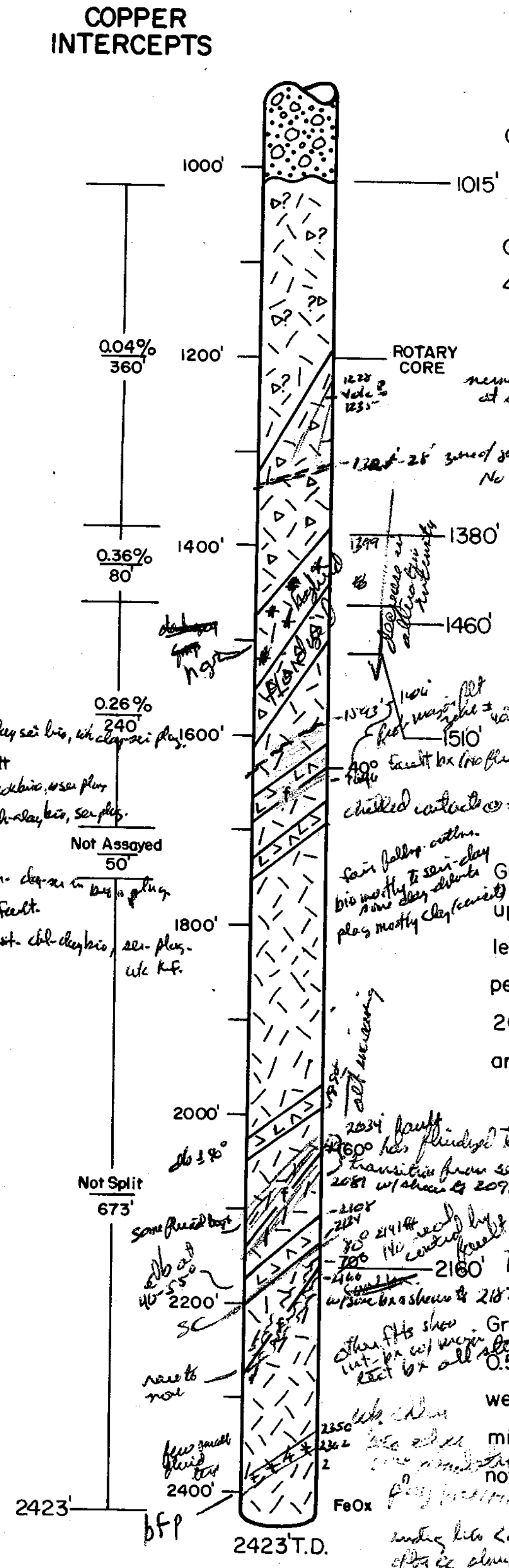
1" = 200'

H. KREIS JULY, 1975

P.6
figure 3
SC-18

mn 2876A dam

SC-20



Conglomerate

Granite, breccia. Leached goethite-hematite capping. About 4% former total sulfides. Strong alteration of biotite, plag, & Kspar

relative coarse bx (Mt + fragments) w/ variable fine to coarse sand matrix

numerous slicks up to 1230', few below. at steep angle +60-80°

-1320-28' zone of jarositic & goethitic crushed gr. dipping ≈40°. maybe same fluid tex.

No slicks ↓

Granite bx as above in text & alt-mineral. to 1367. No anomalous slickensides.

1367 → decrease in Kspar alt. intensity

Granite and ~~quartz monzonite~~ aplite porphyry, some breccia. Chrysocolla in goethite-hematite capping. 1% former total sulfides. Moderate alteration.

decrease in alteration intensity

Granite, breccia. Leached goethite-hematite capping. 5%? former total sulfides. Moderately ~~strong~~ alteration. essentially crushed w/ some fluid text mottled - all very altered 80-90.

-1543' 1601' fault major flt ± 40° [illegible]

-1596 40° fault bx (no fluidized?) w/ numerous slickensides. Main flt 2' down into granite, 3' wide flt (healed) in db w/ 1"-2" gr inclusion with walls @ 40°.

chilled contacts @ ± 40-55° lower.

decreasing alt

1367

↓ wk clay ser bio, wk clay ser plag.

1593-1606 Flt

1606-1613 gr. wk bio, w ser plag

1613-1625 gr. S ch-clay bio, ser plag.

1625-1637 Db

1637-1643 hydr gr. clay-ser in bio, plag

1643-1644 Tect. fault.

1646-1675 - gr. st. chl-clay bio, ser-plag. wk K-F.

fair plag. cattm. bio mostly to ser-clay some clay [illegible] plag mostly clay (sericite)

Granite and local minor diabase dikes. Chrysocolla in the upper 200', and local pyrite-chalcocite remnants in the leached capping below the chrysocolla. Anomalously high percentage of indigenous hematite between 1700' and 2000'. Former total sulfides vary from 0.50 to 1.50% and average 1%. Moderate alteration. local strong qtz-seri. w/ [illegible]

alt. weakening

db ± 80°

2034 fault 60° has fluidized texture. transition from sericite (wk) to chlorite-clay & "fuzzy" in biotite

2081 w/ shear to 2098' sl. stg (alt + mineralized) fract. may have ± 50% transported biomass basal shear 40-60

some fluid text

-2108 -2124 80° 2141 (No control by fault).

db at 40-55°

-70° -2160 Tect bx, minor [illegible] bx text. [illegible] w/ some bx & shears to 2187 & below.

SC

other flts show int-bx w/ weak alter. tect bx all alter.

rare to none

Granite. Leached goethite – hematite capping. Trace chalcocite. on [illegible] fractures 0.50 to 0.75% former total sulfides. Moderately weak to very weak alteration. Distinctly weaker alteration and mineralization than above. Base of oxidation and leaching not intercepted.

wk. [illegible] [illegible] [illegible]

few small fluid tex

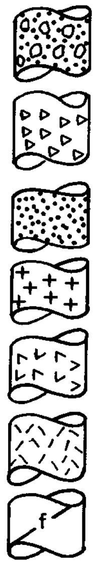
[illegible] (clay?/sericite?)

[illegible] < 0.5% [illegible] along steeply [illegible] fractures

DRILL HOLE SC-20

2423' T.D., 1315' Collar Elevation
Rotary: 0-1200' Hunter-Shelton Drilling
12-12-74 to 12-19-74
Core: NX 1200'-2423' Joy Drilling
4-3-75 to 5-19-75

EXPLANATION



Conglomerate
Breccia
Volcanic agglomerate
Quartz monzonite porphyry
Diabase (only thicker dikes shown)
Granite
Fault

Alteration – Based on degree of replacement plagioclase, K-feldspar and biotite by primarily sericite and kaolinite. Secondary biotite and chlorite in quartz monzonite porphyry, diabase and locally in granite.

Total Sulfides – Visual volume percent estimates.

figure 5

ASARCO
SC–20
GEOLOGIC LOG
SANTA CRUZ PROJECT
ASARCO - FREEPORT J.V.
PINAL CO., ARIZONA

1" = 200'

H.KREIS JULY, 1975

P.8
figure 5
SC-20

mn 2876 C dam

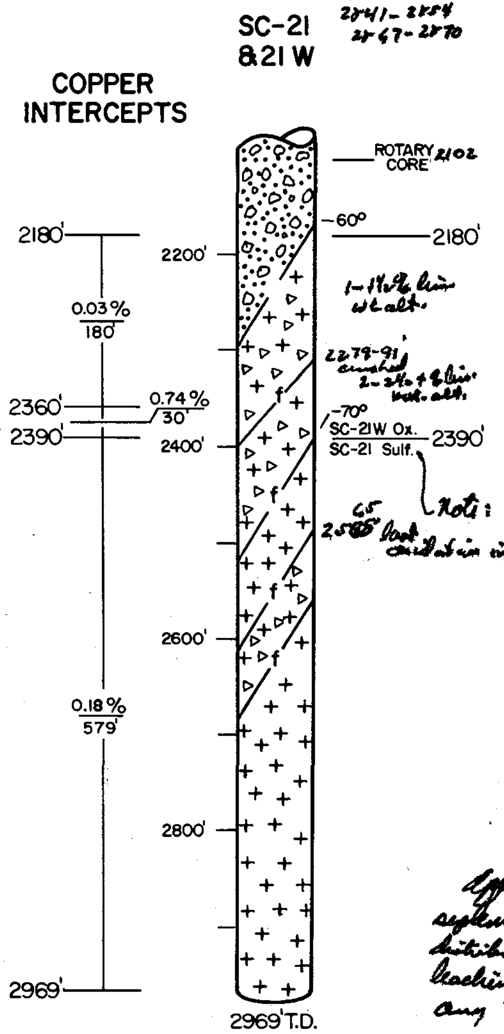
mineralized fracture zones & crushed zones.

2415-20.
2437-40
2449-53
2457-72
continues ± to 2490
2490-2521 very crushed, minor gouge.
2532-2542 " " " "
& continues ± to 2570.
2584-2594
2602-2610
2619-2622
2636-2638
2642-49
2662-63
2675-76
2680 ± 2708
2727-2731
2737-2747
2766-2779
2784-2792
2797-2799
2821-2823
2841-2854
2867-2870

28[illegible]-2875 only crushed, bleached, sulfides. is sheared
2880-2884
2888-2893
2900-2905
2910-2919
2922-2923
2928 ± 2969 T.D.

DRILL HOLE SC-21&21W

2969'T.D., 1314' Collar Elevation
SC-21W wedged out of SC-21 at
2102' and cored (NQ) to 2417'T.D.
Rotary: 0-2364' CXM Drilling
2-25-75 to 3-16-75
Core: SC-21 NQ 2364' – 2969' Longyear
3-20-75 to 4-10-75
SC-21W NQ 2102-2417' Longyear.
4-11-75 to 4-25-75



Conglomerate 7' of mudstone, few small volc. clasts at top. Remainder is well alt p[illegible] set in muddy matrix (70-30) may have steep initial bedding with strike parallel to steep clast boundary. ±60°. flattish bedding

Contact may not be steep fault.

1-1½% lim w/ alt.

2279-91, crushed 2-3% + lim. w/ alt.

Quartz monzonite porphyry breccia. Goethite-hematite leached capping with significant remnants of chalcocite and pyrite in the last 30'. Moderately strong alteration. 1.75 to 2% former total sulfides. Upper and lower contacts are faulted.

No Fluid. numerous hi angle shear & faults Prob. w/ cc leached.

fault 2347-88.' crushed, gouge. py repl. by cc as blebs. ie cc may be post faulting. fault post pyrite.

Note: cc in steep fractures on both sides of fault.

65 2585' last oxidation in fractures w/ tr cc.

Quartz monzonite porphyry with local breccia (2487'-2564'). 0.75 to 1% total former sulfides, pyrite and chalcopyrite (5py : 1 cpy). Moderate alteration with anomalously abundant secondary biotite at top of interval; decreases to weak alteration about 2600' and below. 0.25 to 0.50% calcite.

Appears that the numerous prominent fracture systems & ±60 controlled qtz-sulfide-py-cp. space only distribution and in turn were avenues of alteration. also leaching & cc enrichment followed same to depths below any "blanket" leach-cc zone.

EXPLANATION

- Conglomerate
- Breccia
- Volcanic agglomerate
- Quartz monzonite porphyry
- Diabase (only thicker dikes shown)
- Granite
- Fault

Alteration - Based on degree of replacement plagioclase, K-feldspar and biotite by primarilly sericite and kaolinite. Secondary biotite and chlorite in quartz monzonite porphyry, diabase and locally in granite.

Total Sulfides - Visual volume percent estimates.

figure 6

ASARCO

SC-21 AND 21 W

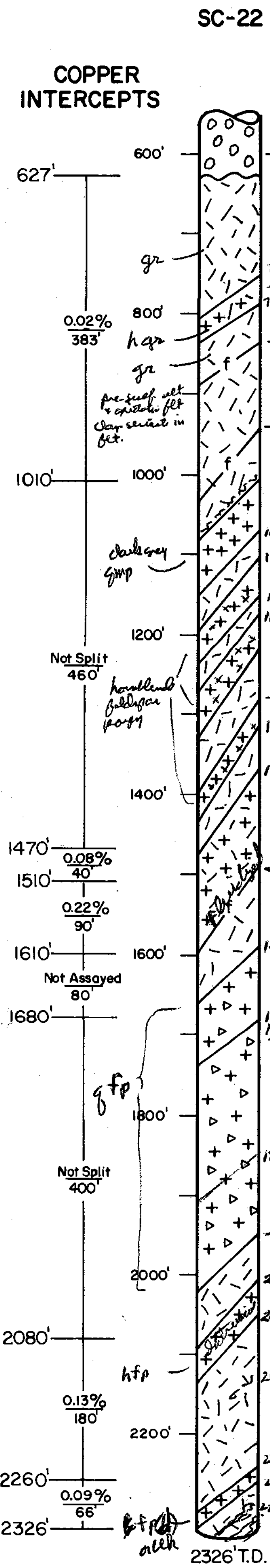
GEOLOGIC LOG
SANTA CRUZ PROJECT

ASARCO-FREEPORT J.V.
PINAL CO., ARIZONA

1" = 200'

H.KREIS JULY, 1975

mn 2876D dam



DRILL HOLE SC-22

2326'T.D., 1312' Collar Elevation
Rotary: 0-600' CXM Drilling
3-29-75 to 4-2-75
Core: HQ 600'-1930' Longyear Drilling
NQ 1930'-2326' Longyear Drilling
4-28-75 to 6-9-75

ROTARY
CORE —— 627'

Conglomerate

biotit to sericit
plag clay-sericit porphy. diss + vn ±3% sulf.
Excellent diss-vnlet leached capping.
after cc

753' – hybrid gr.

784 biotit to sericit-clay,
plag clay, some tough. 1½-2% diss sulf (w/vn) md lim after cc.

Granite. Leached goethite-hematite capping. 2.50% former total sulfides. Moderately strong alteration.

842-51
–65° strong gouge of sericit-clay & qtz.

same as 784-842 in alt-min. ~~perhaps~~ more on fractures. 1½-2% indig lim after cc.

–85° 936-960 flt w/clay gouge, sheared & crushed FeOx w/ slicks on FeOx.
clay-seri of biotite, moderate clay on plag. ~~minor~~ K-spar ca/clay.
3/4-1% limonite, both indig & transported.
crushed zone, slickensides on FeOx 986-1010, prob less 3/4-½% lim, indig & transp.

—— 1010 dips 60-75° indicate both gr & gmp.

overall ½% former sulf on hairline steep +60° fracture. upper part has more numerous fractures & 1½" crushed zone + dissem (perhaps 1½-±2% sulfide)

1079 intrusive contact @ ~~80~~-85°, qtz-seri alt along contact zone. gr badly crushed & bleached. fluidized bx w/ porph frags @ 1092½ light diss & steep 45-70° fract w/ indig lim. +5%.?

Alternating quartz monzonite porphyry and granite. Local minor chrysocolla in goethite-hematite leached capping. 4% former total sulfides. Moderately strong alteration.

1109 light colored (qtz-seri-clay altered)
biotite-feldspar (plagioclase?) – qtz porphyry
1157 intrusive into
1182 gr.

(numerous py cast, aquired weak? enrichment rare)

fluidized zones carry bleached feldspar porp and biotite gmp & others. and gr fragment. all at ±45-80°. This porph bx fluidized in gr zones.

—— 1235' vertical, undulating intrusive contact.

–80° intrusive contact (1292). 1st appear of narrow vns (sulfide) w/ qtz-sericit holos ⅛-¼" 1½-2% diss as vn & pyritic w/ minor cc.

1314' intrusive contact @ 80±°, few clasts of blk gmp.
slight increase in sericit in biot & plag. wk K-F alt. Secondary ragged biotite.
numerous ⅛" seq vnlet w/ qtz-sericit holos (¼") diss + vn @ 3% py w/cc.
1375

Quartz monzonite porphyry and granite. Local minor chrysocolla in goethite-hematite leached capping. 2% former total sulfides. Moderate alteration.

intense qtz-sericit-sulfid (oxidized) veinlets cutting throughout granite with holos up to ½" wide. discolorites the gr. Several "dark volc? intrusive" engulfed blocks also cut by qtz-seri. Numerous clotty areas of increased biotite (secondary?). ±3% lim ~~[illegible]~~ after cc. all steep structure +70°
1495-97 very fluidized w/ db, hematite, w/ leached cavities cc
Probably some light porp in fluidized matrix. Slight increase in total intensity.

FeOx 1497.
—— 1510'

Granite. Pyrite and chalcocite, ~~50%~~ 60±% oxidized and leached. ~~3%~~ 5% former total sulfides. Moderately strong alteration.

FeOx-Py-Cc

steep fract control of cc. biotite to clay-sericit. plag mainly seri. K-spar, wholt.
diss & vnlet (30-70) No alt holos next to sulf. veinlet.
pre hematite crushing & brecciation at contact in gr.

1589 @ 60°
—— 1600'
FeOx

feldspar porp. biotite → clay seri; plagio → clay wk seri; K-spar? gr to wk clay-seri.
3-5% in both diss & matrix bx with ~~stronger~~ hematite in matrix.
entry greater than transported. alt holos appearing on some fractures.

1689 No fault. 1705

Increase breccia texture below. similar alt min to 1705. ~~slight decrease~~ (2%)
slight increase in alt (more silicification) wider holos, but prob. less sulf & indig
to ±1850 where diss & matrix picks up (+3%)

~~Quartz monzonite~~ feldspar porphyry breccia with minor quartz monzonite porphyry and granite. Goethite-hematite leached capping. 3% former total sulfides. Moderately strong alteration.

Few steep fracture +70° some w/ fluid text. gr in bx @ 1727 & 1787

1856 FeOx
increase qtz (silicif) & seri in matrix. increased sulf 3-5% as diss & matrix vn (darned).

HQ / NQ
– 1953 @ 80° prob. intrusive-fluidized contact.
gr bx w/ narrow matrix zones. qtz seri in biot & plag. qtz-seri-Fe in K-spar.

2015. intrusive-fluid(?) contact @ 60-70° few 2-4" qtz seri zones. 1-2% limonite (stronger at contact) as indig & in matrix. minor diss. minor transported overflow of Fe.
hornblende feldspar porp. hb → ~~chlorite~~ -bid? feld → cloudy (clay) w/Fe w/ fine seri.
2051 @ 48-50) intrusive. 1% sulf. ±70% oxidized. Some cc, py. all indig., fracture controlled 45-80°

Note: Structure at 70° ± to fluid? is here slickensided. fault @ 80° inclination.

FeOx —— 2085'
biotite → seri-clay, few fresher to chlorite; plag → milky to clay (seri); K-spar wholt to fresh.
original py (1½%) as diss & fracture control (±=). cc enriched 8 py/lcc., now 70% leached.
mostly overprinted lim; transported in broken zones

2121 fluid zone (4") w/ rock(s?) clasts
FeOx-Py-Cc @ 50-60°

Granite. Pyrite and chalcocite with 80% oxidation and leaching. 1.50% former total sulfides. Moderate alteration.

weak qtz-+seri-day holo developed on some fracture (steep).

2249 @ 85° intrusive contacts, some gouge, bx on both contacts. Black porphyry w/ plag? phen. (30%) set in fine grained qtz-secondary(?) biotite

2262
—— 2250
FeOx-Py-Cpy
2285

Granite with quartz monzonite porphyry and diabase. Limonite, pyrite, chalcopyrite and trace chalcocite. 0.50% total sulfides. Moderate alteration.

2282 start of crushing in gr. Similar alt min to above
2284½-5½ fine chilled db (?)
2285½-2302 gr as above, increased crushing, clay development near base. Crushing & shearing @ +60°
2302-2308. fine xln diabase, weak alt (? second. biotite in groundmass).
Crushed, saussuritized-chlorite on shear slip zone.
½% py to cp. in narrow veinlets as above, limonite holos.
¼" chlorite gouge (fault) at base. some py-hem veins
2308-2326½ T.D. gr. biot → clay seri; plag- wk clay-seri. K-sp wholt.
⅛-1% py- some cp, hematite mainly as vein fracture control on 45-70° fracture.
some disseminated (±0%) incipient crushing. few crushed zone, one at 2324 minor fluidized texture at steep ±60°

EXPLANATION

Conglomerate
Breccia
Volcanic agglomerate
Quartz monzonite porphyry
Diabase (only thicker dikes shown)
Granite
Fault

Alteration – Based on degree of replacement plagioclase, K-feldspar and biotite by primarilly sericite and kaolinite. Secondary biotite and chlorite in quartz monzonite porphyry, diabase and locally in granite.

Total Sulfides – Visual volume percent estimates.

figure 7

ASARCO

SC-22

GEOLOGIC LOG
SANTA CRUZ PROJECT

ASARCO-FREEPORT J.V.
PINAL CO., ARIZONA

1" = 200'

H.KREIS JULY,1975

Partially leached.

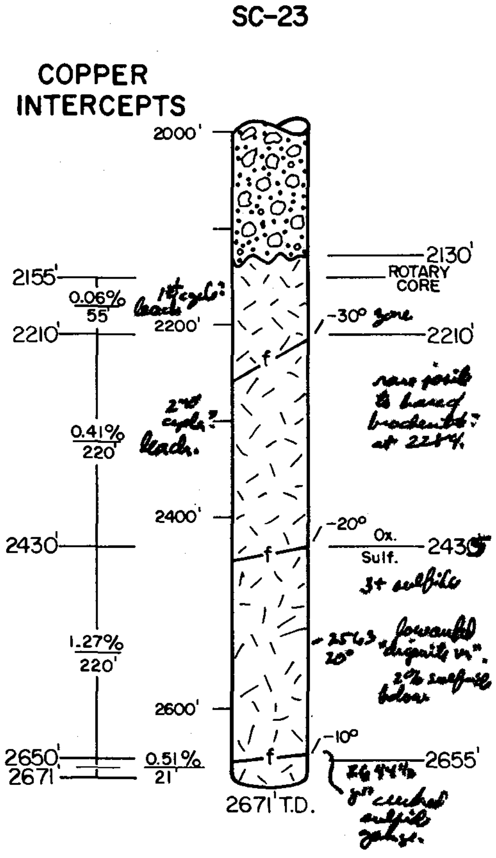
P.10
figure 7
SC-22

mn 2876E dam

DRILL HOLE SC-23

2671' T.D. , 1313' Collar Elevation
Rotary: 0-2154' CXM Drilling
(spot core, 2150'-2154')
4-12-75 to 4-29-75
Core: 2154'—2671' Longyear Drilling
5-10-75 to 5-19-75

Note: 30° structure w/ red-brown gouge
at: 2205 (1"), 2212 (2"?)
2222 (6"), 2227½ (½"),
2228½ (1"-2½"), 2231 (2")
and may represent flat fault zone.
However, also have 1/16"-1/8" gouge above & below
plus chalcocite filled fracture dipping at same
angles as at 2247-2248.
jarosite & poor capping stops at 2242.
brochantite starts at 2241. Good capping starts at 2246.



Conglomerate

Granite. Goethite–hematite w/ jarosite leached poor capping. 1-1½ 2% former total sulfides, mostly fracture controlled. Moderately ~~strong~~ alteration.

Granite. Goethite–hematite good capping with erratic copper oxides (partly atacamite) and one 10' interval of 3.72% copper as chalcocite. 2246½-2248½ 2-3% 2.25% former total sulfides equally in veins and disseminations. nat. cc stringers 2236½-2238½. Moderately strong alteration. Again jarosite-brochantite 2338-? sulfide at 2435. with crushed zone 2407-2415 w/ poor capping in zone & below to sulfide.

Granite. Zone of sulfide enrichment with minor low angle fault at top 3" gouge. and prominent 0–20° dipping fault at bottom. 8" 3-5 2% total sulfides, pyrite, w/ 6' crushed below. chalcopyrite and chalcocite (1Py: 1.5Cpy: 1Cc). Dissemination greater than fracture control. Moderately strong alteration. Composites: 0.0205% Mo, 0.24 oz/ton Ag, and 0.001 oz/ton Au.

Granite. Dominantly primary sulfides, pyrite and chalcopyrite (3 Cpy : 1 Py). d > f 2% total sulfides. Trace to locally weak chalcacite. Moderately strong alteration.

numerous low angle structure both in oxide & cc & primary sulfide zone.

EXPLANATION

- Conglomerate
- Breccia
- Volcanic agglomerate
- Quartz monzonite porphyry
- Diabase (only thicker dikes shown)
- Granite
- Fault

Alteration – Based on degree of replacement plagioclase, K-feldspar and biotite by primarilly sericite and kaolinite. Secondary biotite and chlorite in quartz monzonite porphyry, diabase and locally in granite.

Total Sulfides – Visual volume precent estimates.

figure 8

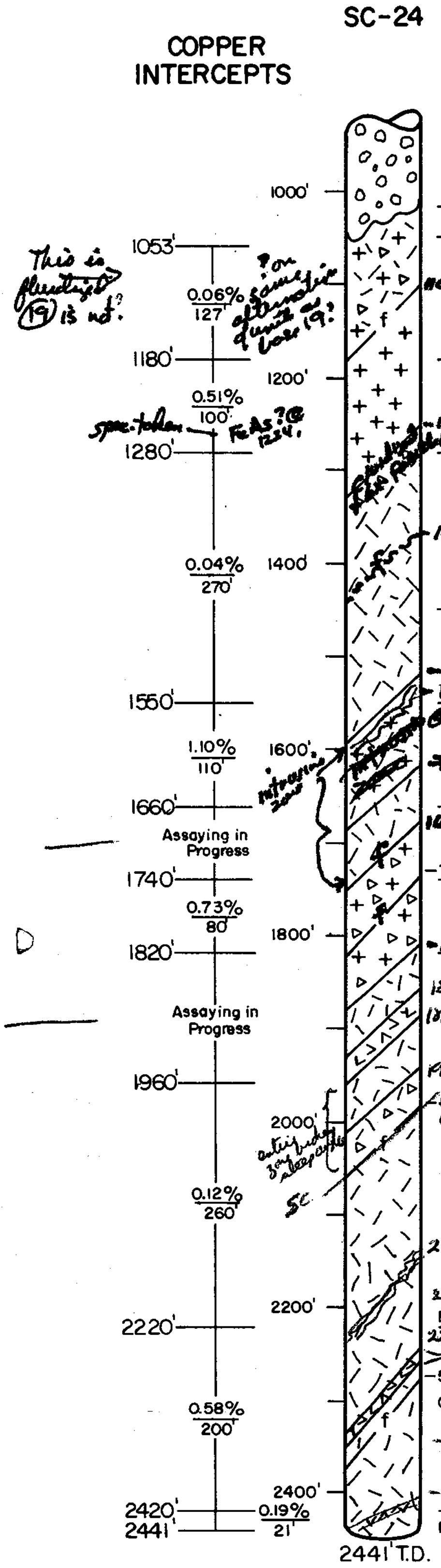
ASARCO
SC-23
GEOLOGIC LOG
SANTA CRUZ PROJECT
ASARCO-FREEPORT J.V.
PINAL CO., ARIZONA

1" = 200'

H. KREIS JULY, 1975

P. 11
figure 8
SC-23

Box 16, 1185.5 gms.



DRILL HOLE SC-24

2441' T.D., 1315' Collar Elevation
Rotary: 0-1053' Hunter-Shelton Drilling
4-21-75 to 4-26-75
Core: NC 1053'-1448' Joy Drilling
NX 1448'-2441' Joy Drilling
5-20-75 to 6-25-75

Conglomerate

—1020' crushed & tect bx, few sulfs. T. trace around grains wk argillic clay. slickensides. ? fluidized ? (1072) (1104-1106) etc. fault, crushed gr. bx contacts between [illegible]

ROTARY CORE < 0.5

1104-06 @ 70° Quartz monzonite porphyry with local granite. Goethite-hematite leached crushed, better examples of fluid zones - all gray variation. few flat slicks capping. ~~1.25%~~ former total sulfides. Moderate alteration.

0.5 upto +1% in vns. faults @ 1129, 1137, the most slickensides are steep (+70°) as is fluid texture. alt increases to wk qz-seri at basal structure (1180) Increased sulfides along steep zones w/ qz-seri alt. 1165-1169 [illegible] to 1/4" vns & diss zone in qz-seri @ 50°-60°.

—1180' few slicks fluidized Quartz monzonite porphyry with granite breccia at bottom of interval. variable alt & min. overall wk-mod alt to clay-seri ; 0.5-5% diss sulf.

~1260 @ 70° clay Chrysocolla and minor atacamite in goethite-hematite capping. Moderate variable py/cc (former) ratios. I. Clay as steep +60° fract filling & argillic [illegible]).

—1280' alteration. clay & gouge, base 1284.

gr, variable alt but mostly strong alt bio + plag → cly-seri, some [illegible] altered. min low < 0.5 except in fluidized & strong qz-seri zone steeply dipping +70° where max + 3%. T > I overall. strong I in qz-seri zones. 5ft gouge in zones all appear clay. basal crushed zone has 6" @ 1368 & 4" @ 1371 of dark fine grained porphyry (db?).

~1371 Granite with minor quartz monzonite porphyry at bottom of interval. Goethite- qz-seri & clay alt throughout. abundant [illegible] & fract. f < d, T < I. in steep shear zones. but throughout hematite leached capping. 1.50% former total sulfides. Moderate to few steep 75-90° sheared zones generally w/ intense qz-seri & strong f & d mineralization. moderately strong alteration.

NC
NX

crushed near contact

~1523° ~~[illegible]~~ intrusive contact. Chilled gray top & bottom w/ gray (70%) including
1545 25-30° and [illegible] gr & needle hornblende fine grained intrusive.

—1550' Granite and quartz monzonite porphyry. Chrysocolla with lesser amount of atacamite in goethite-hematite capping. 0.75% former total sulfides. Moderate alteration.

py-qz?, cc-qz vns @ 30-50 @ 1554-56'. db dike @ 15-25° @ 1561-1567' (chilled). start of CuOx

—1660' 1670 steep. fault contact. sulfide Granite, quartz monzonite porphyry and breccias of both rock types. Goethite- minor principally w/ post sulfide crushing hematite leached capping with traces of black CuOx. 2% former total

-70° w/ gouge, long slicks at base on gray.

—1740' sulfides. Moderately strong alteration. T < I gray [illegible] (fault) at base.

~1814 @ 35° Quartz monzonite porphyry, quartz monzonite porphyry breccia and minor granite. Chrysocolla in goethite-hematite capping. 1% former total sulfides. Moderate alteration. at base. steep contact, then 2' bx qz, then 2 ft of mixed porphyry @ 35° sharp contact w/ gr. to wk

1857-20° ?
db 1891 @ 70?

—1820' f ?= d 2% T > I

~50° 1984 60-80°

steep 70° phyllic zones 4-13' wide w/ f < d, T < I, 2½% partially to completely leached py cc, cut wk → cly seri biot, mod plag, which keeps f >> d, T >> I, ± 1% py > cc granite.

Granite with a thin diabase dike and minor local breccias. Chrysocolla and atacamite in diabase dike. Goethite-hematite leached capping with minor local chalcocite remnants. 2% former total sulfides.

2184-87 70-75° fluid zone.

Moderate alteration. f ?= matrix ?= diss 1½-2% mod-str alt.

2204-07 well fluidized @ 80°

FeOx

2224 —2220' stronger alt qz-seri f≥d = matrix (fluidized: 2232' 70° zone), [illegible].
2-3% vn structure ¾" fluid.

db 2253-64 chilled, faulted upper contact (30°?) w/ epi, clay, py, cp. 25° lower contact, intrusive.

-50°

Cc-Py-FeOx 3/4% Granite with a thin diabase dike. Pyrite, chalcocite, and goethite- granite w/ sheeted zones of phyllic alt (3-4% sulf) few fluid zones. 2nd biot. - ±1%. hematite capping. 50-60% of the interval is totally oxidized and leached.

-2340 cut base of cc. 3/4% sulf as py. 2% former total sulfides. Moderate alteration.

-2402-2403 db, 25° on both contacts. same with biot. weaker but pervasive mod alt. some cc very fine grained

—2420' Py-Cpy Granite, pyrite, chalcopyrite, and trace chalcocite. Trace oxidation. 2% total sulfides (6 Py : 1 Cpy). Moderate alteration.

again in zones w/ < 0.5 between.

bottom qz-seri-diss zone has vuggy texture. Beyond is 6" of sec. biot gr w/ minor sulf. (?), intrusive rock!

EXPLANATION

- Conglomerate
- Breccia
- Volcanic agglomerate
- Quartz monzonite porphyry
- Diabase (only thicker dikes shown)
- Granite
- Fault

Alteration – Based on degree of replacement plagioclase, K-feldspar and biotite by primarily sericite and kaolinite. Secondary biotite and chlorite in quartz monzonite porphyry, diabase and locally in granite.

Total Sulfides – Visual volume percent estimates.

figure 9

ASARCO

SC-24

GEOLOGIC LOG
SANTA CRUZ PROJECT

ASARCO-FREEPORT J.V.
PINAL CO., ARIZONA

1" = 200'

H. KREIS JULY, 1975

figure 10

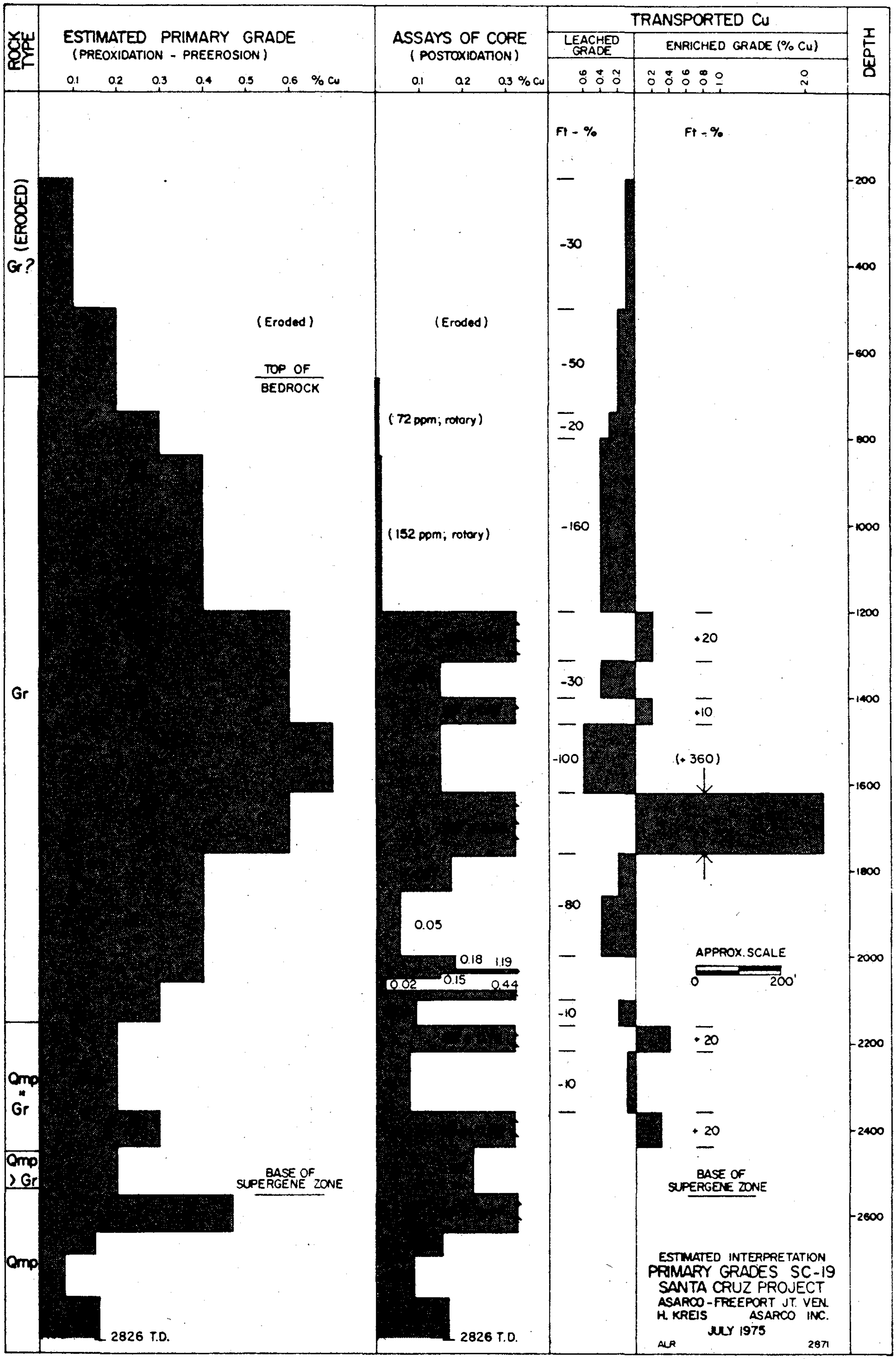
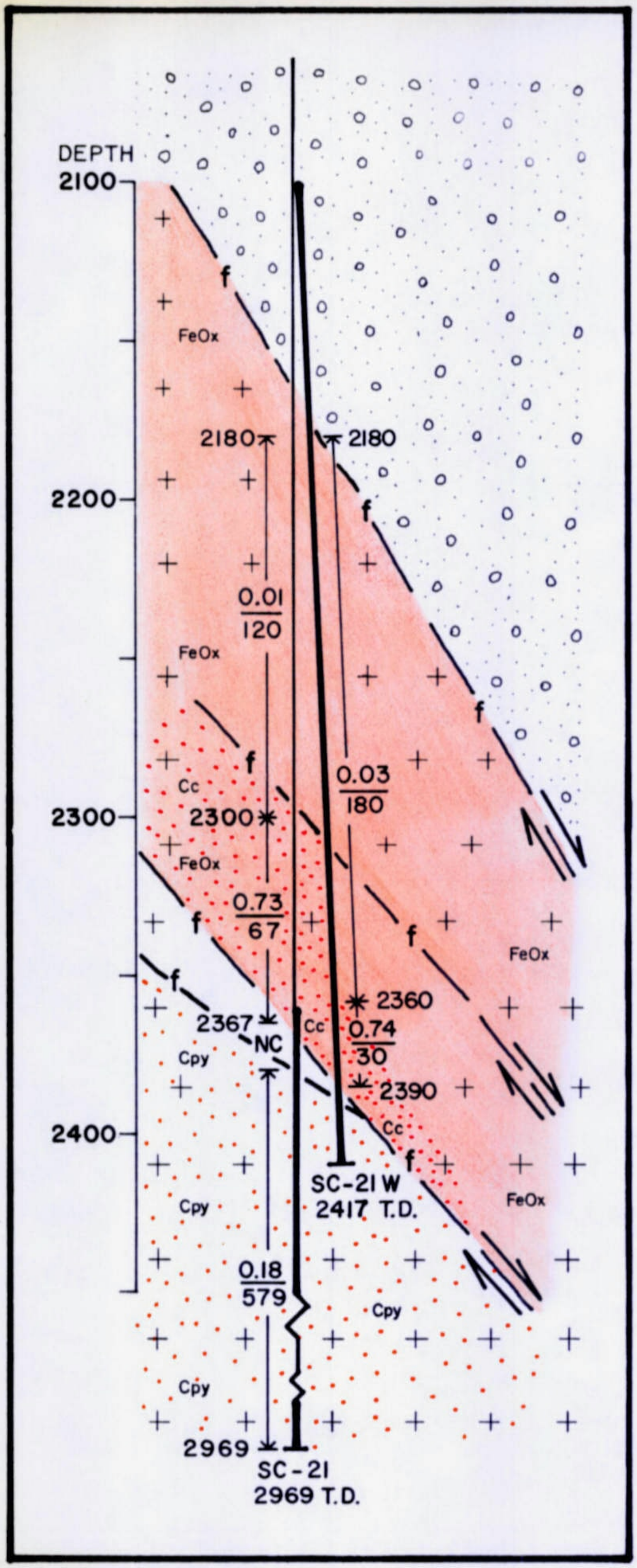

ROCK TYPE
ESTIMATED PRIMARY GRADE
(PREOXIDATION - PREEROSION)
0.1 0.2 0.3 0.4 0.5 0.6 % Cu
ASSAYS OF CORE
(POSTOXIDATION)
0.1 0.2 0.3 % Cu
TRANSPORTED Cu
LEACHED GRADE
0.6 0.4 0.2
ENRICHED GRADE (% Cu)
0.2 0.4 0.6 0.8 1.0 2.0
DEPTH
Ft - %
Ft - %
(ERODED)
Gr?
Gr
Qmp = Gr
Qmp > Gr
Qmp
(Eroded)
(Eroded)
TOP OF BEDROCK
(72 ppm; rotary)
(152 ppm; rotary)
-30
-50
-20
-160
-30
-100
-80
-10
-10
+20
+10
(+ 360)
+ 20
+ 20
0.05
0.18
1.19
0.02
0.15
0.44
APPROX. SCALE
0
200'
BASE OF SUPERGENE ZONE
BASE OF SUPERGENE ZONE
2826 T.D.
2826 T.D.
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
ESTIMATED INTERPRETATION
PRIMARY GRADES SC-19
SANTA CRUZ PROJECT
ASARCO - FREEPORT JT. VEN.
H. KREIS ASARCO INC.
JULY 1975
ALR
2871

figure 11



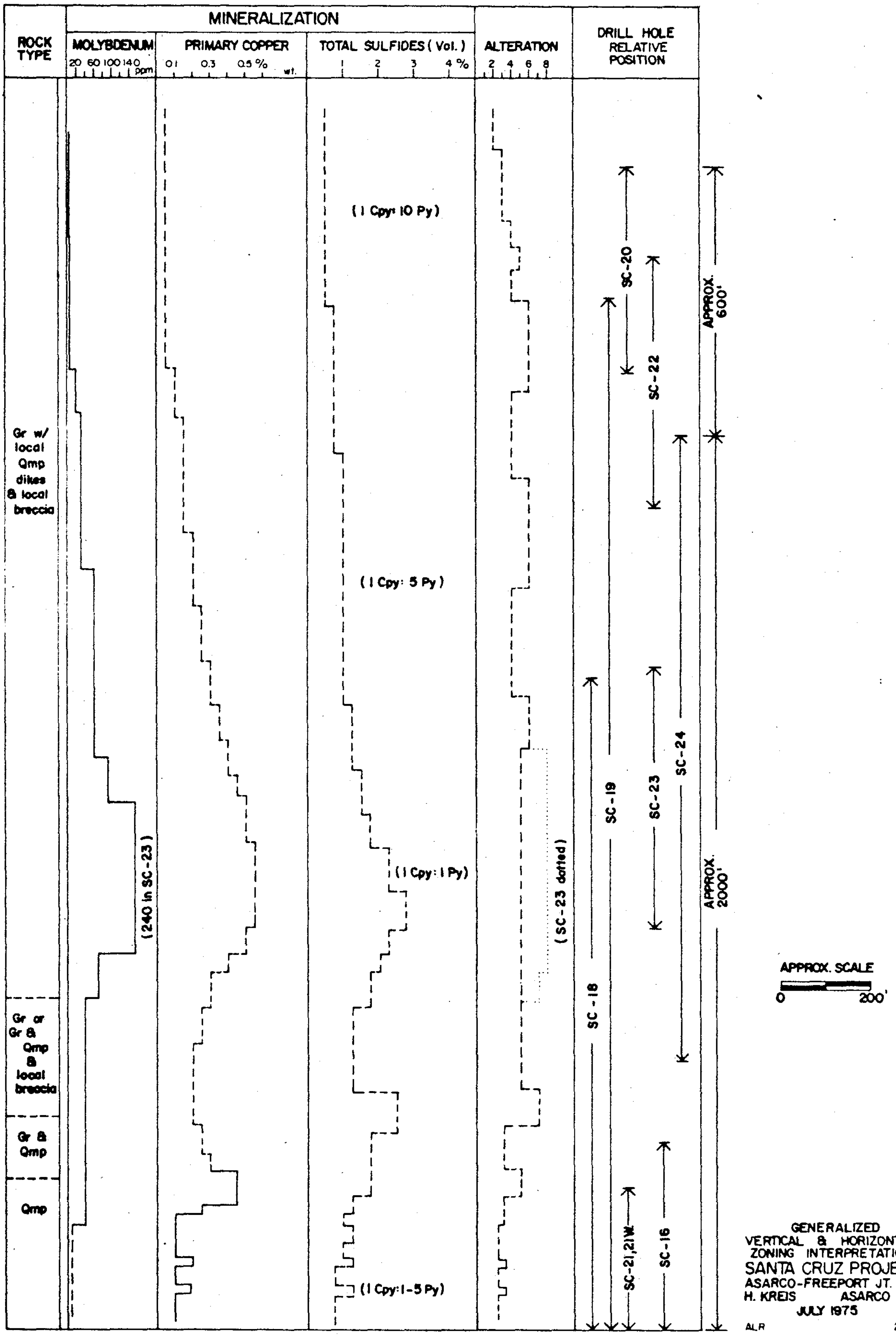
EXPLANATION

⁰₀°	CONGLOMERATE
+ + +	Qmp (Quartz monzonite porphyry)
FeOx	LIMONITE
Cc	CHALCOCITE
Cpy	CHALCOPYRITE
— f —	FAULT
0.75 / 20'	Cu GRADE (%) / INTERVAL
NC	NO CORE
│	ROTARY HOLE
┃	CORE HOLE

SCALE
0
50'

INTERPRETATION OF
SC-21 & 21 W
BASED ON LOGGING (ONLY)
SANTA CRUZ PROJECT
ASARCO-FREEPORT JT. VEN.
H. KREIS ASARCO INC.
JULY 1975
ALR 2872

figure 12



GENERALIZED
VERTICAL & HORIZONTAL
ZONING INTERPRETATION
SANTA CRUZ PROJECT
ASARCO-FREEPORT JT. VEN.
H. KREIS ASARCO INC.
JULY 1975
ALR 2875

figure 13
(1 of 2 pages)

GENERALIZED COPPER ENRICHMENT HISTORY
SANTA CRUZ HORST BLOCK

p€ granite intruded by minor diabase dikes.

Crushing, brecciation, and faulting prior to and contemporaneous with intrusion of quartz monzonite porphyry and associated hydrothermal alteration and mineralization.

Erosion and subsequent leaching and enrichment as shown in Section A on following page.

Horst-graben faulting probably occurred at this time.

Another leaching and enrichment cycle followed by partial leaching of the newly formed enrichment blanket as shown in Section B.

Low angle faulting at Sacaton probably occurred at this time.

EXPLANATION FOR SECTIONS A AND B

Cross sections A and B show progressive geologic development of copper enrichment in the Santa Cruz horst block. The sections are generalized, interpretive, and show only one major fault. The sections are NW-SE through SC-19 and SC-16 and are looking NE.

⁘ Conglomerate

\+ + Laramide Quartz Monzonite Porphyry (Qmp)

⟋ ⟍ p€ Granite (Gr) with Minor Qmp & Diabase Dikes

▨ + 0.3 % Cu as Chalcopyrite Prior to Supergene Enrichment

🟫 Leached Capping

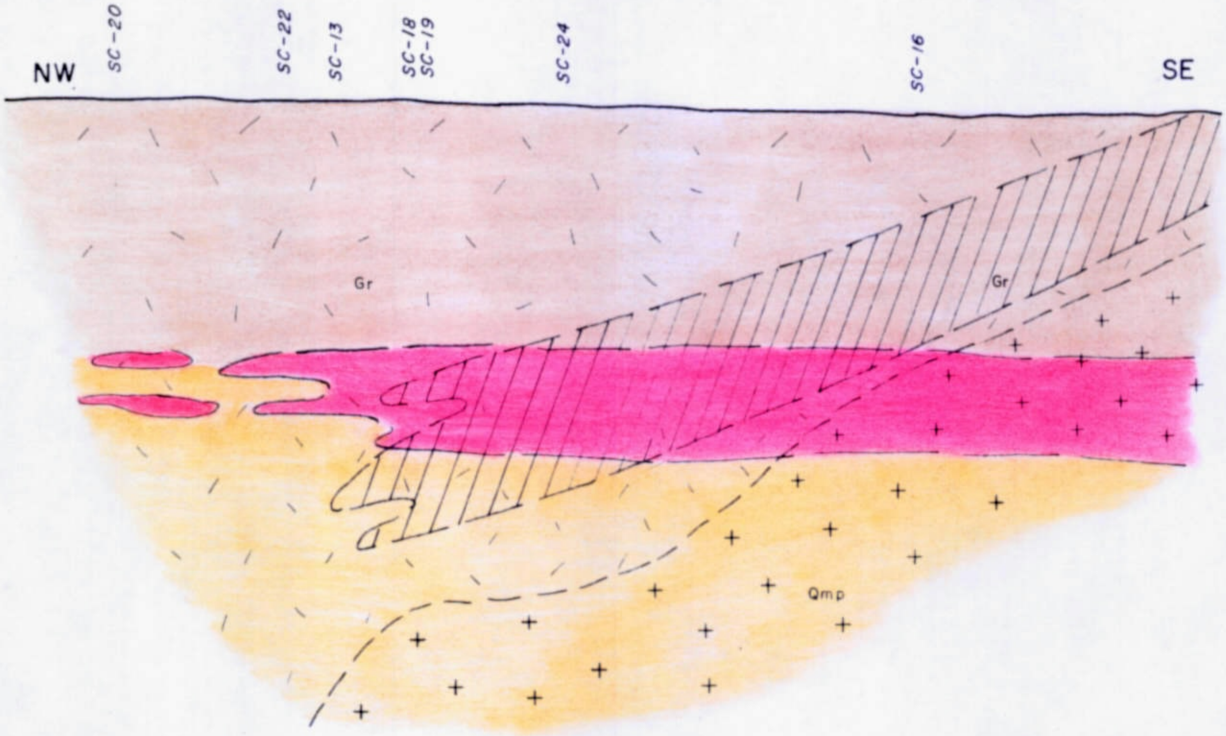
🟩 Copper Oxides

🟥 Supergene Chalcocite Enrichment

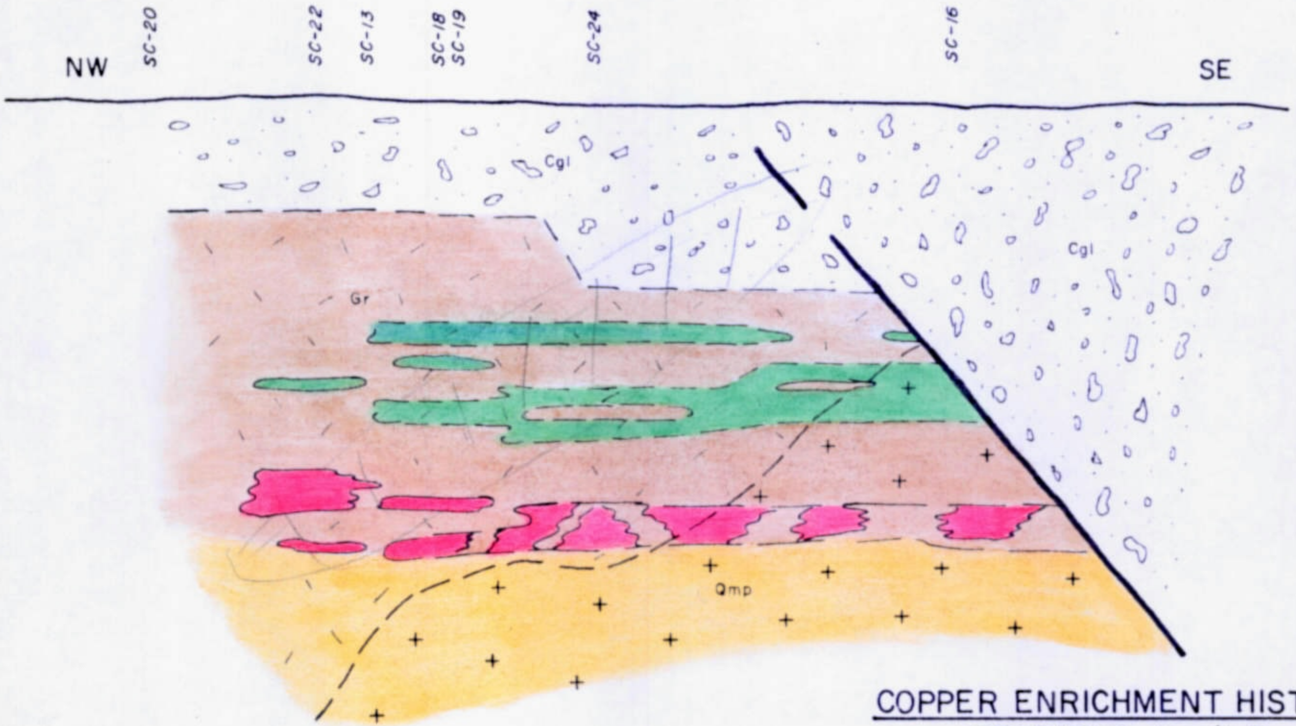
🟧 Primary Sulfides

figure 13
(2 of 2 pages)

SECTION A

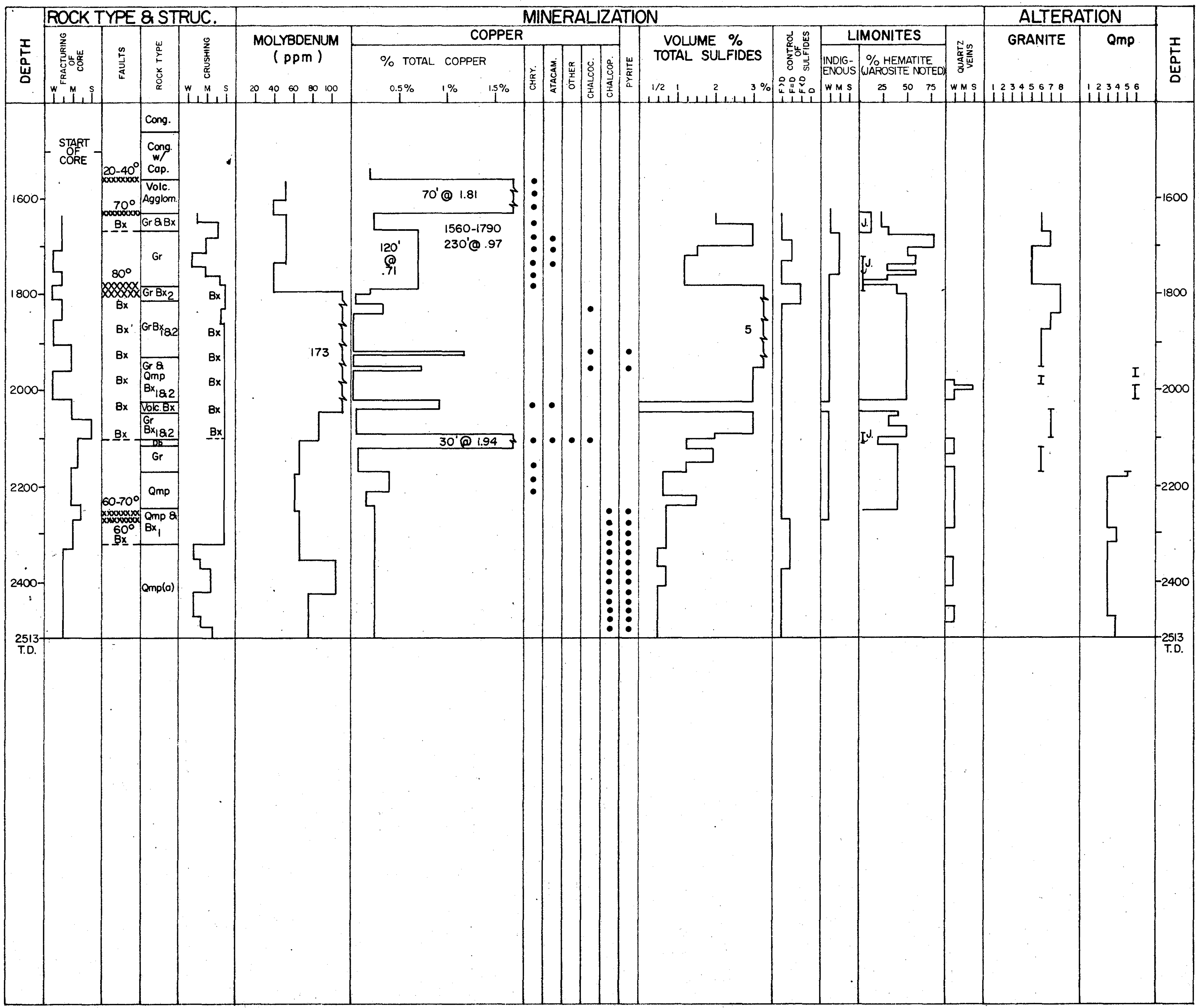


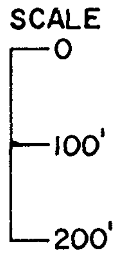
SECTION B



NOTE See Explanation On Previous Page.

COPPER ENRICHMENT HISTORY
SECTIONS A and B
SANTA CRUZ PROJECT
(ASARCO-FREEPORT JOINT VENTURE)
Pinal County, Arizona
SCALE 1" = 1000' Approx.
H.G.K. July-1975
M.V.K. 2879



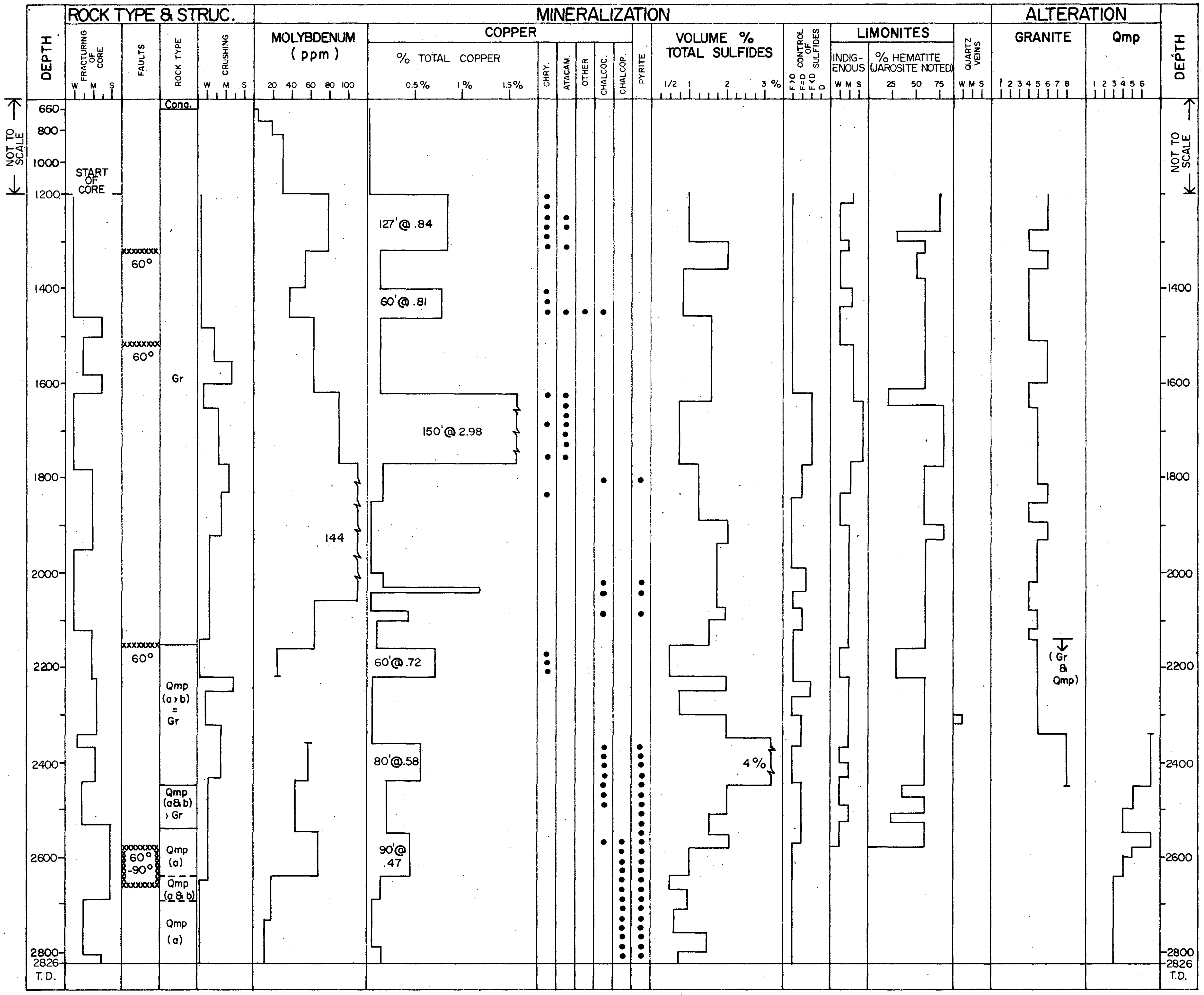


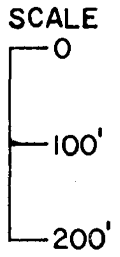
GEOLOGICAL SUMMARY

SC-18

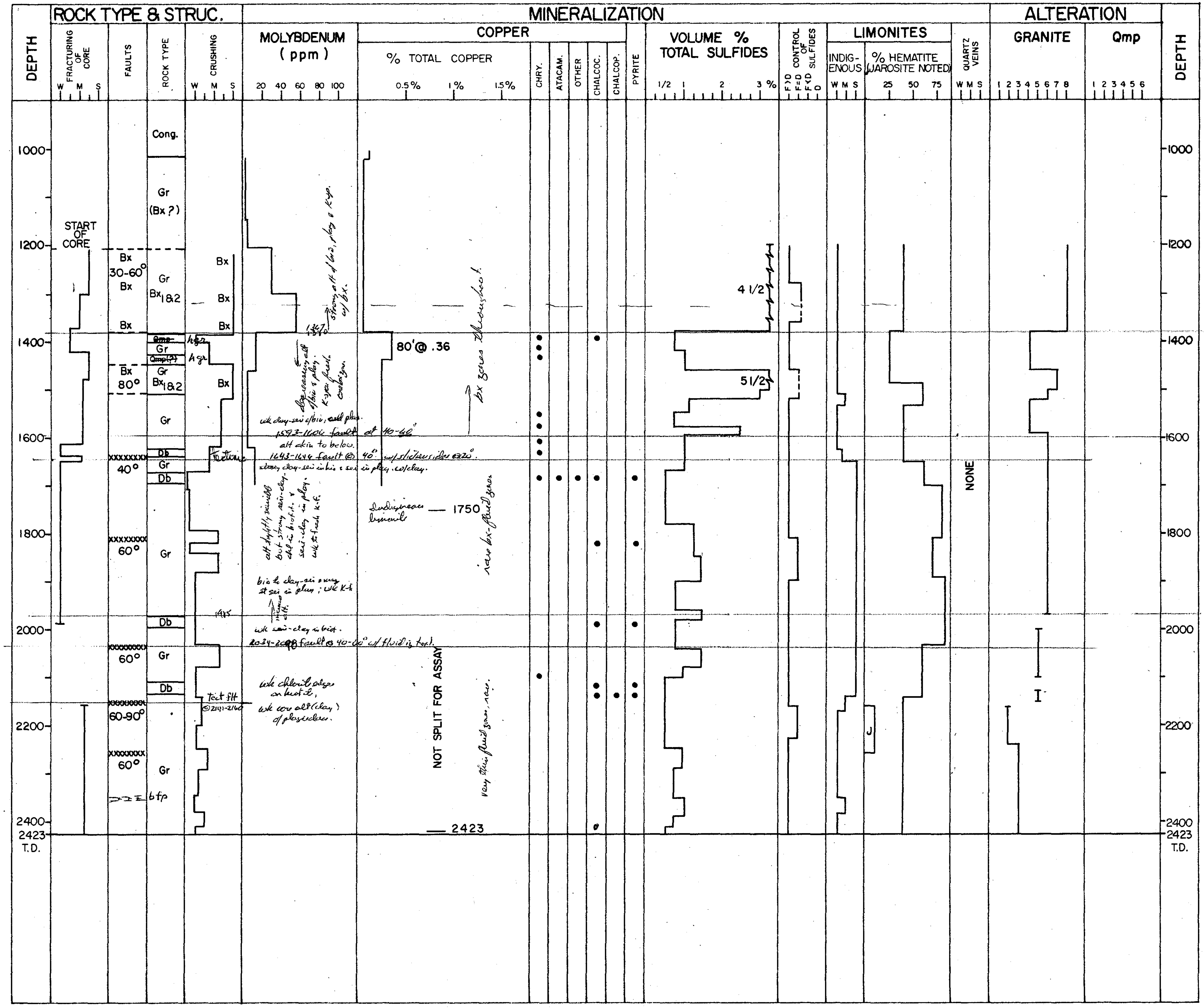
SANTA CRUZ PROJECT
ASARCO-FREEPORT JT. VEN.
H. KREIS ASARCO INC.
JULY 1975

ALR 2870A





GEOLOGICAL SUMMARY
SC-19
SANTA CRUZ PROJECT
ASARCO-FREEPORT JT. VEN.
H. KREIS ASARCO INC.
JULY 1975
ALR 2870B

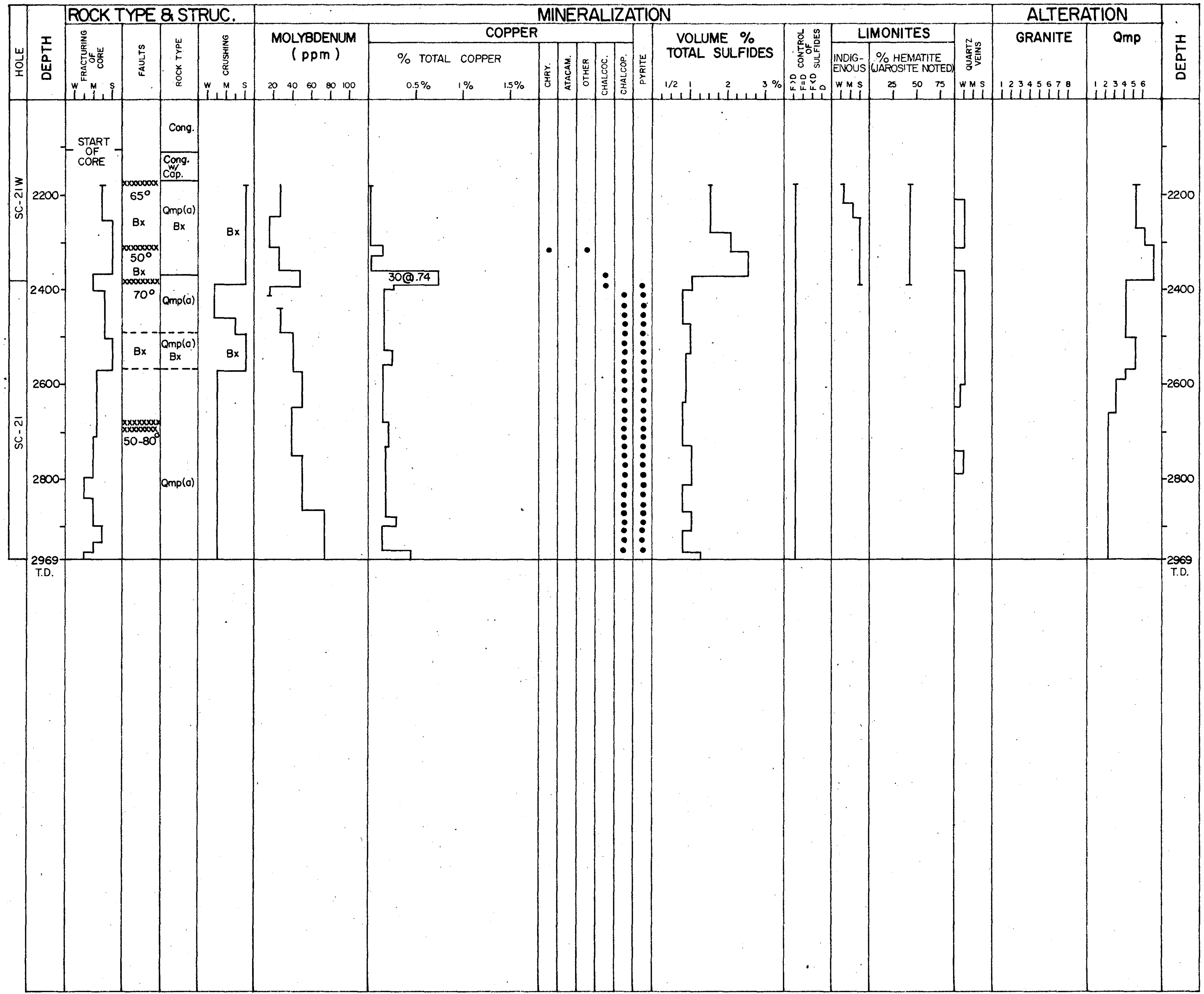


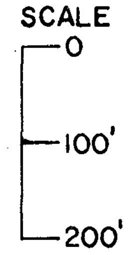
GEOLOGICAL SUMMARY

SC-20

SANTA CRUZ PROJECT
ASARCO-FREEPORT JT. VEN.
H. KREIS ASARCO INC.
JULY 1975

ALR 2870C



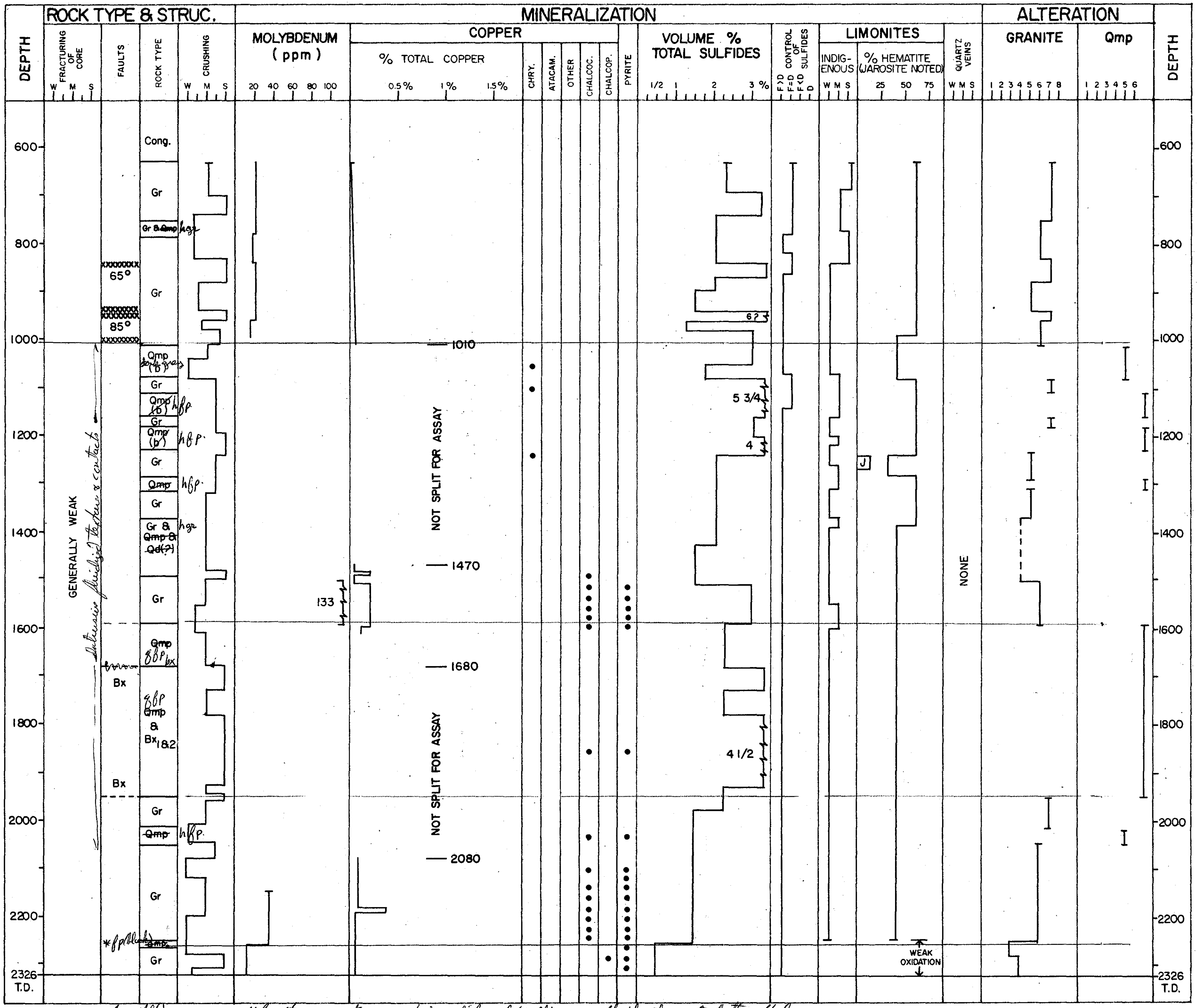


GEOLOGICAL SUMMARY

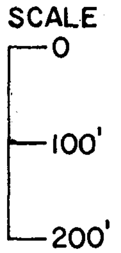
SC-21 & 21 W

SANTA CRUZ PROJECT
ASARCO-FREEPORT JT. VEN.
H. KREIS ASARCO INC.
JULY 1975

ALR 2870D



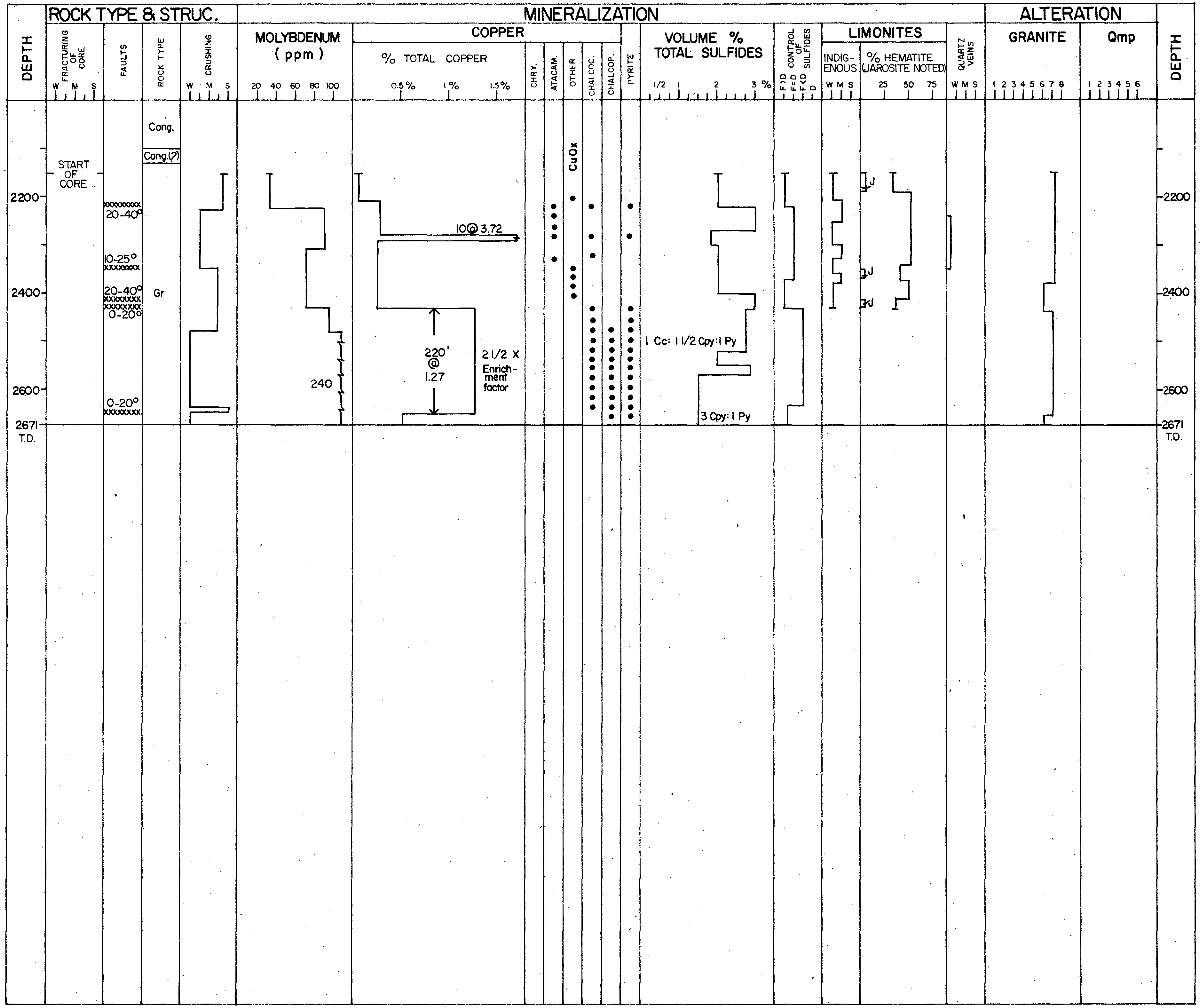
* fpqp(blk) may occupy old fault zone , strong crushing, slickensides (in blk) & rare fluidized zones to bottom of hole.

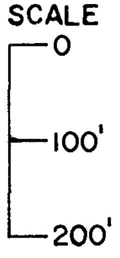


GEOLOGICAL SUMMARY

SC-22

SANTA CRUZ PROJECT
ASARCO-FREEPORT JT. VEN.
H. KREIS ASARCO INC.
JULY 1975
ALR 2870E

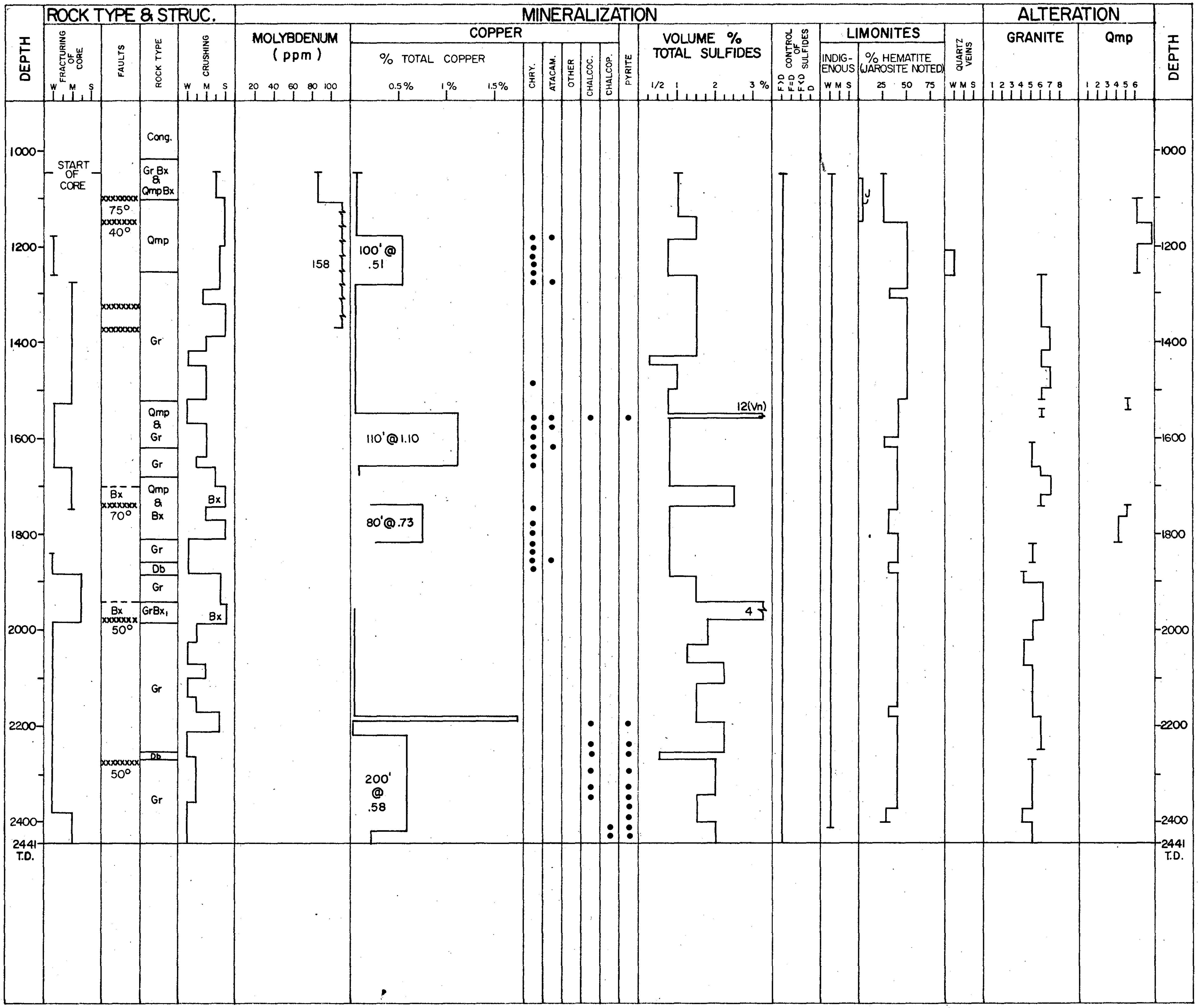


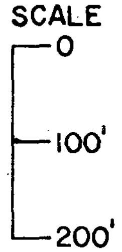


GEOLOGICAL SUMMARY

SC-23

SANTA CRUZ PROJECT
ASARCO-FREEPORT JT. VEN.
H. KREIS ASARCO INC.
JULY 1975
ALR 2870F





GEOLOGICAL SUMMARY

SC-24

SANTA CRUZ PROJECT
ASARCO-FREEPORT JT. VEN.
H. KREIS ASARCO INC.
JULY 1975

ALR 2870G

7- 11- 75

H G Kreis MD 1975 Progress Rpt

Sorry to be so long with my comments Santa Cruz

① I'd prefer figures 2-20 at end of your short text

② I'd prefer figures 3-9 arranged so that didn't have to turn report to look at them — looks to me like no room problem to do this.

However - no need to waste time doing this now. Keep ~~it~~ in mind for next time.

General Comments:

I think the report should have contained a number of cross sections (not just the one generalized worth section) on which the pertinent features could be shown — rather than trying to "get-it-in-mind" fro the little description on pages 13 & 16.

~~If did~~

Sections probably all that needed — could possibly have used contour map of bed rock; top of primary

Think work ~~on~~ on the so called conglomerate is needed - especially that bx(?) range(?) with the altered fragments and red-brown, yellowish, orangish matrix. This may be significant and have structural implications.

Attached is my report, please return, with many margin comments.

cc JDS w/
Attached rpt

You spent a lot of time working on cores, core boards, and cuttings. These facts should have been used in your summary!!!

SUMMARY AND CONCLUSIONS

Recent core drill holes SC-18, -19, -24, and a previous rotary hole, SC-16, have encountered a copper oxide deposit in the Santa Cruz horst block (Figures 1 and 2). Core hole SC-23, a step-out hole between Santa Cruz and Sacaton, drilled through a chalcocite blanket of unknown lateral extent. Significant geologic intercepts including internal leached capping are:

Hole	Depth	Interval	Cu Grade	Cu Form
SC-18	1670[a]-1790	120'	0.71%	CuOx
SC-19	1193 -1770	577'	1.10%	CuOx — very misleading
SC-24	1550 -1820	270'	0.68%[b] (Est.)	CuOx
SC-16	1560 -1650[c]	90'	1.45% (Est.)	CuOx
SC-23	2430[d]-2650	220'	1.27%	Chalcocite

[a] Above is 70' @ 1.81% Cu in volcanic agglomerate (1560-1630).
[b] Assayed except for 80' estimated at 0.05% Cu.
[c] No assays of cuttings of CuOx from 1650-1770 in SC-16.
[d] Overlain by 220' at 0.41% Cu (CuOx and chalcocite).

No reserve calculations have been made at this time. However, the grades and thicknesses of the copper oxide intercepts and their projected extent are compatible with the tonnages and grades upon which the Santa Cruz project was reinitiated (subject to modification by the competition's acquisition of the Collins' property).

The Santa Cruz copper oxide deposit is interpreted to be an oxidized chalcocite enrichment blanket faulted off on the northeast and southeast sides. SC-23, a step-out hole between Santa Cruz and Sacaton drilled through an intact but fault thinned chalcocite enrichment blanket of unknown extent.

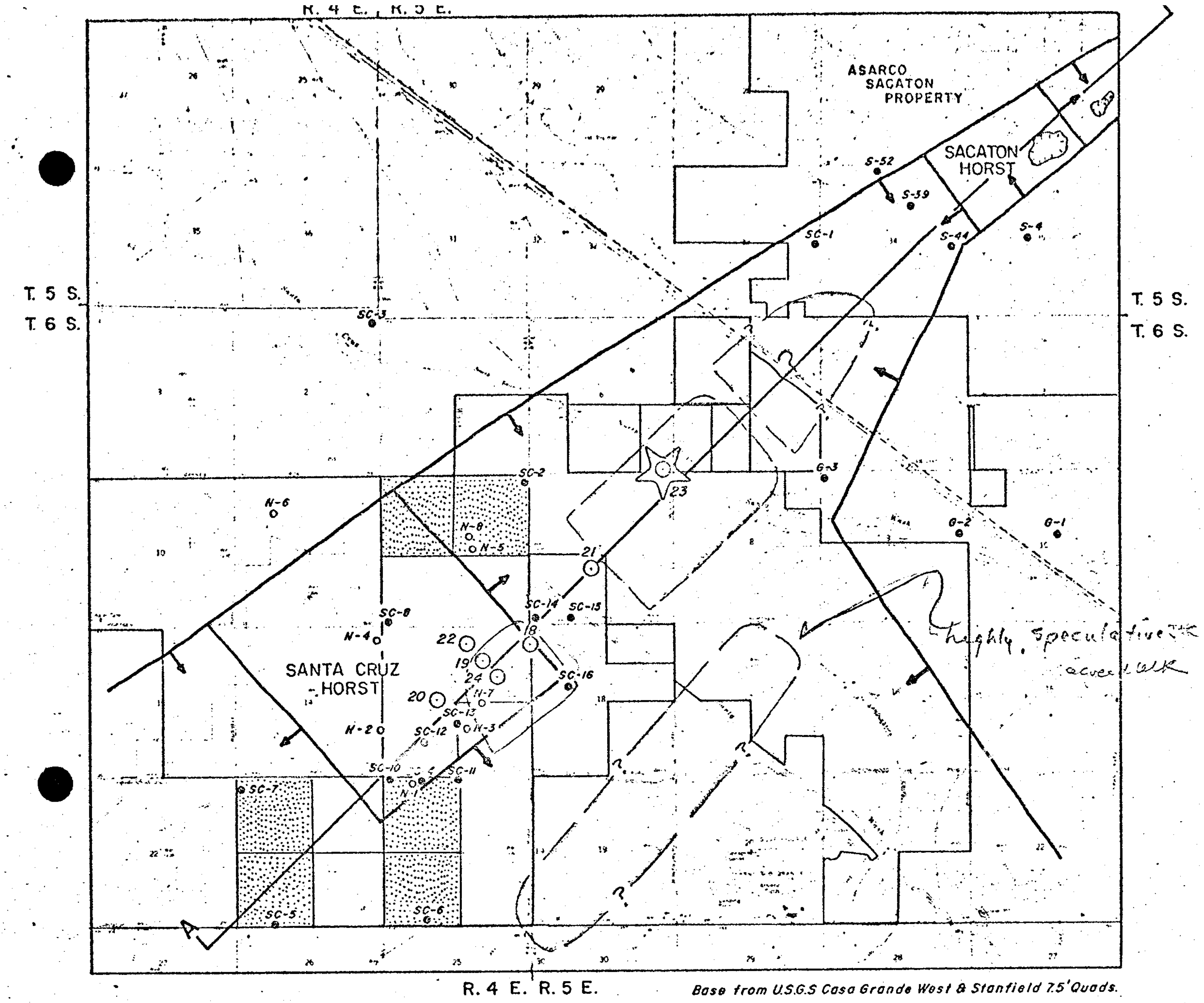
? based on SC-4 ill? 16? ~~[illegible]~~

The Santa Cruz copper oxide deposit and the chalcocite blanket in SC-23 are part of a large buried sulfide system. The extent of the system is only partially defined with the Santa Cruz horst on the southwest, SC-2 just to the north, and the Sacaton barren basement complex on the northeast. The southeast side is completely open. The Santa Cruz sulfide system is believed to be 12,000 to 20,000' long and at least 2,500' wide. — with no extension by faulting

Geologic studies to date suggest a low total sulfide system (2-3% average by volume) hosted by Precambrian granite with small Laramide quartz monzonite porphyry intrusives. The stronger primary copper mineralization appears to have been distributed within 2000' of a large quartz monzonite porphyry mass (intercepted in SC-14, -16, -18, -19, and -21). In the portions of the sulfide system explored to date, the highest primary grades are interpreted to have been about 0.5-0.6% copper prior to oxidation and leaching.

equiv to the small qm

Multiple cyclic enrichment has produced and destroyed chalcocite enrichment blankets. In SC-23 and at Sacaton these enrichment blankets remain. Chalcocite blankets in the Santa Cruz horst block, containing a high ?



highly, speculative TK
[illegible]

Base from U.S.G.S Casa Grande West & Stanfield 7.5' Quads.

EXPLANATION

▭ ASARCO FREEPORT
▨ Newmont Federal Lode Claims

▭ NEWMONT
▨ Newmont Federal Lode Claims

▭ NAAC

● PREVIOUS ASARCO DRILL HOLES

⊙ RECENT ASARCO DRILL HOLES

○ NEWMONT DRILL HOLES

◯ GENERAL AREAS TO EXPLORE for Potential Enrichment (Cu Ox &/or Cc)

▨ COPPER OXIDE MINERALIZATION Estimated Area of + 200 ft.-% Copper

▭ CHALCOCITE MINERALIZATION

Predicted Sea Level Contour of Horst-Graben Faults. Arrow on Down Dropped Side.

⊙ SIGNIFICANT INTERCEPTS

SC-18	1670'-120'-0.71 ox	(2513' T.D.)
SC-19	1193'-127'-0.84 ox 1620'-150'-2.98 ox	(2826' T.D)
SC-20	(2423' T.D.)	
SC-21	(2969' T.D.)	
SC-22	(2326' T.D)	
SC-23	2430'-220'-1.27 sulf	(2671' T.D.)
SC-24	1180'-100'-0.51 ox 1150'-110'-1.10 ox 2220'-200'-0.58 cc	(2441')

ASSAY DATA KEY

depth-length-% Cu
1670'-120'-0.71

PLAN MAP

SANTA CRUZ PROJECT

(ASARCO-FREEPORT JOINT VENTURE)

Pinal County, Arizona

SCALE 1" = 1 mile

HGK July-1975

chalcocite to pyrite ratio, were oxidized without significant leaching to form copper oxide deposits. The enrichment blankets have been offset by horst-graben faulting and more recent low angle (flat) faulting. Sacaton appears to have been faulted from an unknown position within the Santa Cruz sulfide system.

at Santa C documentation

The results of the 1974-75 drilling program are encouraging and more drilling is needed in the Santa Cruz horst block between SC-16, -18, and -19; in the SC-23 area; between SC-23 and Sacaton; and in the area south and east of SC-16 (Sections 17 and 19) as outlined in Figure 1. Testing of the latter three areas would require additional land acquisition. Exploration in these three areas is enhanced by the potential for chalcocite mineralization rather than copper oxide mineralization.

highly speculat

PJHK

38,364' of drilling was done in the 1964-1965 Santa Cruz drilling program and 18,484' in the recent 1974-1975 program, for a total of 56,848'. Although very little is known about Newmont's exploration program, it is guesstimated at 15,000' of rotary-core drilling.

INTRODUCTION

The discovery of the Santa Cruz sulfide system was made by Asarco in September-October 1964 while exploring for the Sacaton "roots" along Sacaton's southwest trend. The exploration program drilled SC-1 through SC-17 from mid-1964 to mid-1965. In mid-1965 Asarco's land position was dropped.

During late 1970 and early 1971 Asarco attempted to reestablish its land position following a favorable geologic report by Bruce Kilpatrick (October 5, 1970). No land was acquired during the following years. In July 1974 Asarco and Freeport Exploration Company entered into a joint exploration agreement. During October 1974 Freeport purchased North American Acceptance Corporation land in and about the area of previous drilling in Section 13 (T6S R5E). Asarco commenced drilling in October 1974 and continued to the end of June 1975. Holes SC-18 through SC-24 were drilled during this time.

reevaluat

surface al mineral?

Ore grade and potentially economic copper intercepts have been encountered in four holes of the recent drilling program. Geologic interpretation of the past and recent drilling results has resulted in a reasonable understanding of the former primary mineralization, enrichment cycles, copper oxide deposit formation, and offsetting fault structures. The purpose of this report is to highlight the results of the recent drilling program and the geologic interpretation resulting from studies since October 1974.

DRILLING RESULTS

The 1964-1965 drilling program consisted of 17 holes totalling 38,364' of rotary and core drilling (Santa Cruz Summary Report, J. Wojcik, May 1966). During the recent program seven holes and one wedged hole (SC-21W) were completed, for a total drilling footage of 18,484' (10,083' of rotary drilling and 8,401' of core drilling). The footages of the recent program are detailed in the following table.

TOTAL RECENT DRILLING

Drill Hole	Rotary	Core	Total
SC-18	1,505'	1,008'	2,513' (T.D.)
SC-19	1,205	1,621	2,826 (T.D.)
SC-20	1,206	1,217	2,423 (T.D.)
SC-21	2,364	605	2,969 (T.D.)
SC-21W	-0-	315	315 (2,417'T.D.)
SC-22	600	1,726	2,326 (T.D.)
SC-23	2,150	521	2,671 (T.D.)
SC-24	1,053	1,388	2,441 (T.D.)
Total	10,083'	8,401'	18,484'

Norm Whaley's calculations (work sheets dated July 30, 1975) show Joy cored 5,240' at an average cost of $15.92/ft. and Longyear cored 3,162' at an average cost of $21.87/ft. (mud and lost casing costs included in both figures). On a comparison basis, the costs would be $16/ft. for Joy versus an estimated $19 to $19.50/ft. for Longyear, adjusting for depth, core size, number of rigs, mud experimentation, wedging, and minimum footage bid (Asarco supervision and overhead not included). From Whaley's calculations, it can be found that Joy drilled at an average rate of 27 ft./calendar day and Longyear averaged 41 ft./calendar day, adjusted for wedging time only. Hunter-Shelton rotary drilled at an average cost of $6.79/ft. and CXM Drilling averaged $11.09/ft. (not adjusted for comparison).

The results of the individual holes are summarized in the following table and Figures 3 through 9. Graphic summary logs of the detailed logging sheets are in Appendix I. Factual and interpretive points of interest for each hole are noted in the following paragraphs.

sections needed

SELECTED COPPER INTERCEPTS
(Geologic Cutoff Grades, Approx. 0.3% Cu)

Hole	From	To	Interval	Copper	Copper Minerals
SC-18	1670'	1790'	120'	0.71%	Chrysocolla
SC-19	1193	1320	127	0.84	Chrysocolla & Atacamite
	1620	1770	150	2.98	Atacamite
SC-23	2430	2650	220	1.27	Chalcocite & Chalcopyrite
SC-24	1180	1280	100	0.51	Chrysocolla
	1550	1660	110	1.10	Chrysocolla & Atacamite
	1740	1820	80	0.73	Chrysocolla
	2220	2420	200	0.58	Chalcocite

) fig 2 shows cc at base ?

Note: SC-13, -14, and -16 of the 1964-1965 drilling program contained significant copper intercepts of questionable grade (rotary cuttings) and some intercepts were not assayed.

Can you [illegible]
contact (á la SC-19 your interp). I personally seriously doubt that you can
read original cpy after 2-3-4 stages of leaching

where did it go? Should it be in SC-24? was it oxidized? maybe at Sacaton?

SC-18: Drill hole SC-18 (Figure 3) went from conglomerate into bedrock across a fault at a depth of 1,560'. This fault is interpreted to have removed about a 900' thickness of capping containing an estimated 100-150' thick blanket of copper oxides averaging 0.5-0.8% total copper. ?

doesn't occur in any other hole

From 1,560 to 1,630' was 70' at 1.81% copper (chrysocolla) hosted in altered volcanic agglomerate. The nature of the host rock and its limited distribution within enrichment blankets suggests that the thickness and definitely the grade should be discounted for projections over 100' distant from SC-18.

how about X section

An anomalous abundance of breccia (mostly in granite) and high former total sulfides yield at depth to typically low grade (0.2% Cu), moderately weakly altered quartz monzonite porphyry (aplitic groundmass). SC-18 penetrated quartz monzonite porphyry with primary sulfides at a depth above copper oxide and chalcocite enrichment blankets that project from SC-19 to SC-14 and are seen in SC-24 as a 50% leached chalcocite blanket.

not as shown on xc[illegible]

SC-19: Drill hole SC-19 intercepted 690 feet-percent copper enrichment in the form of copper oxides and minor chalcocite (Figure 4). The feet percent copper in SC-19 is greater than nearly all the holes at Sacaton, but the economic potential is less because the zones of copper are widely separated by leached capping. The hole bottomed in low grade, weakly altered quartz monzonite porphyry (aplitic groundmass). The suggested interpretation of the former primary grades and the supergene redistribution of copper values are shown in Figure 10. In general copper intercepts in SC-19 correlate nearly horizontally with intercepts in SC-24, SC-18, SC-16, and SC-14.

So what are you saying? Is the center copper [illegible] why primary low why 22-24

also what significance this in [illegible] history

rock types a[illegible] strongly controlled by steeply dipping faults not horizontally (Figure 4)

SC-20: The geology of SC-20 (Figure 5) is divided into two distinct domains that are separated by a fault at 2,150'. Above the fault the former total sulfides averaged about 1% by volume in moderately strongly altered granite and about 5% in strongly altered granite breccia intervals. From about 1,700 to 2,050' was indigenous hematite after chalcocite and pyrite. Below the fault at 2,150' the granite is weakly altered with low (3/4%) former total sulfides. The hole bottomed in leached capping (50 feet of rods lost in hole at a depth of 1,300').

can you tie this in any other [illegible] [illegible] orig cp

SC-21 and SC-21W: The suggested interpretation of the geology of SC-21 and SC-21W (Figure 6) is shown in Figure 11. Remnant enriched sulfides are intermixed with limonites beneath thoroughly leached capping and separated by faulting from the top of the primary sulfides. The hole bottomed in typically low grade copper, weakly altered quartz monzonite porphyry (aplitic groundmass). An apparent increase in molybdenite with depth (see log in Appendix I) is noteworthy and could reflect a change in the geology below the bottom of SC-21.

major movement? [illegible] original copper content [illegible]

Can you do anything with the database — faulting/structure?
Where do these late mineral qu[illegible] dikes(?) appear on your logs, what is significance?

∴ how does this relate ?
SC-19 in terms of orig
orig alt/min zoning
porph copp

SC-22: SC-22 (Figure 7) penetrated only local trace amounts of CuOx and two zones of weak chalcocite enrichment that have experienced about 60% leaching. It appears that the pyrite to copper sulfide ratio, both in the former primary sulfides and in the enrichment zones, remained very high. Reconstruction of the two enrichment horizons prior to leaching at 1,510' to 1,600' and 2,080' to 2,240' suggests 90' at 0.5% and 160' at 0.3% total copper, respectively. The last 80' of SC-22 encountered weakly oxidized, unenriched primary sulfides. No zone of stable enrichment was penetrated by the depth of 2,326', the bottom of the hole.

SC-23: Drill hole SC-23 (Figure 8) has encountered the strongest, most pervasive sericite alteration of all the Santa Cruz drill holes to date (exclusive of strong alteration associated with breccia). Plagioclase and biotite are totally replaced, and K-feldspar is weakly to moderately replaced.

In general there was much more drill core evidence of flat faulting in SC-23 than in any of the holes in the Santa Cruz horst block. The chalcocite enrichment zone in SC-23 was bottomed by a 0-20° dipping fault. Prior to enrichment the last 250' of SC-23 appears to have had a primary grade of 0.5% copper.

not sh
on sect A

SC-24: Drill hole SC-24 (Figure 9) found the conglomerate-bedrock contact 350' lower than projected from SC-22 and SC-19 suggesting a fault between SC-19 and SC-24. As previously discussed, the copper oxide intercepts in SC-24 correlate with intercepts in SC-19, -16, and -18.

how abou
a section

SC-24 encountered a chalcocite enrichment blanket that was 50% leached; from 2,220' to 2,420' was a 200' thickness of 0.58% copper as chalcocite with no copper oxides. The enriched grade prior to leaching is estimated at slightly greater than 1% copper. The top of this blanket correlates with the top of significant chalcocite enrichment in SC-13 which occurred at a depth of 2,250' (SC-13 bottomed at 2,286').

SC-24 bottomed in moderately altered granite with weakly oxidized pyrite and chalcopyrite.

SANTA CRUZ SULFIDE SYSTEM

The Santa Cruz copper deposit is a horst block of part of a large buried sulfide system. The extent of the system is only partially defined with the Santa Cruz horst on the west, SC-2 just to the north, and the Sacaton barren basement complex on the east.

Geologic studies to date suggest a low total sulfide system (2-3% average by volume) hosted by Precambrian granite with small Laramide quartz monzonite porphyry intrusives. The stronger primary copper mineralization appears to have been distributed within 2,000' of a large quartz monzonite porphyry have cored sulfides

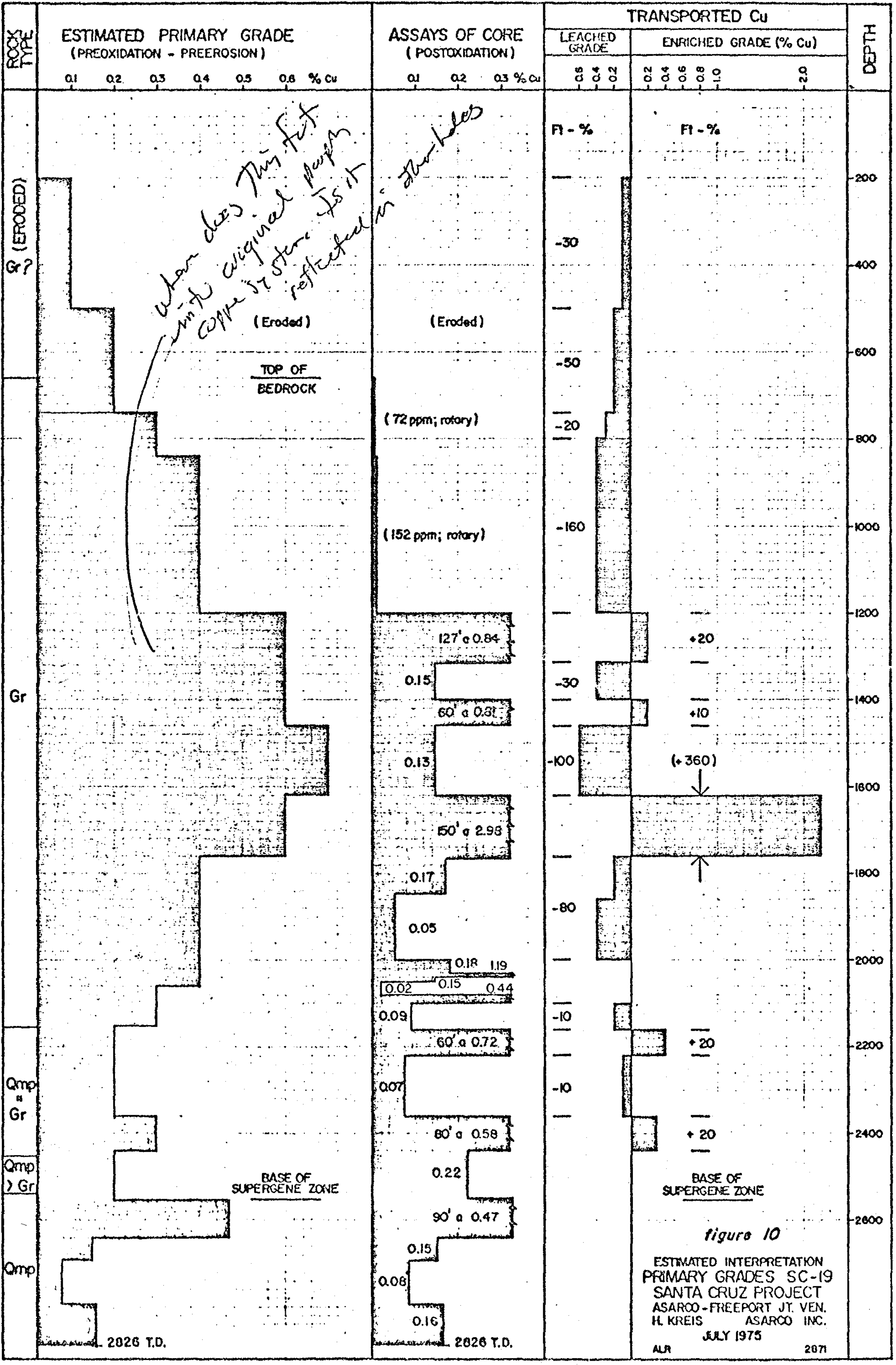
mass. In the portions of the sulfide system explored to date, the highest primary grades are estimated to have been about 0.5-0.6% copper. Figure 12 shows the interpreted vertical and horizontal zoning of alteration and primary mineralization as related to the apparent? quartz monzonite intrusive at depth.

The net programme
read that type
would still
some X-

Multiple cyclic enrichment has produced and destroyed chalcocite enrichment blankets. In SC-23 and at Sacaton these enrichment blankets remain. Chalcocite blankets in the Santa Cruz horst block, however, contained a high chalcocite to pyrite ratio and were oxidized without significant leaching to form copper oxide deposits. The enrichment blankets have been offset by horst-graben faulting. More recent low angle (flat) faulting is seen in SC-23 and at Sacaton.

? TH

The factual and interpretive geology of the Santa Cruz sulfide system is detailed in outline form in Appendix II. Figure 13 depicts a simplified interpretive version of the copper enrichment history of the Santa Cruz horst block.



where does this fit with original porph copper system? Is it reflected in other holes

figure 10

ESTIMATED INTERPRETATION
PRIMARY GRADES SC-19
SANTA CRUZ PROJECT
ASARCO-FREEPORT JT. VEN.
H. KREIS ASARCO INC.
JULY 1975
ALR 2871

ASARCO Incorporated
Tucson Arizona

September 16, 1975

TO: R.B. Cummings

FROM: W.L. Kurtz

On September 10th I discussed with you the desirability of your participating with Messrs. Sell and Kreis in a short intensive study of the Santa Cruz-Sacaton mineralization and structural problem.

Monday, September 22nd would be a convenient starting date and I would contemplate 10 working days for the study. Oh boy! *

If additional time is necessary, I would anticipate your helping on a consulting type basis -- an hour or two now and then.

W.L. Kurtz

WLK:vh

cc: R.B. Meen
T. Edwards
J.D. Sell ☜

*JDS version out May 12, 1976
As of 9/15/76 neither HGK nor RBC
had submitted theirs.
" as of 11/5/76

Cpy for J.D.S.

HGK comment

No list of comment copy available.

Summary

Interpretation of the relogging of the core and rotary samples during the Santa Cruz Studies by Kreis, Cummings, and Sell has suggested that in the horst block area the quartz monzonite porphyry intrusive was emplaced along an older structural zone.

The zone, here named the SC zone, is characterized by the abundance of thin diabase dikes cutting slices of Precambrian granite with thin breccia zones and faulting apparent as subparallel planar structures. The SC zone ①
presently strikes in a general N60°E direction and dips around 40° northwesterly. It is expressed between hole SC-18 on the northeast to SC-20 on the No ②
southwest, a distance of over 4000 feet. It is probably offset 2000 ft. to the south between holes SC-20 and SC-12 by the Westside fault which strikes ?③
N30°-35°W and dips 45° southwesterly. The SC zone is suggested to pass through hole SC-4 and extend~~ing~~ further to the southwest. ④

In Laramide time the SC zone was the site of renewed movement along the faults. Dikes of various porphyry rocks and thicker masses of quartz monzonite porphyry, as well as breccia masses, were emplaced along the zone and principally in the hanging wall of the Precambrian SC zone. The dikes and masses are again mainly subparallel to the planar fabric established during the ⑤
Precambrian events. In the footwall of the SC zone, Precambrian granite is found high and to the west where it is quite massive, although cut by a few diabase dikes which generally have intrusive contacts. Easterly and at depth in the footwall of the SC zone is the Laramide quartz monzonite porphyry. The porphyry was in part guided into its emplacement by the SC zone and, ⑥
although crushed and faulted at the boundary, is most often a massive unit below the SC zone.

The SC zone, on its northwesterly or hanging wall side, is the site for extensive faulting, brecciation, and fluidization of various Precambrian granite and Laramide quartz feldspar porphyry, hornblende porphyry, and various quartz monzonite porphyry units which generally show a preference for steeper contacts. The fluidized zones generally do not mix rock types and exhibit ⑦ all degrees of fluidization and brecciation within the units. Diabase, in general, was not found with a fluidized texture, although in SC-22 a mixed zone of quartz monzonite porphyry and granite had a minor amount of "dark volcanic" and recognizable diabase inclusions.

The zone of massive fluidization and brecciation is noted in holes SC-14, 18, 19, 22, and 24. Outside the zone are numerous zones of narrow fluidization and "internally disintegrated" rock. These narrow zones are found both in the hanging wall granite and in the footwall granite and quartz monzonite porphyry.

The Santa Cruz horst is bounded on the east by the Eastside fault. This structure strikes N20°-25°W and dips 45° northeasterly. Little data is available east of the fault, but it appears to offset the SC zone and the extensive fluidized zone to the north for an unknown distance. As noted, the fluidized and brecciated zone, as exemplified in SC-18 and interpreted for SC-14, is cut by the Eastside fault. The northward offset may amount to around 2000-2500 feet, with the SC zone going to the northeast between holes SC-21 and SC-23.

Coincident with the extensive fluidized and brecciated zone is the occurrence of higher values of molybdenum contouring outward from hole SC-24 ⑧ and a higher center of primary copper grades contouring outward from holes SC-18 and SC-24. Undoubtedly the original grade within this zone was responsible for the better development of a chalcocite blanket, which was subsequently modified and converted into the "copper oxide" blankets as presently known.

In the Santa Cruz horst area the massive quartz monzonite porphyry is known to extend up to an elevation of minus 420 feet below sea level on the footwall side of the SC zone. On the hanging wall side, dike-type units of similar quartz monzonite porphyry were first encountered at an elevation of minus 870 feet below sea level. Precambrian granite is known to extend to a depth of minus 1169 feet below sea level on the hanging wall side.

The various dikes and masses of hornblende porphyry, hornblende feldspar porphyry, quartz feldspar porphyry, grey quartz monzonite porphyry, black quartz monzonite porphyry, and various textures of quartz monzonite porphyry found in the hanging wall of the SC zone probably reflect a monzonitic source area at depth. The occurrence of massive quartz monzonite porphyry at a higher level in the footwall of the SC zone is probably the result of a) a higher level of intrusion of the monzonite mass along the weak zone exemplified by the diabase and faulting in the Precambrian granite, and b) some faulting along the contact which downdropped the hanging wall units both before and after the influx of the Laramide fluidization and brecciation event.

The area of fluidization, brecciation, and mineralization around holes SC-18 and SC-24 is regarded as a center of activity. A second center of mineralization is suggested in the vicinity of hole SC-4 where fluidization, better alteration, and higher molybdenum values are noted. Hole SC-23 to the northeast is regarded as a third area of contrasting alteration-mineralization-tectonic style. (9)

Introduction

The location-plan map of the Santa Cruz project is shown in Figure 1 (MVK-2878) (same as HGK Fig. 1). In September of last year, a relogging-reevaluation of the project drill results was initiated by Kreis, Cummings, and Sell. The main emphasis of study was the Santa Cruz horst block, the area of major drilling and significant results, centered around drill holes SC-22, -19, and -24.

Faulting

Logging and constraints have suggested a number of fault structures in the horst block area (Figure 2). Basically interpreted is an older Precambrian fault trend, here named the SC zone, which strikes N60°E and dips 40° northwesterly. The SC zone horst block is cut, downdropped, and laterally translated by three major structures: 1) the westside fault, which strikes N30°-35°W and dips 45° southwesterly and offsets the SC zone some 2000 feet to the south; 2) the eastside fault, which strikes N30°-25°W and dips 45° northeasterly, offsets the SC zone to the north an unknown distance, but probably between 2000 and 2500 feet; and 3) the southside fault, which is interpreted to cut the westside and eastside structures, strikes N55°-60°E and dips steeply to the southeast. The southside fault may be a series of structures which cumulatively downdrop the south side of the horst block in excess of three thousand feet. A fourth fault structure was cut in hole SC-21 and is interpreted to terminate at the eastside fault while striking N60°E and dipping 50° southeasterly.

Present drill hole data and three point resolutions do not permit the precise determination of the fault directions and dips. It is known that variations exist and the above figures reflect the general trends of the structures.

SC Zone

The SC zone is a totally complex structural-intrusive zone extending from Precambrian thru post-Laramide time.

During Precambrian time, large masses of granite were emplaced in central Arizona in contact with Pinal Schist. The Santa Cruz area appears to be within the granitic mass and the earliest SC zone was characterized by shearing and breakage along the N60°E trend. Part of the zone of weakness was utilized by the emplacement of thin, planar, intrusive diabase dikes having chilled borders.

Figures 3 and 4 are plan maps of the minus 500-foot elevation below sea level and minus 1000-foot elevation below sea level, respectively, in the area of study. As noted, in the northwest side of the SC structure, thin diabase dikes were encountered in nearly each hole in the area. A profusion of slips, faults, and crushed zones is also apparent which appears to belong to the Precambrian fracture system and ~~again~~ again mainly in the northwest or hanging wall of the SC structure. In the southeast or footwall of the SC structure, the Precambrian granite is essentially a massive, unbroken unit with two discrete diabase dike intercepts in hole SC-24. It is realized that the sparsity of drill intercepts into the footwall area of the SC zone does not permit a clarified picture, but there seems little doubt that the hanging wall side of the SC structure as now known was the site of multiple diabase dikes and much more abundant fracturing and faulting.

In Laramide time a mass of quartz monzonite porphyry was emplaced, and it appears to be guided by part of the older SC zone. As presently known in the southeast or footwall side, massive quartz monzonite porphyry was intruded to a fairly high level in the vicinity of holes SC-14, -16, and -18, and several discrete black qmp and black feldspar porphyry dikes were emplaced in the Precambrian granite further west. In the hanging wall side of the SC structure, numerous thin zones of quartz monzonite porphyry with a number of textural variations were emplaced in the sheared granitic terrain. Also in the hanging wall side, extensive brecciation and fluidization of Precambrian granite and Laramide quartz monzonite porphyry were involved. The fluidization exhibits all degrees of intensities and involvement, but in general is restricted to single units and, although granite and qmp may alternate in relatively thin apparently planar slices and each is fluidized, the fluidization generally did not mix rock types. Although the diabase is assigned to the Precambrian and the fluidization as a Laramide event, diabase was rarely found to exhibit fluidization features except very locally along contacts. Post-fluidization fracturing and faulting are common features and occur within the expanded fluidized SC zone. Apparently late hornblende porphyry, quartz feldspar porphyry, and various darker quartz monzonite porphyries were emplaced late in the fluidization sequence. Much of the fluidized and late diking appear to favor steeper structural zones than the diabase and more planar qmp zones.

In the footwall side of the SC structure, rare fluidization was noted. A fluidized qmp dike was noted in drill hole SC-4 while a small fluidized structure of Precambrian granite was found in hole SC-24.

To recap, a cross section of the SC zone has been constructed through drill holes SC-22, -19, and -24. Figure 5 shows the SC structure as a fault (colored blue) with massive granite and qmp below on the footwall side. Minor crushing and shearing with gouge development are also noted along the fault structure and somewhat below. Several gently dipping diabase dikes and one steeper fluidized granite structure are also shown in the footwall block. This massive characteristic is sharply changed across the fault structure and in the hanging wall side a complex intrusive sequence of granite, diabase, and various porphyries, all highly fractured, brecciated, and fluidized to various degrees and involvement, is found to extend some distance away from the fault at the base of the sequence. In the upper part of drill hole SC-19 and the bottom of hole SC-22 are found "internally crushed" granite masses cut by diabase and qmp dikes dipping at moderate angles. In hole SC-22, the majority of the hole contains highly brecciated and fluidized units of granite and various porphyries. The top of the brecciated and fluidized group is marked by a strong fault containing gouge and breccia, and above the fault is massive, weakly shattered granite. The entire zone of brecciated and fluidized units is called the SC zone.

Figure 6 separates the non-brecciated, brecciated, and fluidized granite and porphyries. Drill hole SC-22 was terminated between the two intrusive complex groups, and no data is available in other holes to confirm the depth configuration of the intrusive complex.

Mineralization

Mineralization within the Santa Cruz system as presently known can be divided into four groups: 1) primary sulfides of pyrite and chalcopyrite; 2) a chalcocite zone, often partially leached; 3) a first remnant chalcocite with pyrite zone, often highly leached; and 4) the "oxide copper" zone of chrysocolla, brochantite, and atacamite.

Figure 7 is the cross-section of holes SC-22, -19, and -24 with the above four zones as intercepted. Hole SC-22 did not intercept any oxide copper but found a remnant leached chalcocite-pyrite zone and, further in depth, a leached chalcocite zone before terminating in partially leached primary pyrite-chalcopyrite. Hole SC-19 intercepted three distinct oxide copper zones, then a highly leached zone with sparse remnant chalcocite containing an oxide copper band at its base, then a leached chalcocite zone terminating at a fault (the SC fault) where unleached pyrite-chalcopyrite was encountered to the terminated depth. Hole SC-24 also intercepted three oxide copper zones, then penetrated the SC fault, after which the hole went into highly leached remnant chalcocite-pyrite, followed by a distinct chalcocite zone which bottomed in partially leached and chalcocite-enriched primary values, and terminated in primary pyrite-chalcopyrite values.

Interpretation of this information would suggest a moderate dip to the top of the primary pyrite-chalcopyrite values, which are interpreted to be subparallel to the top of the chalcocite zone drawn between holes SC-22 and -19. Likewise, the line connecting the top of the first remnant chalcocite-pyrite zone is compatible to the lower two surfaces. In Figure 7, the dip assigned to hole SC-24 is determined by association and other control described below.

The oxide copper zones roughly fall at the same elevation but, as shown in Figure 7, appear to be somewhat irregular and are assigned a flattish dip and probably reflect redistribution to the present bedrock surface.

Figure 8 is a plan map showing interpreted structural contours on the top of the oxide copper zone as penetrated in the drilling. As contoured, the top of the zone is a rather sharp ridge which slopes away in three directions, and which appears to reflect the rock surface contours. A further modification is along the Eastside fault where volcanics and granite appear to be along the fault surface and have acted as a trap or sponge for the oxide copper values. (10)

The top of the first remnant chalcocite with pyrite can also be contoured and is shown on Figure 9. The contouring is separated into sectors based on the faulting and offsets, as well as hanging and footwall sectors of the SC zone. In the main area of the hanging wall sector, four control points are available and contouring suggests a slight bowing of the surface subparallel to the SC fault trace and dipping around 20° to the southeast. In the footwall of the SC fault two points are available, but hole SC-24 is in fault contact with the first remnant chalcocite-pyrite zone and hence the true thickness is unknown. The contours are drawn in the footwall based on the 250-foot thickness in hole SC-13. However, as suggested in the hanging wall block, the thickness increases from west to east across the block, and if this is true in the footwall block then any increase in thickness would move the contours to the south, as shown by the plus (+) marks, and the final configuration would be subparallel on both sides of the SC fault. Note that there is over 100 feet of displacement across the fault, with the hanging wall down in relation to the footwall. This is also reflected in the cross-section of Figure 7.

Only one point is available in the block containing hole SC-4, but does exhibit the lateral offset of contours from the adjacent blocks.

The top of the chalcocite zone contours is shown in Figure 10. On the hanging wall side of the SC fault, three points afford some control and reflect a 25° southeast dipping surface subparallel to the SC fault. On the footwall side, only one clear data point is available, with constraints placed by the use of three additional points. The construction suggests the same subparallel strike direction, but the surface probably dips much shallower at around 10° to the southeast. TFPy w/FeOx Pyrite was noted in the quartz monzonite porphyry at the bottom of hole SC-16. The depth does not conform to the contouring and is presently anomalous. The pyrite could reflect a part of the remnant chalcocite-pyrite zone but would again be at an elevation higher than the contourable data, or more probably it reflects a non-leached and non-enriched area. Possibly other complicating fault structures are present and they would clarify the data.

(11)

Again, hole SC-4 is a single control point but emphasizes the offset feature.

little difference between SC-13 & SC-4 (160'!)

Figure 11 lists the elevation of the primary sulfides with comments in each hole of the Santa Cruz study area. As the various structures offset the top of the surface and few holes have contacts represented by the base of the chalcocite zone for reference, the data is not contoured. It should be noted, however, that holes SC-14, -18, and -19 all encountered unleached sulfides immediately below the SC fault. Also, hole SC-15 encountered primary sulfide at and in the basal structures of the Eastside fault (dipping easterly), while hole SC-21 entered primary sulfides below an interpreted south dipping fault.

Centers of Intrusive Activity and Mineralization

As exemplified on the plan maps of Figures 3 and 4, and the cross-section of Figures 5 and 6, the area containing holes SC-14, -18, -19, -22, and -24 is one of extensive brecciation and fluidization of Precambrian and Laramide units. Eastward the intrusive complex zone is cut and displaced by the Eastside fault, to the south it terminates against the SC fault, westward it apparently becomes narrower and less complicated, while to the north it terminates in a high angled fault zone against Precambrian granite. A center for the extensive fluidization would appear to be around the hole SC-14, -18, and -19 area and ~~being~~ displaced on the east side.

A massive qmp-granite contact occurs on the footwall side of the SC fault and had little fluidization and brecciation associated with the contact.

Scattered molybdenum values have been obtained from both the rotary and core drilling. Figure 12 plots the moly values in units above the SC fault. A partial closure, with a high of plus 150 ppm, can be drawn in the vicinity of holes SC-18, -19, -22, and -24, the same area as the extensive brecciation and fluidization features. Another tighter closure of plus 100 ppm is suggested for the hole SC-4 area. A possible easterly axis is suggested for the larger closure.

In the footwall of the SC fault, Figure 13, a closure is suggestive in the holes SC-18 and -24 area with less than 100 ppm. Very low values are recorded in hole SC-4 area. Across the Eastside fault in hole SC-21, the progressive increase in moly values at depth suggests either a new center or an offset continuation of the holes SC-18 and -24 closure. A more northeasterly axial trend is suggested subparallel to the SC structural zone.

Also shown on Figure 13 ~~is~~ are the copper values found in the primary zone intercepted in the drill holes. ~~This~~ These data, mainly in the footwall block of the SC fault, indicate~~s~~ the highest copper values are in the general high moly area.

Another type of mineral center is suggested in the overall distribution of the copper oxides. Figure 8 shows that hole SC-20 and -24 have chrysocolla as the oxide mineral, whereas hole SC-18 has predominatly chrysocolla with brochantite, while SC-19 has chrysocolla with antlerite? Further outside this grouping of holes, on the east SC-14 and -16 show brochantite greater than antlerite, while to the southwest SC-13 shows antlerite predominantly over brochantite and chrysocolla.

Chrysocolla is also the mineral type in the area of SC-4.

The high copper oxide values (plus 1%) in holes SC-16 and -18 occur in volcanic agglomerate mixed with granite breccia. A volcanic agglomerate dike is noted lower in hole SC-18 and was highly altered and also contained plus 1% copper oxide values. Similar volcanic agglomerate and granite breccia were apparently intercepted in the rotary hole SC-15, and there the copper values were predominantly chalcocite.

The role of the highly altered volcanic agglomerate as a site mineralization is open to question, but one thought is that the volcanic agglomerate was essentially emplaced along the Eastside fault line and available to the early enrichment cycle of migrated chalcocite. The chalcocite was later downdropped to the present level on the east, and the chalcocite on the upthrown side was subsequently oxidized in place to form the oxide values as now known.

Exploration Targets

The excellent alteration, leached capping, and chalcocite zone found in hole SC-23, a mile and one quarter northeast of hole SC-14, is a distinct and 7 No
separate entity from the Santa Cruz horst area. The flat fault complications cannot be resolved with the single data point, and the thin interval of chalcopyrite intercepted just prior to the termination of the hole is a tantalizing feature. Additional drilling in this area should have the greatest priority.

The concept of a Precambrian zone of weakness, which was the loci of an extensive zone of brecciation and fluidization as well as the major zone of mineralization in the Laramide, can be used as a guide. As developed, a substantial portion of the zone is probably offset along the Eastside fault and is projected to pass north of hole SC-21 and south of hole SC-23. A hole or holes located north of SC-21 would probe for this zone in Target Area A.

The chalcocite in the Eastside fault zone volcanic agglomerate-granite breccia of hole SC-15 and the southside downdropping of the block south of SC-21 suggest that a relatively thick chalcocite enriched area may be preserved east and south of the two holes and between the extension of the Southside fault, as in Target Area B. ⑫

The preservation of chalcocite in the footwall of the SC zone in the area of hole SC-24 suggests a relatively thin and probably local amount of chalcocite would be preserved in a zone subparallel to the SC zone on the footwall side in Target Area C. ⑬

On the hanging wall side, a substantial zone of oxide copper is probably preserved between hole SC-19 and the Eastside fault. The southern extent of the oxide zone is questionable south of holes SC-24 and SC-18 toward hole SC-16. A hole placed in the triangle out of the reach of either the Eastside or Southside faults would clarify the picture in Target Area D.

A deep primary zone is suggested to underlie the intensive fluidized zone exemplified in holes SC-18 and -24. Fluid inclusions suggest these two holes have excellent characteristics for containing ore grade copper as chalcopyrite near the boiling interface. Reviewing Figures 5 and 6, it is probable that the loci of the fluidized central vent undoubtedly lies below the SC fault as shown, and at some point rupture~~s~~d the zone and then partially used the zone as a structural control to expand upward as the drilling has shown. The constraint placed by hole SC-14, which penetrated the SC fault and into massive qmp, suggests the test hole should be placed north of a line connecting holes SC-14 and SC-22 and possibly as much as 500 feet north in Target Area E. Valuable information on this problem would have been gained by deepening hole SC-22 into and through the lower intrusive complex. (14)

The Southside fault and its probably continued step-down system appears to be a strong basin controlling system. Present thought is that it is deep (plus 2500 to 3000 feet) to the bedrock units at a short distance south of hole SC-16. The rock type is unknown, but it is likely Precambrian granite near the south contact of the main mass of qmp. As more information is gleaned as to the characteristic of the northern contact, it may be justified in probing for and along the south contact.

Draft: JDSell - 3/8/78

comments to
for RB Cummings
review - critic
mark as you see fit & return.
Will send completed copy to you in future.

Summary

Interpretation of the relogging of the core and rotary samples during the Santa Cruz Studies by Kreis, Cummings, and Sell has suggested that in the horst block area the quartz monzonite porphyry intrusive was emplaced along an older structural zone.

The zone, here named the SC zone, is characterized by the abundance of thin diabase dikes cutting slices of Precambrian granite with thin breccia zones and faulting apparent as subparallel planar structures. The SC zone presently strikes in a general N60°E direction and dips around 40° northwesterly. It is expressed between hole SC-18 on the northeast to SC-20 on the southwest, a distance of over 4000 feet. It is probably offset 2000 ft. to the south between holes SC-20 and SC-12 by the Westside fault which strikes N30°-35°W and dips 45° southwesterly. The SC zone is suggested to pass through hole SC-4 and extend~~ing~~ further to the southwest.

Note: At Sac dh (main mass at depth on N side) dips 30° West

Could 40° dip be due to tilting?

Tilted?

In Laramide time the SC zone was the site of renewed movement along the faults. Dikes of various porphyry rocks and thicker masses of quartz monzonite porphyry, as well as breccia masses, were emplaced along the zone and principally in the hanging wall of the Precambrian SC zone. The dikes and masses are again mainly subparallel to the planar fabric established during the Precambrian events. In the footwall of the SC zone, Precambrian granite is found high and to the west where it is quite massive, although cut by a few diabase dikes which generally have intrusive contacts. Easterly and at depth in the footwall of the SC zone is the Laramide quartz monzonite porphyry. The porphyry was in part guided into its emplacement by the SC zone and, although crushed and faulted at the boundary, is most often a massive unit below the SC zone.

The SC zone, on its northwesterly or hanging wall side, is the site for extensive faulting, brecciation, and fluidization of various Precambrian granite and Laramide quartz feldspar porphyry, hornblende porphyry, and various quartz monzonite porphyry units which generally show a preference for steeper contacts. The fluidized zones generally do not mix rock types and exhibit all degrees of fluidization and brecciation within the units. Diabase, in general, was not (→ True @ -Sac also) found with a fluidized texture, although in SC-22 a mixed zone of quartz monzonite porphyry and granite had a minor amount of "dark volcanic" and recognizable diabase inclusions.

The zone of massive fluidization and brecciation is noted in holes SC-14, 18, 19, 22, and 24. Outside the zone are numerous zones of narrow fluidization and "internally disintegrated" rock. These narrow zones are found both in the hanging wall granite and in the footwall granite and quartz monzonite porphyry.

The Santa Cruz horst is bounded on the east by the Eastside fault. This structure strikes N20°-25°W and dips 45° northeasterly. Little data is available east of the fault, but it appears to offset the SC zone and the extensive fluidized zone to the north for an unknown distance. As noted, the fluidized and brecciated zone, as exemplified in SC-18 and interpreted for SC-14, is cut by the Eastside fault. The northward offset may amount to around 2000-2500 feet, with the SC zone trending going to the northeast between holes SC-21 and SC-23. But No Fluid in 21+23 ? NW ?

Coincident with the extensive fluidized and brecciated zone is the occurrence of higher values of molybdenum contouring outward from hole SC-24 and a higher center of primary copper grades contouring outward from holes SC-18 and SC-24. Undoubtedly the original grade within this zone was responsible for the better development of a chalcocite blanket, which was subsequently modified and converted into the "copper oxide" blankets as presently known.

In the Santa Cruz horst area the massive quartz monzonite porphyry is known to extend up to an elevation of minus 420 feet below sea level on the footwall side of the SC zone. On the hanging wall side, dike-type units of similar quartz monzonite porphyry were first encountered at an elevation of minus 870 feet below sea level. Precambrian granite is known to extend to a depth of minus 1169 feet below sea level on the hanging wall side.

The various dikes and masses of hornblende porphyry, hornblende feldspar porphyry, quartz feldspar porphyry, grey quartz monzonite porphyry, black quartz monzonite porphyry, and various textures of quartz monzonite porphyry found in the hanging wall of the SC zone probably reflect a monzonitic source area at depth. The occurrence of massive quartz monzonite porphyry at a higher level in the footwall of the SC zone is probably the result of a) a higher level of intrusion of the monzonite mass along the weak zone exemplified by the diabase and faulting in the Precambrian granite, and b) some faulting along the contact which downdropped the hanging wall units both before and after the influx of the Laramide fluidization and brecciation event.

The area of fluidization, brecciation, and mineralization around holes SC-18 and SC-24 is regarded as a center of activity. A second center of mineralization is suggested in the vicinity of hole SC-4 where fluidization, better alteration, and higher molybdenum values are noted. Hole SC-23 to the northeast is regarded as a third area of contrasting alteration-mineralization-tectonic style.

Introduction

The location-plan map of the Santa Cruz project is shown in Figure 1 (MVK-2878) (same as HGK Fig. 1). In September of last year, a relogging-reevaluation of the project drill results was initiated by Kreis, Cummings, and Sell. The main emphasis of study was the Santa Cruz horst block, the area of major drilling and significant results, centered around drill holes SC-22, -19, and -24.

Faulting

Logging and constraints have suggested a number of fault structures in the horst block area (Figure 2). Basically interpreted is an older Precambrian fault trend, here named the SC zone, which strikes N60°E and dips 40° northwesterly. The SC zone horst block is cut, downdropped, and laterally translated by three major structures: 1) the westside fault, which strikes N30°-35°W and dips 45° southwesterly and offsets the SC zone some 2000 feet to the south; 2) the eastside fault, which strikes N30°-25°W and dips 45° northeasterly, offsets the SC zone to the north an unknown distance, but probably between 2000 and 2500 feet; and 3) the southside fault, which is interpreted to cut the westside and eastside structures, strikes N55°-60°E and dips steeply to the southeast. The southside fault may be a series of structures which cumulatively downdrop the south side of the horst block in excess of three thousand feet. A fourth fault structure was cut in hole SC-21 and is interpreted to terminate at the eastside fault while striking N60°E and dipping 50° southeasterly.

All strike
slip??
L. Lat

Present drill hole data and three point resolutions do not permit the precise determination of the fault directions and dips. It is known that variations exist and the above figures reflect the general trends of the structures.

SC Zone

The SC zone is a totally complex structural-intrusive zone extending from Precambrian thru post-Laramide time.

During Precambrian time, large masses of granite were emplaced in central Arizona in contact with Pinal Schist. The Santa Cruz area appears to be within the granitic mass and the earliest SC zone was characterized by shearing and breakage along the N60°E trend. Part of the zone of weakness was utilized by the emplacement of thin, planar, intrusive diabase dikes having chilled borders.

What evidence for this other than db dikes

Figures 3 and 4 are plan maps of the minus 500-foot elevation below sea level and minus 1000-foot elevation below sea level, respectively, in the area of study. As noted, in the northwest side of the SC structure, thin diabase dikes were encountered in nearly each hole in the area. A profusion of slips, faults, and crushed zones is also apparent which appears to belong to the Precambrian fracture system and ~~again~~ again mainly in the northwest or hanging wall of the SC structure. In the southeast or footwall of the SC structure, the Precambrian granite is essentially a massive, unbroken unit with two discrete diabase dike intercepts in hole SC-24. It is realized that the sparsity of drill intercepts into the footwall area of the SC zone does not permit a clarified picture, but there seems little doubt that the hanging wall side of the SC structure as now known was the site of multiple diabase dikes and much more abundant fracturing and faulting.

In Laramide time a mass of quartz monzonite porphyry was emplaced, and it appears to be guided by part of the older SC zone. As presently known in the southeast or footwall side, massive quartz monzonite porphyry was intruded to a fairly high level in the vicinity of holes SC-14, -16, and -18, and several discrete black qmp and black feldspar porphyry dikes were emplaced in the Precambrian granite further west. In the hanging wall side of the SC structure, numerous thin zones of quartz monzonite porphyry with a number of textural variations were emplaced in the sheared granitic terrain. Also in the hanging wall side, extensive brecciation and fluidization of Precambrian granite and Laramide quartz monzonite porphyry were involved. The fluidization exhibits all degrees of intensities and involvement, but in general is restricted to single units and, although granite and qmp may alternate in relatively thin apparently planar slices and each is fluidized, the fluidization generally did not mix rock types. Although the diabase is assigned to the Precambrian and the fluidization as a Laramide event, diabase was rarely found to exhibit fluidization features except very locally along contacts. Post-fluidization fracturing and faulting are common features and occur within the expanded fluidized SC zone. True at SAC also Apparently late hornblende porphyry, quartz feldspar porphyry, and various darker quartz monzonite porphyries were emplaced late in the fluidization sequence. Much of the fluidized and late diking appear to favor steeper structural zones Not True at SAC than the diabase and more planar qmp zones.

In the footwall side of the SC structure, rare fluidization was noted. A fluidized qmp dike was noted in drill hole SC-4 while a small fluidized structure of Precambrian granite was found in hole SC-24.

To recap, a cross section of the SC zone has been constructed through drill holes SC-22, -19, and -24. Figure 5 shows the SC structure as a fault (colored blue) with massive granite and qmp below on the footwall side. Minor crushing and shearing with gouge development are also noted along the fault structure and somewhat below. Several gently dipping diabase dikes move up front and one steeper fluidized granite structure are also shown in the footwall block. This massive characteristic is sharply changed across the fault structure and in the hanging wall side a complex intrusive sequence of granite, diabase, and various porphyries, all highly fractured, brecciated, and fluidized to various degrees and involvement, is found to extend some distance away from the fault at the base of the sequence. In the upper part of drill hole SC-19 and the bottom of hole SC-22 are found "internally crushed" granite masses cut by diabase and qmp dikes dipping at moderate angles. In hole SC-22, the majority of the hole contains highly brecciated and fluidized units of granite and various porphyries. The top of the brecciated and fluidized group is marked by a strong fault containing gouge and breccia, and above the fault is massive, weakly shattered granite. The entire zone of brecciated and fluidized units is called the SC zone.

Figure 6 separates the non-brecciated, brecciated, and fluidized granite and porphyries. Drill hole SC-22 was terminated between the two intrusive complex groups, and no data is available in other holes to confirm the depth configuration of the intrusive complex.

Mineralization

Mineralization within the Santa Cruz system as presently known can be divided into four groups: 1) primary sulfides of pyrite and chalcopyrite; 2) a chalcocite zone, often partially leached; 3) a first remnant chalcocite with pyrite zone, often highly leached; and 4) the "oxide copper" zone of chrysocolla, brochantite, and atacamite.

Figure 7 is the cross-section of holes SC-22, -19, and -24 with the above four zones as intercepted. Hole SC-22 did not intercept any oxide copper but found a remnant leached chalcocite-pyrite zone and, further in depth, a leached chalcocite zone before terminating in partially leached primary pyrite-chalcopyrite. Hole SC-19 intercepted three distinct oxide copper zones, then a highly leached zone with sparse remnant chalcocite containing an oxide copper band at its base, then a leached chalcocite zone terminating at a fault (the SC fault) where unleached pyrite-chalcopyrite was encountered to the terminated depth. Hole SC-24 also intercepted three oxide copper zones, then penetrated the SC fault, after which the hole went into highly leached remnant chalcocite-pyrite, followed by a distinct chalcocite zone which bottomed in partially leached and chalcocite-enriched primary values, and terminated in primary pyrite-chalcopyrite values.

Interpretation of this information would suggest a moderate dip to the top of the primary pyrite-chalcopyrite values, which are interpreted to be subparallel to the top of the chalcocite zone drawn between holes SC-22 and -19. Likewise, the line connecting the top of the first remnant chalcocite-pyrite zone is compatible to the lower two surfaces. In Figure 7, the dip assigned to hole SC-24 is determined by association and other control described below.

The oxide copper zones roughly fall at the same elevation but, as shown in Figure 7, appear to be somewhat irregular and are assigned a flattish dip and probably reflect redistribution to the present bedrock surface.

Figure 8 is a plan map showing interpreted structural contours on the top of the oxide copper zone as penetrated in the drilling. As contoured, the top of the zone is a rather sharp ridge which slopes away in three directions, and which appears to reflect the rock surface contours. A further modification is along the Eastside fault where volcanics and granite appear to be along the fault surface and have acted as a trap or sponge for the oxide copper values.

The top of the first remnant chalcocite with pyrite can also be contoured and is shown on Figure 9. The contouring is separated into sectors based on the faulting and offsets, as well as hanging and footwall sectors of the SC zone. In the main area of the hanging wall sector, four control points are available and contouring suggests a slight bowing of the surface subparallel to the SC fault trace and dipping around 20° to the southeast. In the footwall of the SC fault two points are available, but hole SC-24 is in fault contact with the first remnant chalcocite-pyrite zone and hence the true thickness is unknown. The contours are drawn in the footwall based on the 250-foot thickness in hole SC-13. However, as suggested in the hanging wall block, the thickness increases from west to east across the block, and if this is true in the footwall block then any increase in thickness would move the contours to the south, as shown by the plus (+) marks, and the final configuration would be subparallel on both sides of the SC fault. Note that there is over 100 feet of displacement across the fault, with the hanging wall down in relation to the footwall. This is also reflected in the cross-section of Figure 7.

Only one point is available in the block containing hole SC-4, but does exhibit the lateral offset of contours from the adjacent blocks.

The top of the chalcocite zone contours is shown in Figure 10. On the hanging wall side of the SC fault, three points afford some control and reflect a 25° southeast dipping surface subparallel to the SC fault. On the footwall side, only one clear data point is available, with constraints placed by the use of three additional points. The construction suggests the same subparallel strike direction, but the surface probably dips much shallower at around 10° to the southeast. Pyrite was noted in the quartz monzonite porphyry at the bottom of hole SC-16. The depth does not conform to the contouring and is presently anomalous. The pyrite could reflect a part of the remnant chalcocite-pyrite zone but would again be at an elevation higher than the contourable data, or more probably it reflects a non-leached and non-enriched area. Possibly other complicating fault structures are present and they would clarify the data.

Again, hole SC-4 is a single control point but emphasizes the offset feature.

Figure 11 lists the elevation of the primary sulfides with comments in each hole of the Santa Cruz study area. As the various structures offset the top of the surface and few holes have contacts represented by the base of the chalcocite zone for reference, the data is not contoured. It should be noted, however, that holes SC-14, -18, and -19 all encountered unleached sulfides immediately below the SC fault. Also, hole SC-15 encountered primary sulfide at and in the basal structures of the Eastside fault (dipping easterly), while hole SC-21 entered primary sulfides below an interpreted south dipping fault.

Centers of Intrusive Activity and Mineralization

As exemplified on the plan maps of Figures 3 and 4, and the cross-section of Figures 5 and 6, the area containing holes SC-14, -18, -19, -22, and -24 is one of extensive brecciation and fluidization of Precambrian and Laramide units. Eastward the intrusive complex zone is cut and displaced by the Eastside fault, to the south it terminates against the SC fault, westward it apparently becomes narrower and less complicated, while to the north it terminates in a high angled fault zone against Precambrian granite. A center for the extensive fluidization would appear to be around the hole SC-14, -18, and -19 area and ~~being~~ displaced on the east side.

A massive qmp-granite contact occurs on the footwall side of the SC fault and had little fluidization and brecciation associated with the contact.

Scattered molybdenum values have been obtained from both the rotary and core drilling. Figure 12 plots the moly values in units above the SC fault. A partial closure, with a high of plus 150 ppm, can be drawn in the vicinity of holes SC-18, -19, -22, and -24, the same area as the extensive brecciation and fluidization features. Another tighter closure of plus 100 ppm is suggested for the hole SC-4 area. A possible easterly axis is suggested for the larger closure.

In the footwall of the SC fault, Figure 13, a closure is suggestive in the holes SC-18 and -24 area with less than 100 ppm. Very low values are recorded in hole SC-4 area. Across the Eastside fault in hole SC-21, the progressive increase in moly values at depth suggests either a new center or an offset continuation of the holes SC-18 and -24 closure. A more northeasterly axial trend is suggested subparallel to the SC structural zone.

Also shown on Figure 13 ~~xx~~ are the copper values found in the primary zone intercepted in the drill holes. ~~This~~ These data, mainly in the footwall block of the SC fault, indicate~~s~~ the highest copper values are in the general high moly area.

Another type of mineral center is suggested in the overall distribution of the copper oxides. Figure 8 shows that hole SC-20 and -24 have chrysocolla as the oxide mineral, whereas hole SC-18 has predominatly chrysocolla with brochantite, while SC-19 has chrysocolla with ~~xxxxxxxxx~~ antlerite. Further outside this grouping of holes, on the east SC-14 and -16 show brochantite greater than antlerite, while to the southwest SC-13 shows antlerite predominantly over brochantite and chrysocolla.

Chrysocolla is also the mineral type in the area of SC-4.

The high copper oxide values (plus 1%) in holes SC-16 and -18 occur in volcanic agglomerate mixed with granite breccia. A volcanic agglomerate dike is noted lower in hole SC-18 and was highly altered and also contained plus 1% copper oxide values. Similar volcanic agglomerate and granite breccia were apparently intercepted in the rotary hole SC-15, and there the copper values were predominantly chalcocite.

The role of the highly altered volcanic agglomerate as a site mineralization is open to question, but one thought is that the volcanic agglomerate was essentially emplaced along the Eastside fault line and available to the early enrichment cycle of migrated chalcocite. The chalcocite was later downdropped to the present level on the east, and the chalcocite on the upthrown side was subsequently oxidized in place to form the oxide values as now known.

Exploration Targets

The excellent alteration, leached capping, and chalcocite zone found in hole SC-23, a mile and one quarter northeast of hole SC-14, is a distinct and separate entity from the Santa Cruz horst area. The flat fault complications cannot be resolved with the single data point, and the thin interval of chalcopyrite intercepted just prior to the termination of the hole is a tantalizing feature. Additional drilling in this area should have the greatest priority.

The concept of a Precambrian zone of weakness, which was the loci of an extensive zone of brecciation and fluidization as well as the major zone of mineralization in the Laramide, can be used as a guide. As developed, a substantial portion of the zone is probably offset along the Eastside fault and is projected to pass north of hole SC-21 and south of hole SC-23. A hole or holes located north of SC-21 would probe for this zone in Target Area A.

The chalcocite in the Eastside fault zone volcanic agglomerate-granite breccia of hole SC-15 and the southside downdropping of the block south of SC-21 suggest that a relatively thick chalcocite enriched area may be preserved east and south of the two holes and between the extension of the Southside fault, as in Target Area B.

The preservation of chalcocite in the footwall of the SC zone in the area of hole SC-24 suggests a relatively thin and probably local amount of chalcocite would be preserved in a zone subparallel to the SC zone on the footwall side in Target Area C.

On the hanging wall side, a substantial zone of oxide copper is probably preserved between hole SC-19 and the Eastside fault. The southern extent of the oxide zone is questionable south of holes SC-24 and SC-18 toward hole SC-16. A hole placed in the triangle out of the reach of either the Eastside or Southside faults would clarify the picture in Target Area D.

A deep primary zone is suggested to underlie the intensive fluidized zone exemplified in holes SC-18 and -24. Fluid inclusions suggest these two holes have excellent characteristics for containing ore grade copper as chalcopyrite near the boiling interface. Reviewing Figures 5 and 6, it is probable that the loci of the fluidized central vent undoubtedly lies below the SC fault as shown, and at some point rupture~~s~~d the zone and then partially used the zone as a structural control to expand upward as the drilling has shown. The constraint placed by hole SC-14, which penetrated the SC fault and into massive qmp, suggests the test hole should be placed north of a line connecting holes SC-14 and SC-22 and possibly as much as 500 feet north in Target Area E. Valuable information on this problem would have been gained by deepening hole SC-22 into and through the lower intrusive complex.

The Southside fault and its probably continued step-down system appears to be a strong basin controlling system. Present thought is that it is deep (plus 2500 to 3000 feet) to the bedrock units at a short distance south of hole SC-16. The rock type is unknown, but it is likely Precambrian granite near the south contact of the main mass of qmp. As more information is gleaned as to the characteristic of the northern contact, it may be justified in probing for and along the south contact.

Draft: HGKreis - 3/8/76
Santa Cruz

LIMONITES

Oxidation, leaching, and copper enrichment have affected part of the Santa Cruz sulfide system. In Section 13 (T6S, R4E) the Santa Cruz Project drilling program has located geologic copper oxide reserves (H.K. memo 12-1-75) within the capping of the much larger sulfide system. The following discussion of capping is based on the drilling results in Section 13, and the observations and interpretations are consistent with those presented in previous verbal and written reports.

The limonites were studied in limited detail during the initial logging of the core. Limonite descriptions consisted of an estimation of the absolute abundance, mineral ratios, and relative abundance of indigenous to transported limonite. Detailed logging descriptions also included the rock type, percent former total sulfides, alteration, and copper mineralogy. Descriptions of geology were made of wet core and recorded for each and every ten-foot interval. The observations and descriptions were made by H. Kreis; the logs are on file; and detailed summary logs can be found in Appendix I of the Santa Cruz Progress Report Mid-1975 (H. Kreis, August 8, 1975). More detailed studies, should they be so justified, would include detailed textural descriptions and instrumental confirmation of the limonite types and relative abundance.

It has been concluded that the limonites, when viewed as a separate entity in the detail of the descriptions as done to date, do not provide sufficient information to fully interpret the former hypogene sulfide distribution and subsequent distribution of former copper sulfide enriched zones. The interpretation of hypogene and supergene copper sulfide distribution can be done on a generalized basis through the use of supportive geologic information including such features as alteration, the distribution of copper minerals in the capping, molybdenum geochemical values, and the apparent contact relationship of the hypogene copper zone with an apparent large quartz monzonite porphyry intrusive at depth. The interpretation of this capping can be found in the aforementioned Santa Cruz progress report, elsewhere in this report, and partially in the following geologic description of the capping.

Limonites occur in all rock types and are present from the top of conglomerate covered bedrock to general depths of 2400 to 2550'. SC-19 penetrated 1900' of capping, the maximum vertical thickness to date. The lateral extent of the limonites cannot be determined at this time because of insufficient drill hole information. In the Santa Cruz horst block variations in capping thickness have resulted more from structural thinning than erosion. The bottom of the oxide zone, therefore, is frequently in fault contact with primary sulfides (such as in SC-18 and -19). In holes such as SC-22 and SC-24 partially leached sulfides (chalcocite and pyrite) are present in a zone about 200' thick near the base of oxidation.

The limonites formed from the oxidation of iron sulfides during multicyclic oxidation and enrichment. Locally minor amounts of limonites appear to have formed from magnetite associated with the alteration of biotite.

The abundance of limonites commonly range from 1-5% by volume and appear to be directly related to the abundance of former iron sulfide minerals. In the capping there is an inverse relationship between limonite abundance and copper abundance. This inverse relationship resulted from lower than average abundance of former total sulfides and a higher copper sulfide to pyrite ratio in the copper oxide zones. The higher copper sulfide to pyrite ratio resulted in part from the low total sulfide abundance during supergene enrichment. Areas of high total sulfide content with a low copper sulfide to pyrite ratio in the former chalcocite enrichment blanket produced more thorough leaching and can be expected to cause discontinuity of copper oxide zones in the capping.

The composition of the limonites is thought to be a mixture of goethite and hematite based on the reddish-brown to brownish-red color. The mixture appears to be 40 to 60% and locally up to 80% hematite. Locally minor amounts of a goethite-jarosite mixture are present.

The limonites consist of variable ratios of transported and indigenous occurrence. In general the abundance of transported limonite equals or exceeds indigenous limonite. Although not studied in detail, the texture of the indigenous limonite is compact, and fluffy-relief limonite is present but not common. The indigenous limonite grades into transported limonite of similar texture. However, much of the transported limonite texture varies from stain in feldspar alteration products to paint on fractures to botryoidal. There is no obvious change in the composition of transported limonite and indigenous limonite in the same interval. In a few localities limonites formed casts of a subsequently leached mineral. The casts reflect an elongate crystal shape that may have been a copper sulfate mineral.

Evidence suggests that transportation of iron by supergene solutions was minimal for leaching conditions. Transported limonites appear to have formed from iron transported less than a foot from its source. There are no zones of wholesale leaching and subsequent enrichment of iron in the capping. Minerals such as alunite and supergene silica that are indicative of highly oxidizing-leaching supergene solutions are not present in the Santa Cruz capping. The greatest degree of silica-alumina mobilization is represented by kaolinite seams in SC-22 between 1050 and 1550'. SC-22 is interpreted to be in the pyrite zone with an above average abundance of former total sulfides and probably represents the highest degree of oxidizing-leaching potential achieved by supergene solutions in the presently observed Santa Cruz capping.

In capping of thorough leaching, the copper grades are 0.01 to 0.06% total copper. Copper oxide intercepts, zones of minimal leaching, generally average 0.5 to 1% total copper. Local minor remnants of chalcocite-pyrite occur as high as 750' above the base of oxidation.

In summary, the composition of the limonites and their textures are interpreted to have been derived from the oxidation and leaching of varying proportions of secondary chalcocite and primary sulfides. This took place in a low total sulfide environment that produced supergene solutions having highly variable but generally of moderately to weakly oxidizing and leaching potential.

LIMONITES

Santa Cruz 3/8/76

Oxidation, leaching, and copper enrichment have affected part of the Santa Cruz sulfide system. In Section 13 (T6S, R4E) the Santa Cruz Project drilling program has located geologic copper oxide reserves (H.K. memo 12-1-75) within the capping of the much larger sulfide system. The following discussion of capping is based on the drilling results in Section 13, and the observations and interpretations are consistent with those presented in previous verbal and written reports.

The limonites were studied in limited detail during the initial logging of the core. Limonite descriptions consisted of an estimation of the absolute abundance, mineral ratios, and relative abundance of indigenous to transported limonite. Detailed logging descriptions also included the rock type, percent former total sulfides, alteration, and copper mineralogy. Descriptions of geology were made of wet core and recorded for each and every ten-foot interval. The observations and descriptions were made by H. Kreis; the logs are on file; and detailed summary logs can be found in Appendix I of the Santa Cruz Progress Report Mid-1975 (H. Kreis, August 8, 1975). More detailed studies, should they be so justified, would include detailed textural descriptions and instrumental confirmation of the limonite types and relative abundance.

It has been concluded that the limonites, when viewed as a separate entity in the detail of the descriptions as done to date, do not provide sufficient information to fully interpret the former hypogene sulfide distribution and subsequent distribution of former copper sulfide enriched zones. The interpretation of hypogene and supergene copper sulfide distribution can be done on a generalized basis through the use of supportive geologic information including such features as alteration, the distribution of copper minerals in the capping, molybdenum geochemical values, and the apparent contact relationship of the hypogene copper zone with an apparent large quartz monzonite porphyry intrusive at depth. The interpretation of this capping can be found in the aforementioned Santa Cruz progress report, elsewhere in this report, and partially in the following geologic description of the capping.

Limonites occur in all rock types and are present from the top of conglomerate covered bedrock to general depths of 2400 to 2550'. SC-19 penetrated 1900' of capping, the maximum vertical thickness to date. The lateral extent of the limonites cannot be determined at this time because of insufficient drill hole information. In the Santa Cruz horst block variations in capping thickness have resulted more from structural thinning than erosion. The bottom of the oxide zone, therefore, is frequently in fault contact with primary sulfides (such as in SC-18 and -19). In holes such as SC-22 and SC-24 partially leached sulfides (chalcocite and pyrite) are present in a zone about 200' thick near the base of oxidation.

The limonites formed from the oxidation of iron sulfides during multicyclic oxidation and enrichment. Locally minor amounts of limonites appear to have formed from magnetite associated with the alteration of biotite.

The abundance of limonites commonly range from 1-5% by volume and appear to be directly related to the abundance of former iron sulfide minerals. In the capping there is an inverse relationship between limonite abundance and copper abundance. This inverse relationship resulted from a lower than average abundance of former total sulfides and a higher copper sulfide to pyrite ratio in the copper oxide zones. The higher copper sulfide to pyrite ratio resulted in part from the low total sulfide abundance during supergene enrichment. Areas of high total sulfide content with a low copper sulfide to pyrite ratio in the former chalcocite enrichment blanket produced more thorough leaching and can be expected to cause discontinuity of copper oxide zones in the capping.

The composition of the limonites is thought to be a mixture of goethite and hematite based on the reddish-brown to brownish-red color. The mixture appears to be 40 to 60% and locally up to 80% hematite. Locally minor amounts of a goethite-jarosite mixture are present.

The limonites consist of variable ratios of transported and indigenous occurrence. In general the abundance of transported limonite equals or exceeds indigenous limonite. Although not studied in detail, the texture of the indigenous limonite is compact, and fluffy-relief limonite is present but not common. The indigenous limonite grades into transported limonite of similar texture. However, much of the transported limonite texture varies from stain in feldspar alteration products to paint on fractures to botryoidal. There is no obvious change in the composition of transported limonite and indigenous limonite in the same interval. In a few localities limonites formed casts of a subsequently leached mineral. The casts reflect an elongate crystal shape that may have been a copper sulfate mineral.

Evidence suggests that transportation of iron by supergene solutions was minimal for leaching conditions. Transported limonites appear to have formed from iron transported less than a foot from its source. There are no zones of wholesale leaching and subsequent enrichment of iron in the capping. Minerals such as alunite and supergene silica that are indicative of highly oxidizing-leaching supergene solutions are not present in the Santa Cruz capping. The greatest degree of silica-alumina mobilization is represented by kaolinite seams in SC-22 between 1050 and 1550'. SC-22 is interpreted to be in the pyrite zone with an above average abundance of former total sulfides and probably represents the highest degree of oxidizing-leaching potential achieved by supergene solutions in the presently observed Santa Cruz capping.

In capping of thorough leaching, the copper grades are 0.01 to 0.06% total copper. Copper oxide intercepts, zones of minimal leaching, generally average 0.5 to 1% total copper. Local minor remnants of chalcocite-pyrite occur as high as 750' above the base of oxidation.

In summary, the composition of the limonites and their textures are interpreted to have been derived from the oxidation and leaching of varying proportions of secondary chalcocite and primary sulfides. This took place in a low total sulfide environment that produced supergene solutions having highly variable but generally of moderately to weakly oxidizing and leaching potential.

draft: HG Kreis
3/8/76

3/24/74

Limonite JDS Draft

~~the~~ The limonites were studied in limited detail during the initial logging of the core by HG Kries. Limonite descriptions consisted of an estimation of the absolute abundance, mineral ratios, a relative abundance of indigenous to transported limonite. Detailed logging description also included the rock type, percentage former total sulfides, alteration, and copper mineralogy. All of these logs and the detailed summary logs are filed separately & in Appendix 1 of the Santa Cruz Progress Report Mid-1975 (H.G. Kreis, August 8, 1975).

During the relogging, the values determined earlier were generally confirmed. As previously pointed out by Kreis, the limonite interpretation is not conclusive. Interpretation problems include the variability of original sulfides in the ~~various~~ several rock types, ~~to~~ in the various breccias and fluidized zones, and in the amount of apparent late transportation and overflooding of iron oxides during the multiple oxidation cycles.

The overall former sulfide content is around 2-3%

above the basal SC fault and below the fault often drops to below 1%, although parts of holes SC-13 and SC-24 have intervals of 2-3%, with several of the holes terminating in primary sulfides of low tenor.

In general, the highest (+4%) former sulfide values are in the upper, probably late stage, portion of the proposed fluidized zone as exemplified in holes SC-20 and SC-22. Higher values are also in the extensive fluidized zone near the basal SC fault in hole SC-18. Coarse breccia zones may have fillings of 6-8% former sulfides, but such zones have limited core exposure.

The central holes SC-14, 18, 19, 22, and 24 all have intervals of 2-4% former sulfide ~~which~~ while the outlying holes SC-4, 8, 11, 12, 16, and the lower part of SC-20 have less than 2% values; a relationship also reflected in the bulk of the oxide copper distribution as well as in the overall geochemical molybdenum values.

Limonites after chalcocite was noted in only a few limited areas. In holes SC-19 and SC-22, the zones were found above the occurrence of first remnant pyrite-chalcocite and both zones were in a weakly fractured granite with moderate alteration feature and a 2-4% former sulfide content. In hole SC-19, a lower band of oxide copper occupied part of the limonite-after-chalcocite zone whereas hole SC-22 had no copper oxide in the entire hole. In holes SC-14 and SC-20, chalcocite derived limonite were noted within the zone of first remnant pyrite-chalcocite and in both cases no copper oxides were associated with the zone of chalcocite limonites. The interpreted volume of former sulfide was estimated to be less than 2%.

As noted, the drill holes show leaching and oxidation below the first & remnant pyrite-chalcocite occurrence and most of the holes do not exhibit chalcocite limonites in this zone. This may reflect the erratic nature of the chalcocitic enrichment as well as the amount of copper being ~~held~~ immobilized within the oxide copper blankets during the subsequent oxidation and leaching cycles.

Patterns of indigenous versus transported limonites are not clearly established but in general, the zones of copper oxide and anomalous moly areas have the highest incident of indigenous limonite while the more outlying holes have more transported limonite types. Undoubtably this is partially a function of the ratio of former pyrite to chalcopyrite content, with the higher pyrite values being in the outside holes, but this feature is not readily logged in the present limonites.

Notes on Limonites after CC & top of remnant CC zones.

SC-4 1850 - 1st remnant

SC-13 2010 - 1st remnant (below sc structure).

SC-14 1980-2078 l/a/cc } in E side flt contact, probably within
2280 - 1st remnant } 1st remnant zone.

SC-18 1784 - 1st remnant

SC-19 1525-1597 ; 1620(?)-1648 ; 1648-1757 l/a/cc
1740 - 1st remnant.

SC-20 1700-2050 ; 1800-1915 l/a/cc
1770 - 1st remnant

SC-22 627-936 ; 1495-1497 l/a/cc
1497 - 1st remnant

SC-24 at & below SC fault at 1974 flt contact. - 1st remnant.

ASARCO

Southwestern Exploration Division

May 12, 1976

TO: F. T. Graybeal

FROM: J. D. Sell

Santa Cruz Project Studies
Pinal County, Arizona

Attached is my report: A Structural and Related Mineral Reinterpretation of the Santa Cruz Horst Block.

The study was undertaken with H. G. Kreis, Santa Cruz Project Geologist, and R. B. Cummings, Resident Geologist-Sacaton. Both contributed numerous ideas and comments and have reviewed the draft of this report.

James D. Sell
James D. Sell

JDS:lb
Att.

cc: HGKreis
RBCummings

A STRUCTURAL AND RELATED MINERAL REINTERPRETATION OF THE SANTA CRUZ HORST BLOCK

Summary

Interpretation of the relogging of the core and rotary samples during the Santa Cruz Studies has suggested to Sell that in the horst block area the quartz monzonite porphyry intrusive was emplaced along an older structural zone.

The zone, here named the SC zone, is characterized by the abundance of thin diabase dikes cutting slices of Precambrian granite with thin breccia zones and faulting as subparallel planar structures. In Precambrian time, the zone of weakness was probably a near vertical feature but has since been involved in rotational, tilting movement. The axis of rotational movement was subparallel to the present strike trend of the zone. The SC zone presently strikes in a general N60°E direction and dips around 40° northwesterly. It is expressed between holes SC-18 on the northeast to SC-20 on the southwest, a distance of over 4000 feet. It is probably offset 2000 ft. to the south between holes SC-20 and SC-12 by the Westside fault which strikes N30°-35°W and dips 45° southwesterly. The SC zone is suggested to pass through hole SC-4 and continue further to the southwest.

In Laramide time the SC zone was the site of renewed movement along the faults, and a part of the tilting probably occurred at this time. Dikes of various porphyry rocks and thicker masses of quartz monzonite porphyry, as well as breccia masses, were emplaced along the zone and principally in the hanging wall of the Precambrian SC zone. The dikes and masses are again mainly subparallel to the planar fabric established during the Precambrian events. In the footwall of the SC zone, Precambrian granite is found high and to the west where it is quite massive, although cut by a few diabase dikes which generally have intrusive contacts. Easterly and at depth in the footwall of the SC zone is the Laramide quartz monzonite porphyry. The porphyry was in part guided into its emplacement by the SC zone and, although crushed and faulted at the boundary, is most often a massive unit below the SC zone.

The SC zone, on its northwesterly or hanging wall side, is the site for extensive faulting, brecciation, and fluidization of various Precambrian granite and Laramide quartz feldspar porphyry, hornblende porphyry, and various quartz monzonite porphyry units which generally show a preference for steeper contacts. The fluidized zones generally do not mix rock types and exhibit all degrees of fluidization and brecciation within the units. Diabase, in general, was not found with a fluidized texture, although in SC-22 a mixed zone of quartz monzonite porphyry and granite had a minor amount of "dark volcanic" and recognizable diabase inclusions.

The zone of massive fluidization and brecciation is noted in holes SC-14, 18, 19, 22, and 24. Outside the zone are numerous zones of narrow fluidization and "internally disintegrated" rock. These narrow zones are found both in the hanging wall granite and in the footwall granite and quartz monzonite porphyry.

The Santa Cruz horst is bounded on the east by the Eastside fault. This structure strikes N20°-25°W and dips 45° northeasterly. Little data is available east of the fault, but it appears to offset the SC zone and the extensive fluidized zone to the north for an unknown distance. As noted, the fluidized and brecciated zone, as exemplified in SC-18 and interpreted for SC-14, is cut by the Eastside fault. The northward offset may amount to around 2000-2500 feet of dominant strike-slip movement. The SC zone continues to the northeast between holes SC-21 and SC-23. No extensive fluidization features were noted in either SC-21 or SC-23, but the change from Precambrian granite on the north in SC-23 to Laramide monzonite on the south in SC-21 is the same type of change as found across the top part of SC-22 over to SC-24 (allowing for the difference in elevation of the monzonite mass).

Coincident with the extensive fluidized and brecciated zone is the occurrence of higher values of molybdenum contouring outward from hole SC-24 and a higher center of primary copper grades contouring outward from holes SC-18 and SC-24. Undoubtedly the original grade within this zone was responsible for the better development of a chalcocite blanket, which was subsequently modified and converted into the "copper oxide" blankets as presently known.

In the Santa Cruz horst area the massive quartz monzonite porphyry is known to extend up to an elevation of minus 420 feet below sea level on the footwall side of the SC zone. On the hanging wall side, dike-type units of similar quartz monzonite porphyry were first encountered at an elevation of minus 870 feet below sea level. Precambrian granite is known to extend to a depth of minus 1169 feet below sea level on the hanging wall side.

The various dikes and masses of hornblende porphyry, hornblende feldspar porphyry, quartz feldspar porphyry, grey quartz monzonite porphyry, black quartz monzonite porphyry, and various textures of quartz monzonite porphyry found in the hanging wall of the SC zone probably reflect a monzonitic source area at depth. The occurrence of massive quartz monzonite porphyry at a higher level in the footwall of the SC zone is probably the result of a) a higher level of intrusion of the monzonite mass along the weak zone exemplified by the diabase and faulting in the Precambrian granite, and b) some faulting along the contact which downdropped and tilted the hanging wall units both before and after the influx of the Laramide fluidization and brecciation event.

The area of fluidization, brecciation, and mineralization around holes SC-18 and SC-24 is regarded as a center of activity. A second center of mineralization is suggested in the vicinity of hole SC-4 where fluidization, better alteration, and higher molybdenum values are noted. Hole SC-23 to the northeast is regarded as a third area of contrasting alteration-mineralization-tectonic style.

Introduction

The location-plan map of the Santa Cruz project is shown in Figure 1 (modified from HGK Fig. 1). In September of last year, a relogging-reevaluation of the project drill results was initiated by Kreis, Cummings, and Sell. The main emphasis of study was the Santa Cruz horst block, the area of major drilling and significant results, centered around drill holes SC-22, -19, and -24.

Many thoughts were expressed and discussed by all involved. This report was written by Sell and has been reviewed by Kreis and Cummings. Neither Kreis nor Cummings agrees with portions of the text, and it was not feasible to clarify these differences at this time. Kreis will incorporate his comments in a forthcoming comprehensive report, and Cummings will submit a separate memo comparing features of the Sacaton and Santa Cruz areas. The study ended with drill hole SC-24, and no review of the subsequent holes, presently being drilled, has been made.

Faulting

Logging and constraints have suggested a number of fault structures in the horst block area (Fig. 2). Basically interpreted is an older Precambrian fault trend, here named the SC zone, which strikes N60°E and presently dips 40° northwesterly. The SC zone horst block is cut, downdropped, and laterally translated by three major structures: 1) the westside fault, which strikes N30°-35°W and dips 45° southwesterly and offsets the SC zone some 2000 feet to the south mainly by strike-slip movement; 2) the eastside fault, which
20-25 strikes N~~3~~20°-~~3~~25°W and dips 45° northeasterly, offsets the SC zone to the north an unknown distance but probably between 2000 and 2500 feet, also by strike-slip movement; and 3) the southside fault, which is interpreted to cut the westside and eastside structures, strikes N55°-60°E and dips steeply to the southeast. The southside fault may be a series of structures which cumulatively downdrop the south side of the horst block in excess of three thousand feet. A fourth fault structure was cut in hole SC-21 and is interpreted to terminate at the eastside fault while striking N60°E and dipping 50° southeasterly. This structure is based on one hole intercept and true strike direction is unknown.

Present drill hole data and three point resolutions do not permit the precise determination of the fault directions and dips. It is known that variations exist and the above figures reflect the general trends of the structures.

SC Zone

The SC zone is a totally complex structural-intrusive zone extending from Precambrian thru post-Laramide time.

A cross-section of the SC zone has been constructed through drill holes SC-22, -19, and -24. Figure 3 shows the SC structure as a fault (colored blue) with massive granite and quartz monzonite porphyry below on the footwall side. Minor crushing and shearing with gouge development are also noted along the fault structure and somewhat below. Several gently dipping diabase dikes and one steeper fluidized granite structure are also shown in the footwall block. This massive characteristic is sharply changed across the fault structure and in the hanging wall side of the fault a complex intrusive sequence of granite, diabase, and various porphyries, all highly fractured, brecciated, and fluidized to various degrees and involvement, is found to extend some distance away from the fault at the base of the sequence. In the upper part of drill hole SC-19 and the bottom of hole SC-22 are found "internally crushed" granite masses cut by diabase and quartz monzonite porphyry dikes dipping at moderate angles. In hole SC-22, the majority of the hole contains highly brecciated and fluidized units of granite and various porphyries. The top of the brecciated and fluidized group is marked by a strong fault containing gouge and breccia, and above the fault is massive, weakly shattered granite. The entire zone of brecciated and fluidized units is called the SC zone.

The events leading up to this complex picture are as follows: During Precambrian time, large masses of granite were emplaced in central Arizona generally in contact with Pinal Schist. The Santa Cruz area appears to be within the granitic mass and the earliest SC zone was characterized by shearing and breakage along the N60°E trend. Part of the zone of weakness was utilized by the emplacement of thin, planar, intrusive diabase dikes having chilled borders. Although no age dates are available from the Santa Cruz area, I believe the diabase is Precambrian in age as expressed by Balla (1972) in the Sacaton area. Further, I feel the diabase was initially injected as near vertical dikes and their present attitude reflects later tilting of the blocks.

Figures 4 and 5 are plan maps of the minus 500-foot elevation below sea level and minus 1000-foot elevation below sea level, respectively, in the area of study. On the northwest side of the SC structure, as noted in Figures 3, 4, and 5, thin diabase dikes were encountered in nearly each hole in the area. A profusion of slips, faults, and crushed zones is also apparent which appears to belong to the Precambrian fracture system and again mainly in the northwest or hanging wall of the SC structure. In the southeast or footwall of the SC structure, the Precambrian granite is essentially a massive, unbroken unit with two discrete diabase dike intercepts in hole SC-24. It is realized that the sparsity of drill intercepts into the footwall area of the SC zone does not permit a clarified picture, but there seems little doubt that the hanging wall side of the SC structure, as now known, was the site of multiple diabase dikes and much more abundant fracturing and faulting.

In Laramide time a mass of quartz monzonite porphyry was emplaced, and it appears to be guided by part of the older SC zone. As presently known in the southeast or footwall side, massive quartz monzonite porphyry was intruded to a fairly high level in the vicinity of holes SC-14, -16, and -18, and several discrete black quartz monzonite porphyry and black feldspar porphyry dikes were emplaced in the Precambrian granite further west. In the hanging wall side of the SC structure, numerous thin zones of quartz monzonite porphyry with a number of textural variations were emplaced in the sheared granitic terrain. Also in the hanging wall side, extensive brecciation and fluidization of Precambrian granite and Laramide quartz monzonite porphyry were involved. The fluidization exhibits all degrees of intensities and involvement, but in general is restricted to single units and, although granite and quartz monzonite porphyry may alternate in relatively thin apparently planar slices and each is fluidized, the fluidization generally did not mix rock types. Although the diabase is assigned to the Precambrian and the fluidization as a Laramide event, diabase was rarely found to exhibit fluidization features except very locally along contacts. Post-fluidization fracturing and faulting are common features and occur within the expanded fluidized SC zone. Apparently late hornblende porphyry, quartz feldspar porphyry, and various darker quartz monzonite porphyries were emplaced late in the fluidization sequence. Much of the fluidized and late diking appear to favor steeper structural zones than the diabase and more planar quartz monzonite porphyry zones and may represent continued rotational adjustment along the SC zone.

In the footwall side of the SC structure, rare fluidization was noted. A fluidized quartz monzonite porphyry dike was noted in drill hole SC-4 while a small fluidized structure of Precambrian granite was found in hole SC-24.

Figure 6 separates the non-brecciated, brecciated, and fluidized granite and porphyries. Drill hole SC-22 was terminated between the two intrusive complex groups, and no data is available in other holes to confirm the depth configuration of the intrusive complex. Figure 6 also indicates the probable continuing tilting and rotational movement of the Santa Cruz Horst block with the passage of time. Assuming a near vertical zone during the emplacement of the diabase, then each succeeding event was accompanied by rotational movement, so that the diabase presently has a flatter attitude than does the monzonite, followed by the fluiding event and culminating in the late hornblende feldspar porphyry dikes which cut the fluidized zones at a generally steeper angle.

Mineralization

Mineralization within the Santa Cruz system as presently known can be divided into four groups: 1) primary sulfides of pyrite and chalcopyrite; 2) a chalcocite zone, often partially leached; 3) a first remnant chalcocite with pyrite zone, often highly leached; and 4) the "oxide copper" zone of chrysocolla, brochantite, and ataçamite.

Figure 7 is the cross-section of holes SC-22, -19, and -24 with the above four zones as intercepted. Hole SC-22 did not intercept any oxide copper but found a remnant leached chalcocite-pyrite zone and, further in depth, a leached chalcocite zone before terminating in partially leached primary pyrite-chalcopyrite. Hole SC-19 intercepted three distinct oxide copper zones, then a highly leached zone with sparse remnant chalcocite containing an oxide copper band at its base, then a leached chalcocite zone terminating at a fault (the SC fault) where unleached pyrite-chalcopyrite was encountered to the terminated depth. Hole SC-24 also intercepted three oxide copper zones, then penetrated the SC fault, after which the hole went into highly leached remnant chalcocite-pyrite, followed by a distinct chalcocite zone which bottomed in partially leached and chalcocite-enriched primary values, and terminated in primary pyrite-chalcopyrite values.

Interpretation of this information would suggest a moderate dip to the top of the primary pyrite-chalcopyrite values, which are interpreted to be subparallel to the top of the chalcocite zone drawn between holes SC-22 and -19. Likewise, the line connecting the top of the first remnant chalcocite-pyrite zone is compatible to the lower two surfaces. In Figure 7, the dip assigned to hole SC-24 is determined by association and other control described below.

If the top of the chalcocite zone between holes SC-19 and SC-22 is taken to have formed at a near horizontal surface, then the present surface has been rotated to the increased slope. Note that if the surface is rotated back to near horizontal, then the late stage features found in hole SC-22 assume a near vertical emplacement trend.

The oxide copper zones roughly fall at the same elevation but, as shown in Figure 7, appear to be somewhat irregular and are assigned a flattish dip and probably reflect redistribution to the present bedrock surface. Intra-spaced drilling of the oxide deposit will resolve this problem more fully.

Figure 8 is a plan map showing interpreted structural contours on the top of the oxide copper zone as penetrated in the present drilling. As contoured, the top of the zone is a rather sharp ridge which slopes away in three directions, and which appears to reflect the rock surface contours. A further modification is along the Eastside fault where volcanics and granite appear to be along the fault surface and have acted as a trap or sponge for the oxide copper values.

The top of the first remnant chalcocite with pyrite can also be contoured and is shown on Figure 9. The contouring is separated into sectors based on the faulting and offsets, as well as hanging and footwall sectors of the SC zone. In the main area of the hanging wall sector, four control points are available and contouring suggests a slight bowing of the surface subparallel to the SC fault trace and dipping around 20° to the southeast. In the footwall of the SC fault two points are available, but hole SC-24 is in fault contact with the first remnant chalcocite-pyrite zone and hence the true thickness is unknown. The contours are drawn in the footwall based on the 250-foot thickness in hole SC-13. However, as suggested in the hanging wall block, the thickness increases from west to east across the block, and if this is true in the footwall block then any increase in thickness would move the contours to the south, as shown by the plus (+) marks, and the final configuration would be subparallel on both sides of the SC fault. Note that there is over 100 feet of displacement across the fault, with the hanging wall down in relation to the footwall. This is also reflected in the cross-section of Figure 7.

Only one point is available in the block containing hole SC-4, but does exhibit the lateral strike-slip offset of contours from the adjacent blocks.

The top of the chalcocite zone contours is shown in Figure 10. On the hanging wall side of the SC fault, three points afford some control and reflect a 25° southeast dipping surface subparallel to the SC fault. On the footwall side, only one clear data point is available, with constraints placed by the use of three additional points. The construction suggests the same subparallel strike direction, but the surface probably dips much shallower at around 10° to the southeast. Pyrite was noted in the quartz monzonite porphyry at the bottom of hole SC-16. The depth does not conform to the contouring and is presently anomalous. The pyrite could reflect a part of the remnant chalcocite-pyrite zone but would again be at an elevation higher than the contourable data, or more probably it reflects a non-leached and non-enriched area. Possibly other complicating fault structures are present and the would clarify the data.

Again, hole SC-4 is a single control point but emphasizes the offset feature.

Figure 11 lists the elevation of the primary sulfides with comments in each hole of the Santa Cruz study area. As the various structures offset the top of the surface and few holes have contacts represented by the base of the chalcocite zone for reference, the data is not contoured. It should be noted, however, that holes SC-14, -18, and -19 all encountered unleached sulfides immediately below the SC fault. Also, hole SC-15 encountered primary sulfide at and in the basal structures of the Eastside fault (dipping easterly), while hole SC-21 entered primary sulfides below an interpreted south dipping fault.

Centers of Intrusive Activity and Mineralization

As exemplified on the plan maps of Figures 4 and 5, and the cross-section of Figures 3 and 6, the area containing holes SC-14, -18, -19, -22, and -24 is one of extensive brecciation and fluidization of Precambrian and Laramide units. Eastward the intrusive complex zone is cut and displaced by the Eastside fault, to the south it terminates against the SC fault, westward it apparently becomes narrower and less complicated, while to the north it terminates in a high angled fault zone against Precambrian granite. A center for the extensive fluidization would appear to be around the holes SC-14, -18, and -19 area and displaced on the east side.

A massive quartz monzonite porphyry-granite contact occurs on the footwall side of the SC fault and had little fluidization and brecciation associated with the contact, as shown by the logging of the basal portions of holes SC-19 and SC-24.

Interpretation of this feature suggests that the fluidization is a later event than the emplacement of the quartz monzonite porphyry and, although the fluidization source undoubtedly utilized the nearby granite-quartz monzonite porphyry contact on the northerly side of the porphyry mass, it is a manifestation of a deeper, later monzonite source and not a contact phenomenon.

Scattered molybdenum values have been obtained from both the rotary and core drilling. Figure 12 plots the molybdenum values in units above the SC fault. A partial closure, with a high of plus 150 ppm, can be drawn in the vicinity of holes SC-18, -19, -22, and -24, the same area as the extensive brecciation and fluidization features. Another tighter closure of plus 100 ppm is suggested for the hole SC-4 area. A possible easterly axis is suggested for the larger closure.

In the footwall of the SC fault, Figure 13, a closure is suggestive in the holes SC-18 and -24 area with less than 100 ppm. Very low values are recorded in hole SC-4 area. Across the Eastside fault in hole SC-21, the progressive increase in molybdenum values at depth suggests either a new center or an offset continuation of the holes SC-18 and -24 closure. A more northeasterly axial trend is suggested subparallel to the SC structural zone.

Also shown on Figure 13 are the copper values found in the primary zone intercepted in the drill holes. These data, mainly in the footwall block of the SC fault, indicate the highest copper values are in the general high molybdenum area.

Another type of mineral center is suggested in the overall distribution of the copper oxides. (Based on descriptive footage, may not be as clear based on weighted copper assay.) Figure 8 shows that holes SC-20 and -24 have chrysocolla as the oxide mineral, whereas hole SC-18 has predominantly chrysocolla with brochantite, while SC-19 has chrysocolla with antlerite. Further outside this grouping of holes, on the east, SC-14 and -16 show brochantite greater than antlerite, while to the southwest SC-13 shows antlerite predominantly over brochantite and chrysocolla.

Chrysocolla is also the mineral type in the area of SC-4.

The high copper oxide values (plus 1%) in holes SC-16 and -18 occur in volcanic agglomerate mixed with granite breccia. A volcanic agglomerate dike is noted lower in hole SC-18 and was highly altered and also contained plus 1% copper oxide values. Similar volcanic agglomerate and granite breccia were apparently intercepted in the rotary hole SC-15, and there the copper values were predominantly chalcocite.

The role of the highly altered volcanic agglomerate as a site mineralization is open to question, but one thought is that the volcanic agglomerate was essentially emplaced along the Eastside fault line and available to the early enrichment cycle of migrated chalcocite. The chalcocite was later downdropped to the present level on the east, and the chalcocite on the upthrown side was subsequently oxidized in place to form the oxide values as now known.

Exploration Targets

The excellent alteration, leached capping, and chalcocite zone found in hole SC-23, a mile and one quarter northeast of hole SC-14, is a distinct and separate entity from the Santa Cruz horst area. The flat fault complications cannot be resolved with the single data point, and the thin interval of chalcopyrite intercepted just prior to the termination of the hole is a tantalizing feature. Additional drilling in this area should have the greatest priority.

The concept of a Precambrian zone of weakness, which was the loci of an extensive zone of brecciation and fluidization as well as the major zone of mineralization in the Laramide, can be used as a guide. As developed, a substantial portion of the zone in the horst area of SC-14 and SC-18 is probably offset along the Eastside fault and the offset is projected to pass north of hole SC-21 and south of hole SC-23. A hole or holes located north of SC-21 would probe for this fluidized zone in Target Area A. Positive results would clarify the mineral projection across a large block of presently noncontrolled ground.

The chalcocite in the Eastside fault zone volcanic agglomerate-granite breccia of hole SC-15 and the southside downdropping of the block south of SC-21 suggest that a relatively thick chalcocite enriched area may be preserved east and south of the two holes and between the extension of the Southside fault, as in Target Area B.

The preservation of chalcocite in the footwall of the SC zone in the area of hole SC-24 suggests a relatively thin and probably local amount of chalcocite would be preserved in a zone subparallel to the SC zone on the footwall side in Target Area C.

On the hanging wall side, a substantial zone of oxide copper is probably preserved between hole SC-19 and the Eastside fault. The southern extent of the oxide zone is questionable south of holes SC-24 and SC-18 toward hole SC-16. A hole placed in the triangle out of the reach of either the Eastside or Southside faults would claify the picture in Target Area D.

A deep primary zone is suggested to underlie the intensive fluidized zone exemplified in holes SC-18 and -24. Fluid inclusions suggest these two holes have excellent characteristics for containing ore grade copper as chalcopyrite near the boiling interface. Reviewing Figures 3 and 6, it is probable that the loci of the fluidized central vent undoubtedly lies below the SC fault as shown, and at some point ruptured the zone and then partially used the zone as a structural control to expand upward, as the drilling has shown. The constraint placed by hole SC-14, which penetrated the SC fault and into massive quartz monzonite porphyry, suggests the test hole should be placed north of a line connecting holes SC-14 and SC-22 and possibly as much as 500 feet north in Target Area E. Valueable information on this problem would have been gained by deepening hole SC-22 into and through the lower intrusive complex.

The Southside fault and its probably continued step-down system appears to be a strong basin controlling system. Present thought is that it is deep (plus 2500 to 3000 feet) to the bedrock units at a short distance south of hole SC-16. The rock type is unknown, but it is likely Precambrian granite near the south contact of the main mass of quartz monzonite porphyry. As more information is gleaned as to the characteristic of the northern contact, it may be justified in probing for and along the south contact. (Apparently hole SC-25, drilled after the preliminary draft of this report, intercepted unaltered Precambrian granite at a much shallower depth southwest of SC-16 than would have been suggested by the foregoing interpretation Probing the south contact would be a much shallower target area.)

James D. Sell
May 1976

ASARCO

Southwestern Exploration Division

August 6, 1976

TO: F. T. Graybeal

FROM: J. D. Sell

Hanna Personnel
Francisco Grande
Santa Cruz Project
Pinal County, Arizona

On Monday night (August 2) I had dinner with Steve Van Nort, Exploration Manager, Tucson Office of Hanna. In the evening chat he said that:

1) He has been pulled off of all other work and assigned to the Project (no name) to trouble shoot the drilling and get it done.

2) They are up against the deadline and need more coring for the evaluation.

3) All core is taken to Tucson and logged by J. D. Lowell & Associates.

4) He is sort of miffed that Newmont sweet-talked them into the adventure and then shortly thereafter pulled out, but he was happy that all the previous information was free (i.e., Newmont was not reimbursed in any manner.

5) Only two partners remain and the other is undoubtedly Getty Oil.

6) Getty pays up promptly and can't understand why more money can't be spent (i.e., would like to see the program increased).

7) Getty's representative gets to Tucson every other month for a conference.

8) All of Hanna's activity and drive is out of Cleveland with their Chief Geologist (?) Mr. Stone.

On Tuesday three Hanna people, Steve, Charles Dowd (Landman), and Robert Bartholomew (Ass't. to President), all had breakfast with Mr. Jack Kane (General Manager of Francisco Grande of the NAAC group). They were apparently all out together for the day and came in about 8:00 P.M. They met one other man, named "Bill," for dinner.

On Wednesday, just Charlie and Bob had breakfast with Jack and in the evening were with two other people (unknown to me) who apparently were on their way out at the time I came in to the hotel.

Thursday, the three again had breakfast and included Mrs. Dowd. The stay was complete as they were heading north via Kingman.

Could Hanna be interested in buying the hotel, etc.?

J. D. Sell/lb
J. D. Sell

JDS:lb

cc: HGKreis

ASARCO

Southwestern Exploration Division

August 6, 1976

TO: F. T. Graybeal

FROM: J. D. Sell

Rumor -- Drilling
"Hanna-Getty" Project
Pinal County, Arizona

Tony Benavidez has supplied the following rumors, plus some tidbits from elsewhere, on the drilling around our Santa Cruz Project.

N-3, 2500 feet
N-6, 2700 feet (the deepest drilled by Barnes Drilling Co.)
N-12 or N-13, 2100 feet

A Joy diamond rig moved onto hole N-21 on July 24, 1976. This is the fourth core rig for Joy now on the Hanna-Getty ground.

The rotary hole N-22 was terminated on July 27. The contractor, J. O. Barnes, was also terminated at that time due to "conflict of interest" in that another rig from the contractor was being employed by Asarco.

The rotary hole N-23 was spudded in one quarter of a mile west of Midway Road and some 100 feet south of Clayton Road (top center of the NE1/4 of Section 24, T6S, R4E) by C & W Drilling Company (Tommy Cissell) on July 28 and terminated on August 4. May have had between 1000 and 1200 feet of rods in the rack.

Hanna surveys all the holes and finds some of them very crooked. This includes N-19 which has been in constant trouble and is now at BX. Also, hole N-22 was exceptionally crooked and apparently the Barnes' rig performance has continued to deteriorate in the last number of holes. Hole N-22 is just several hundred feet from our property boundary.

Hanna-Getty offset (N-17) of our hole SC-25 was a direct result of blind competitive operations, and at least one man thought they had some "egg on their face" for drilling such a "blank hole." (This would suggest that they do not have a strong pipeline into our drilling or else they would not have drilled their N-17.)

They are baffled by the very rough topographic bedrock surface which they have found; i.e., 900 ft. in one hole and 2900 feet in an adjacent hole and have not solved the fault problems.

Newmont has run abundant GP surveys, including attempts at down-the-hole, but interpretations are not very satisfactory, either at predicting bedrock surface nor mineralization.

Their interest in the water problem was probably "premature" but honest, suggesting this will be a major problem to be worked on prior to any mining plan evaluation.

J. D. Sell /lb

J. D. Sell

JDS:lb

cc: HGKreis

ASARCO

Southwestern Exploration Division

August 31, 1976

TO: F. T. Graybeal

FROM: J. D. Sell

Santa Cruz Area
Pinal County, Arizona

Today, August 31, Steve Van Nort invited me to lunch with him. He asked that I pass on the following points:

1) They have sufficient encouragment to stay and will take over the Collins option (99+% sure).

2) As they are concentrating in the south and Asarco is apparently concentrating in the north -- he would like to swap north lands for south lands, specifically he would like the SW1/4 of section 18 (SC-25).

3) They are drilling, more or less, on a rectangular 500-foot grid, and he offers this grid to Asarco so that if we do further drilling in the south we could extend the pattern for ease of integration.

Other items:

The water problem is a problem and they have retained John Harshbarger for an evaluation. John says it will cost them a substantial amount to handle this in any underground operation.

Getty Oil is the other partner and very interested and, when Newmont pulled out, the relationship resumed to 50-50. Hanna is the manager by virtue of having an office here.

Newmont has no retained interest of any kind nor is any payment due Newmont.

Lowell and Associates handle all the geology, etc.; Clark Arnold is the principal investigator and all work is done in Tucson. Mounts is the field hand and brings the core, reports, etc. in every other day.

Fault problems and/or pre-gravel topography interpretation are creating abundant problems in elevation, mineral trends, etc. Notwithstanding these facts, Hanna-Getty believe the units of copper are sufficient and they are expanding as they can. The recent National Exhibition and private parcel pickups were not basic mineral potential trends but will be needed in any future operations. Steve feels that it is only a matter of time before the area is unitized. He cannot reason why Newmont would pull out unless they have large reserves of +0.4-0.5% that they can get at easier than at Casa Grande.

Yesterday, August 30, was the first day that all four core rigs were getting core at the same time. One rig was doing redrilling after being down for 6 weeks and so the core wasn't new, but it was core!

The rigs are running better and he attributes it to a little more concern on Hanna's part. Lowell etc. are letting the drillers and Joy run the rigs.

Hanna looked into the Francisco Grande and admits it is a losing proposition -- but that the golf course is the major drain. Thus they may still be interested via help from another party or by closing the major drain and picking up the hotel trade (and/or letting someone else have the hotel while they take the surrounding ground).

They are interested in the NAAC ground but are confronted with numerous problems.

There seemed to be no qualms that Hanna and Getty are in for the long pull and will consolidate their position the best they can.

James D. Sell
James D. Sell

JDS:lb

cc: HGKreis