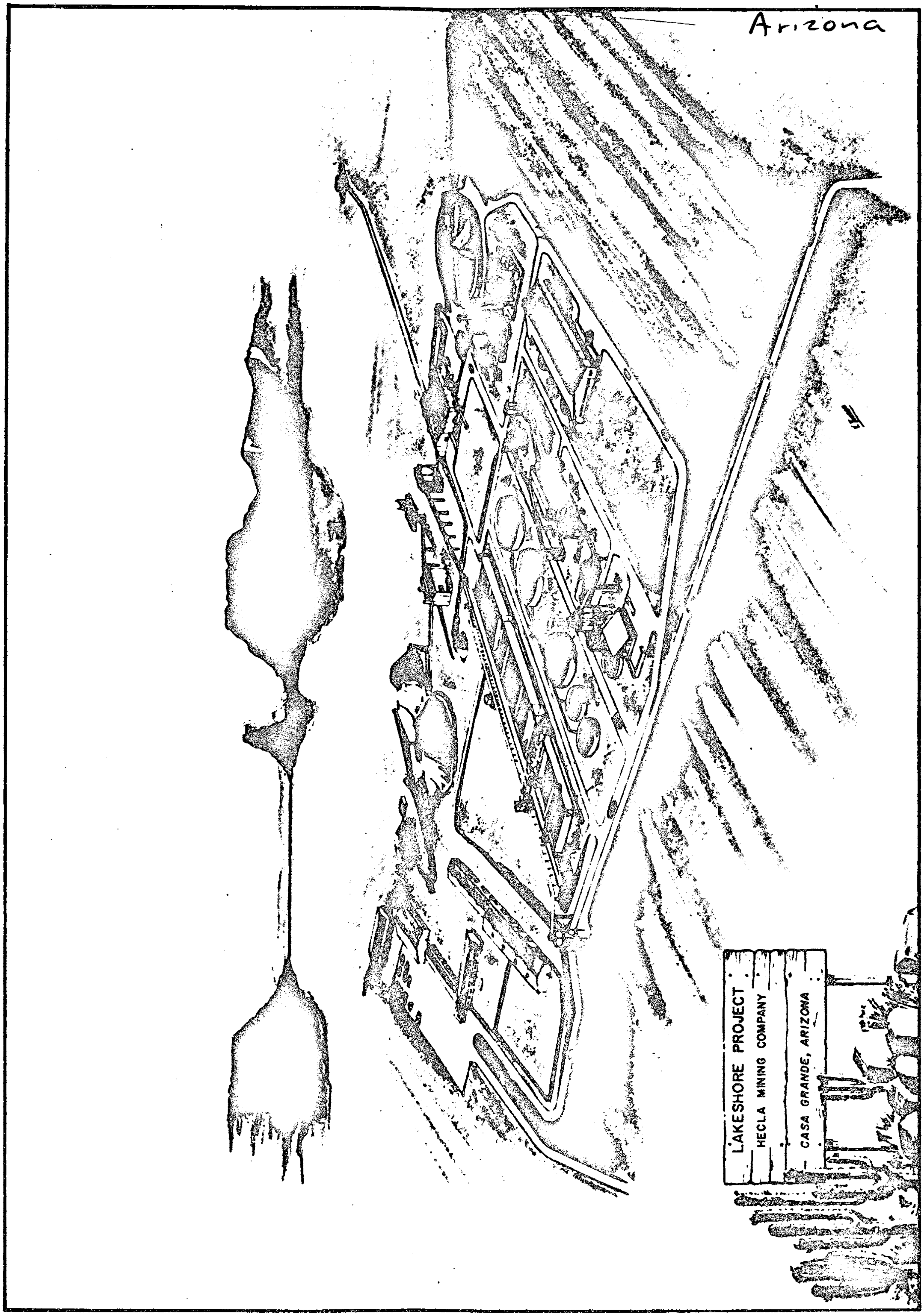
CONTACT INFORMATION
Mining Records Curator
Arizona Geological Survey
3550 N. Central Ave, 2nd floor
Phoenix, AZ, 85012
602-771-1601
http://www.azgs.az.gov
inquiries@azgs.az.gov

File: Lakeshore Mine
Arizona



ARIZONA SECTION

Society of Mining Engineers
Underground Mining Division
Spring Meeting

May 18, 1974

PROGRAM

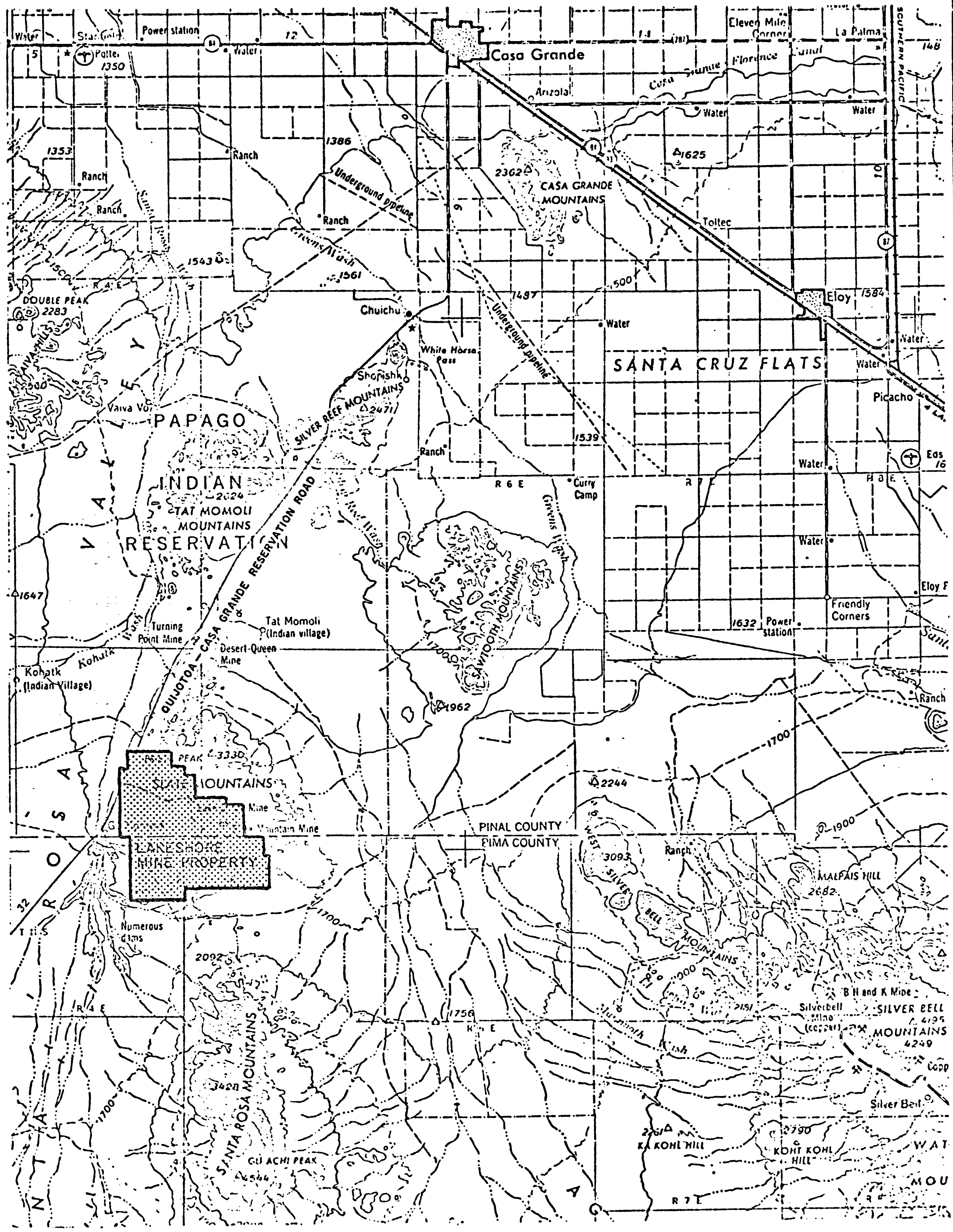
Registration	8:00-9:00 a.m.
Tours	9:00-12:30 p.m.
Lunch	12:30-1:45 p.m.
Program	1:45-3:30 p.m.
Welcoming	J. H. Hunter-Project Manager
Location & History	Craig Hansen-Geologist
Geology	Dan Munter-Geologist
Mine Planning	Hans Nilberg-Mine Engineer
Shotcrete	Jeremiah Chitunda-Mine Engineer
Plant Facilities	Tom Phillips-Chief Elec.&Mech. Eng.
Metallurgy	J. G. Craig-Plant Sup't

LAKESHORE MINE
HECLA MINING COMPANY

LAKESHORE

AT A GLANCE

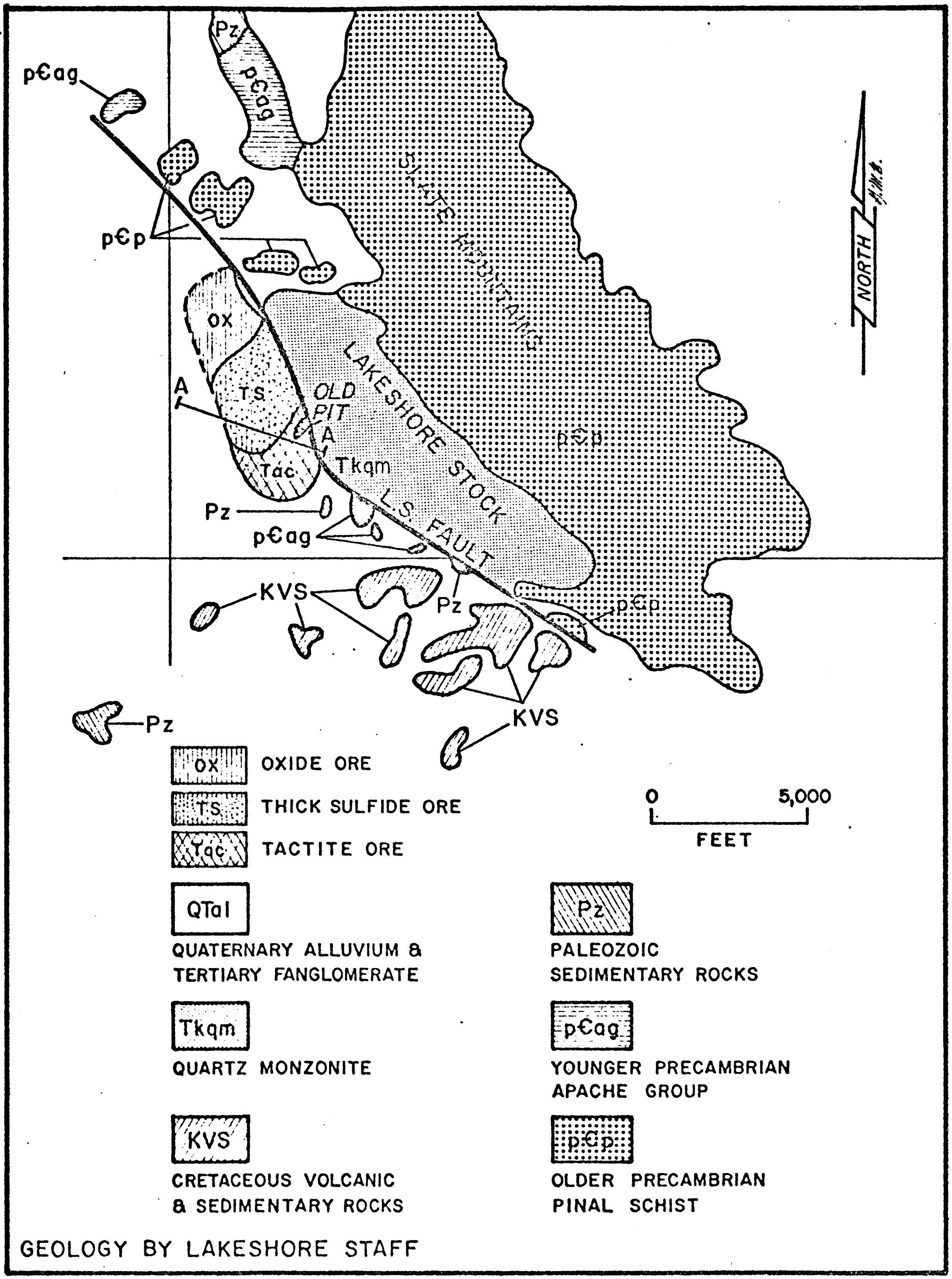
Location:	Slate Mountains 28 miles south-southwest of Casa Grande, Arizona 70 miles south of Phoenix, and 60 miles northwest of Tucson.
Elevation:	1900 feet above sea level
Ecosystem:	Typical Sonoran Desert
Temperature Range: (1970 - 1973 records)	22° F Low 116° F High
Annual Precipitation:	8 inches
Property:	10,500 acres
Ownership:	Leased from The Papago Tribe by El Paso Natural Gas Co. (50%) and Hecla Mining Co. (50%)
Operator:	Hecla Mining Co.
Work Force:	1200 maximum (construction and development phase) 1200 (production)
Mining Method:	Underground
Ore Treatment:	Hydrometallurgical
Planned Production:	9,150 tons/day sulfide ore 6,450 tons/day oxide ore



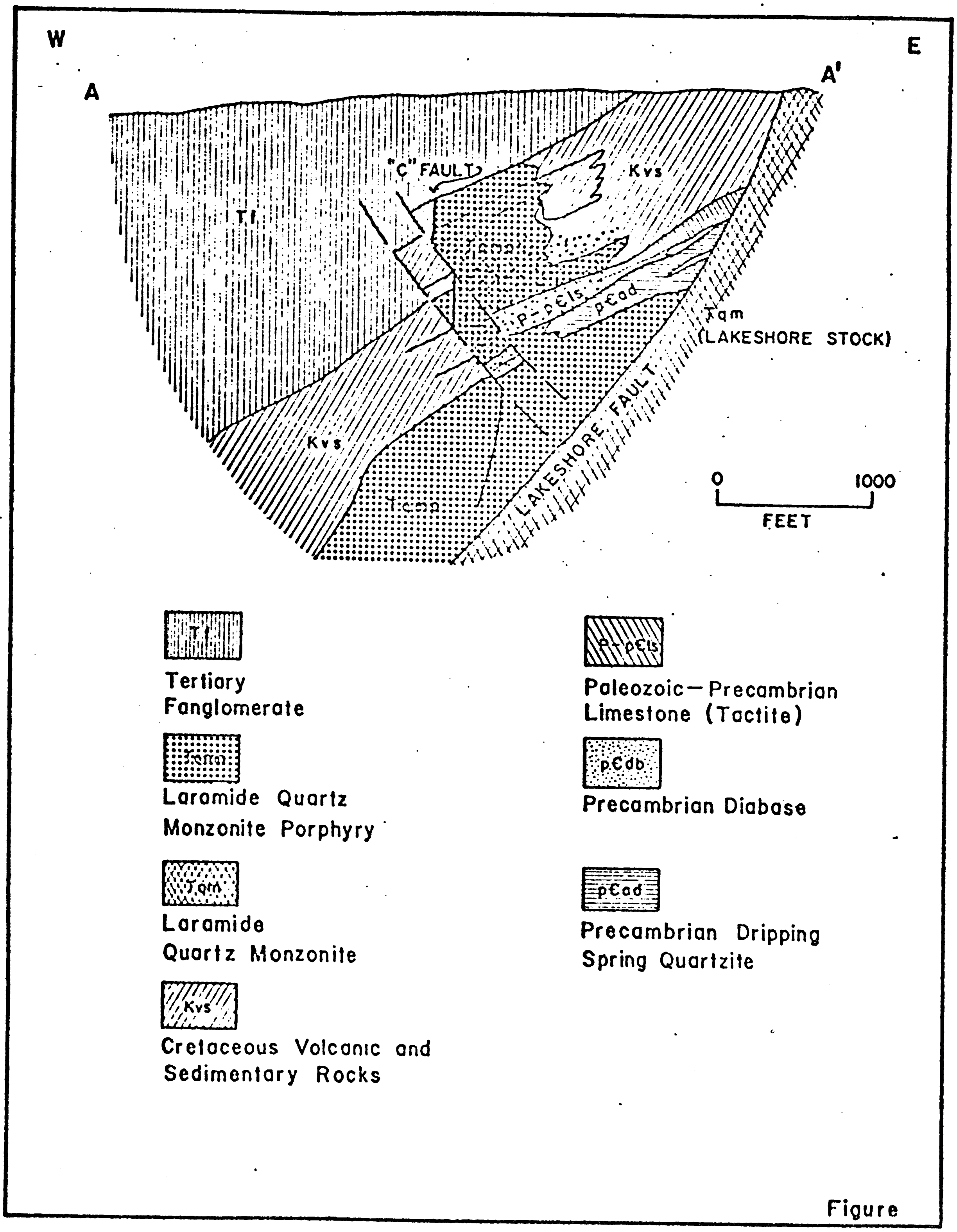
INDEX MAP SHOWING LOCATION OF LAKESHORE MINE PROPERTY

SCALE: 1" = 4 miles

Fig. 1

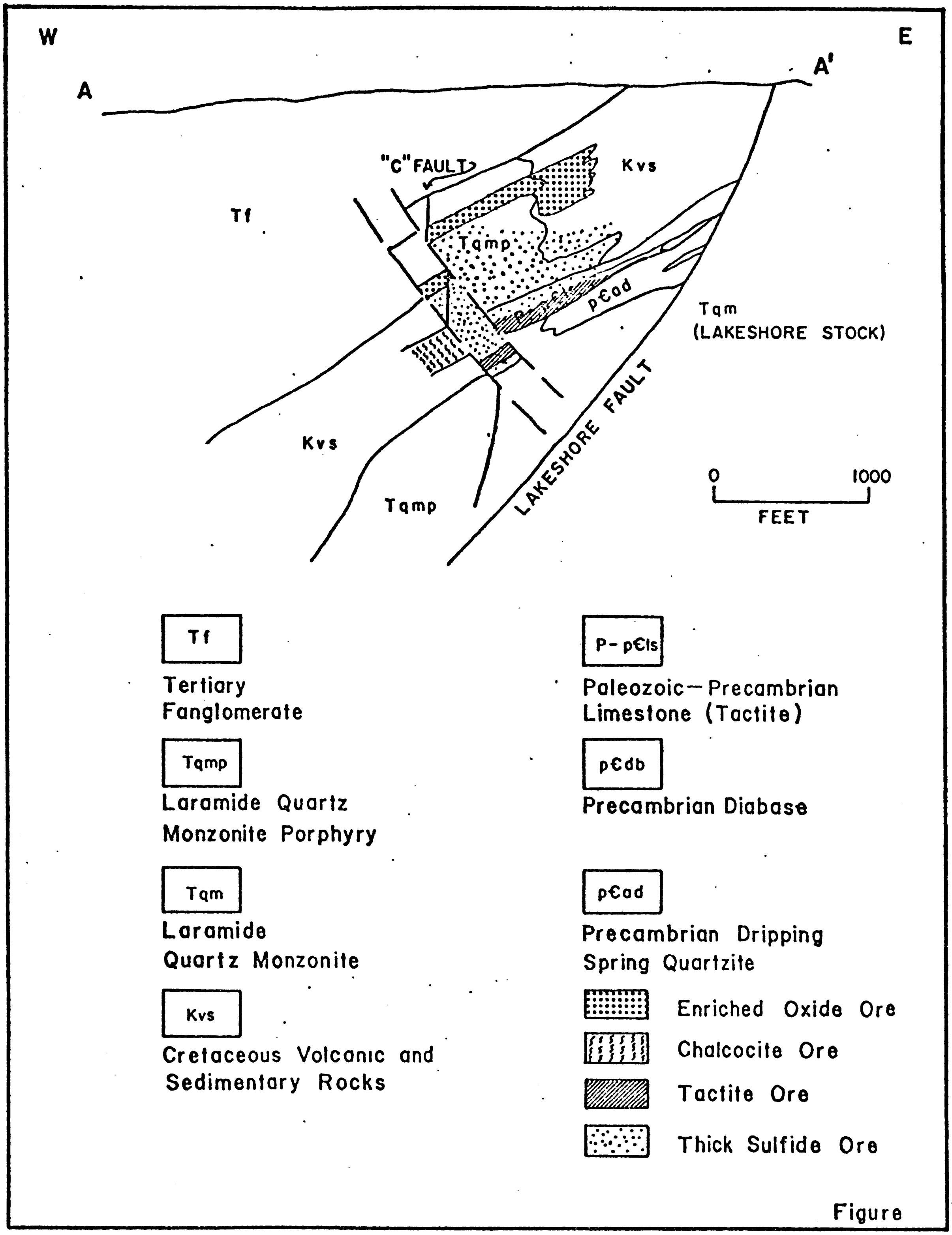


SURFACE GEOLOGY, LAKESHORE MINING AREA

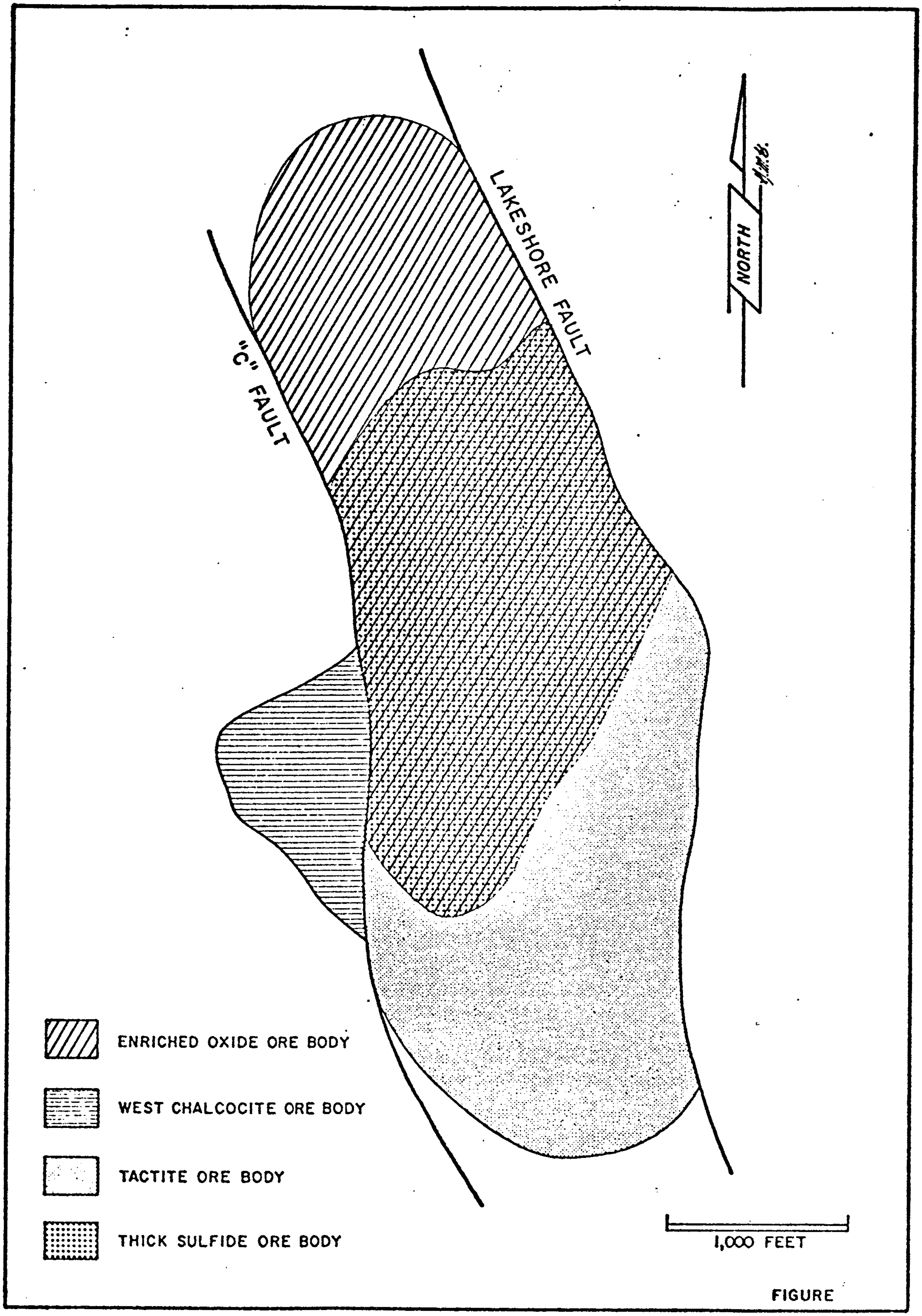


Figure

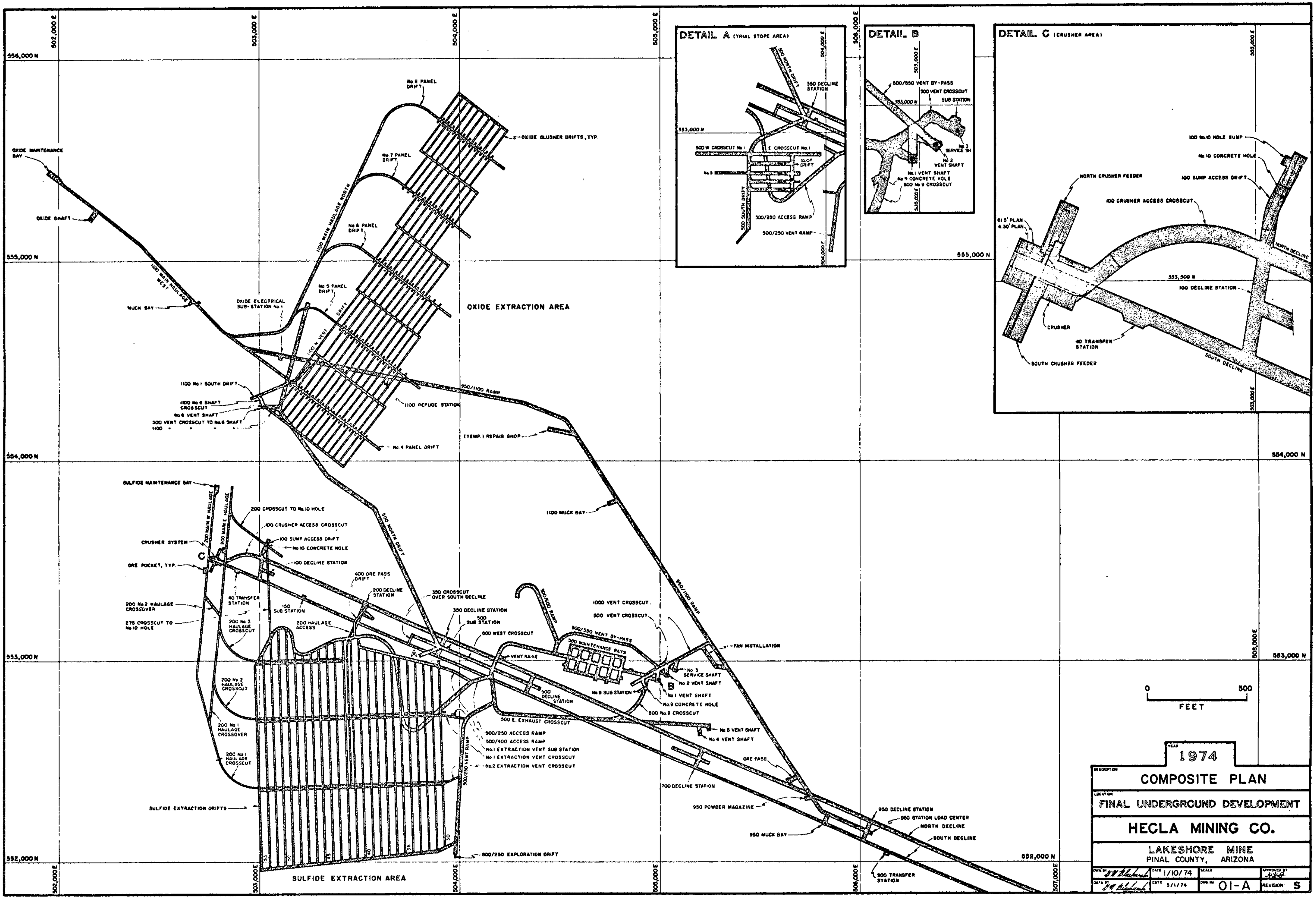
GENERALIZED GEOLOGIC CROSS SECTION, LAKESHORE MINE, ARIZONA



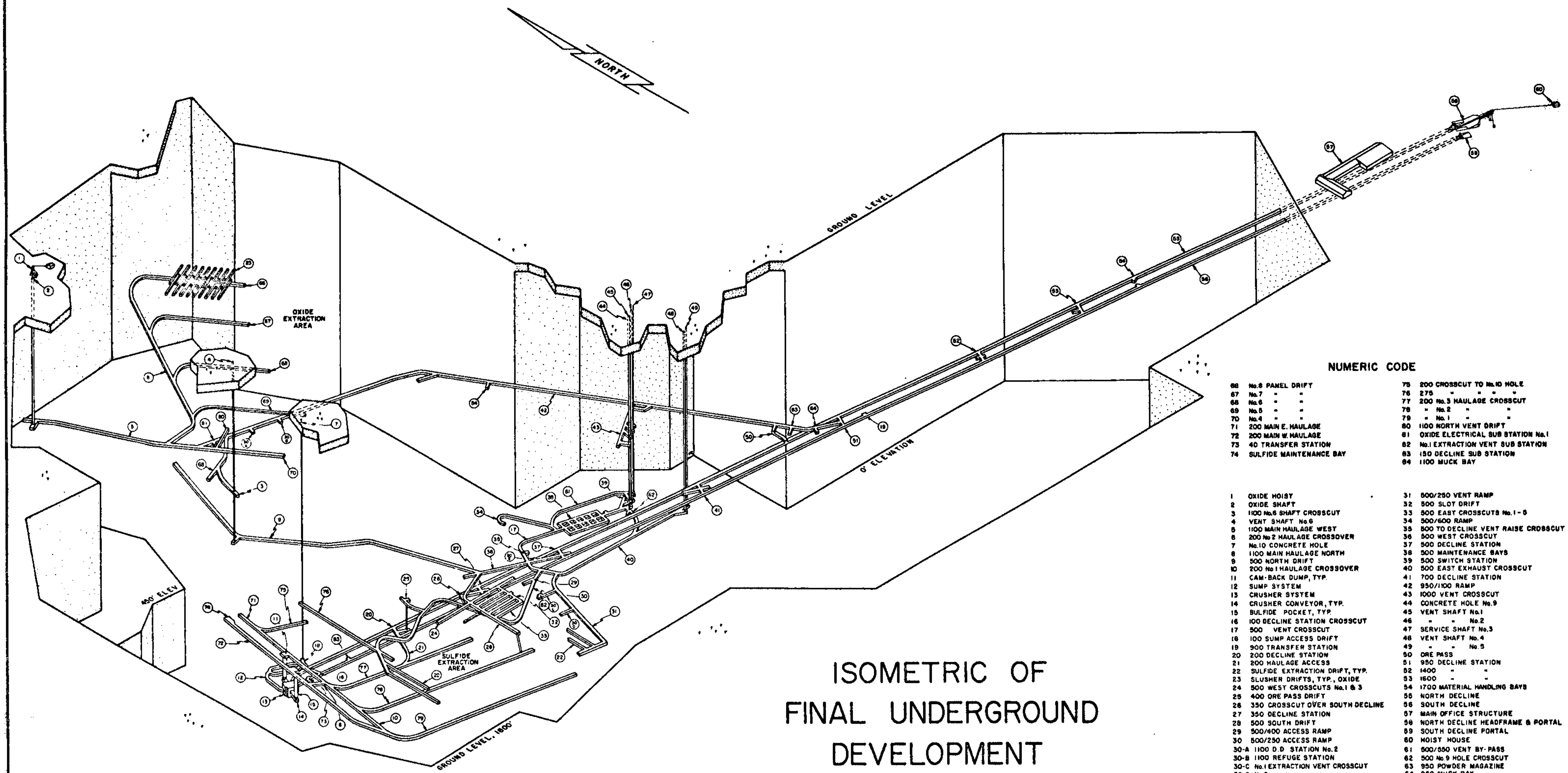
GENERALIZED ECONOMIC CROSS SECTION, LAKESHORE MINE, ARIZONA



GENERALIZED COMPOSITE ECONOMIC PLAN: LAKESHORE ORE BODY



DETAIL A (TRIAL STOPE AREA)
500 NORTH DRIFT
350 DECLINE STATION
500 W CROSSCUT No. 1
E CROSSCUT No. 1
SLOT DRIFT
500 SOUTH DRIFT
500/250 ACCESS RAMP
500/250 VENT RAMP
DETAIL B
500/550 VENT BY-PASS
500 VENT CROSSCUT
SUB STATION
No. 3 SERVICE SH
No. 2 VENT SHAFT
No. 1 VENT SHAFT
No. 9 CONCRETE HOLE
500 No. 9 CROSSCUT
DETAIL C (CRUSHER AREA)
100 No. 10 HOLE SUMP
No. 10 CONCRETE HOLE
100 SUMP ACCESS DRIFT
NORTH CRUSHER FEEDER
100 CRUSHER ACCESS CROSSCUT
NORTH DECLINE
100 DECLINE STATION
CRUSHER
40 TRANSFER STATION
SOUTH CRUSHER FEEDER
SOUTH DECLINE
OXIDE MAINTENANCE BAY
OXIDE SHAFT
1100 MAIN HAULAGE WEST
MUCK BAY
1100 MAIN HAULAGE NORTH
No. 8 PANEL DRIFT
No. 7 PANEL DRIFT
No. 6 PANEL DRIFT
No. 5 PANEL DRIFT
No. 4 PANEL DRIFT
OXIDE SLUSHER DRIFTS, TYP.
OXIDE EXTRACTION AREA
OXIDE ELECTRICAL SUB-STATION No. 1
1100 No. 1 SOUTH DRIFT
1100 No. 6 SHAFT CROSSCUT
No. 6 VENT SHAFT
500 VENT CROSSCUT TO No. 6 SHAFT
1100 REFUGE STATION
950/1100 RAMP
(TEMP.) REPAIR SHOP
1100 MUCK BAY
SULFIDE MAINTENANCE BAY
200 MAIN W HAULAGE
200 MAIN E HAULAGE
CRUSHER SYSTEM
ORE POCKET, TYP.
200 CROSSCUT TO No. 10 HOLE
100 CRUSHER ACCESS CROSSCUT
100 SUMP ACCESS DRIFT
No. 10 CONCRETE HOLE
100 DECLINE STATION
400 ORE PASS DRIFT
200 DECLINE STATION
300 NORTH DRIFT
350 CROSSCUT OVER SOUTH DECLINE
350 DECLINE STATION
500 SUB STATION
600 WEST CROSSCUT
500/500 RAMP
500/550 VENT BY-PASS
500 MAINTENANCE BAYS
VENT RAISE
1000 VENT CROSSCUT
500 VENT CROSSCUT
FAN INSTALLATION
No. 3 SERVICE SHAFT
No. 2 VENT SHAFT
No. 9 SUB STATION
No. 1 VENT SHAFT
No. 9 CONCRETE HOLE
500 No. 9 CROSSCUT
500 DECLINE STATION
500 E. EXHAUST CROSSCUT
No. 5 VENT SHAFT
No. 4 VENT SHAFT
40 TRANSFER STATION
150 SUB STATION
200 HAULAGE ACCESS
200 No. 2 HAULAGE CROSSOVER
275 CROSSCUT TO No. 10 HOLE
200 No. 3 HAULAGE CROSSCUT
200 No. 2 HAULAGE CROSSCUT
200 No. 1 HAULAGE CROSSOVER
200 No. 1 HAULAGE CROSSCUT
500/250 ACCESS RAMP
500/400 ACCESS RAMP
No. 1 EXTRACTION VENT SUB STATION
No. 1 EXTRACTION VENT CROSSCUT
No. 2 EXTRACTION VENT CROSSCUT
500/250 VENT RAMP
SULFIDE EXTRACTION DRIFTS
500/250 EXPLORATION DRIFT
SULFIDE EXTRACTION AREA
700 DECLINE STATION
ORE PASS
950 POWDER MAGAZINE
950 MUCK BAY
950 DECLINE STATION
950 STATION LOAD CENTER
NORTH DECLINE
SOUTH DECLINE
900 TRANSFER STATION
0 500 FEET
1974
COMPOSITE PLAN
FINAL UNDERGROUND DEVELOPMENT
HECLA MINING CO.
LAKESHORE MINE
PINAL COUNTY, ARIZONA
DATE 1/10/74
DATE 5/1/74
01-A
REVISION S



NUMERIC CODE

66	No.8 PANEL DRIFT	75	200 CROSSCUT TO No.10 HOLE
67	No.7 " "	76	275 " " " "
68	No.6 " "	77	200 No.3 HAULAGE CROSSCUT
69	No.5 " "	78	" No.2 " "
70	No.4 " "	79	" No.1 " "
71	200 MAIN E. HAULAGE	80	1100 NORTH VENT DRIFT
72	200 MAIN W. HAULAGE	81	OXIDE ELECTRICAL SUB STATION No.1
73	40 TRANSFER STATION	82	No.1 EXTRACTION VENT SUB STATION
74	SULFIDE MAINTENANCE BAY	83	150 DECLINE SUB STATION
		84	1100 MUCK BAY

1	OXIDE HOIST	31	500/250 VENT RAMP
2	OXIDE SHAFT	32	500 SLOT DRIFT
3	1100 No.6 SHAFT CROSSCUT	33	500 EAST CROSSCUTS No.1 - 5
4	VENT SHAFT No.6	34	500/600 RAMP
5	1100 MAIN HAULAGE WEST	35	500 TO DECLINE VENT RAISE CROSSCUT
6	200 No 2 HAULAGE CROSSOVER	36	500 WEST CROSSCUT
7	No.10 CONCRETE HOLE	37	500 DECLINE STATION
8	1100 MAIN HAULAGE NORTH	38	500 MAINTENANCE BAYS
9	500 NORTH DRIFT	39	500 SWITCH STATION
10	200 No 1 HAULAGE CROSSOVER	40	500 EAST EXHAUST CROSSCUT
11	CAM-BACK DUMP, TYP.	41	700 DECLINE STATION
12	SUMP SYSTEM	42	950/1100 RAMP
13	CRUSHER SYSTEM	43	1000 VENT CROSSCUT
14	CRUSHER CONVEYOR, TYP.	44	CONCRETE HOLE No.9
15	SULFIDE POCKET, TYP.	45	VENT SHAFT No.1
16	100 DECLINE STATION CROSSCUT	46	" " No.2
17	500 VENT CROSSCUT	47	SERVICE SHAFT No.3
18	100 SUMP ACCESS DRIFT	48	VENT SHAFT No.4
19	900 TRANSFER STATION	49	" " No.5
20	200 DECLINE STATION	50	ORE PASS
21	200 HAULAGE ACCESS	51	950 DECLINE STATION
22	SULFIDE EXTRACTION DRIFT, TYP.	52	1400 " "
23	SLUSHER DRIFTS, TYP., OXIDE	53	1600 " "
24	500 WEST CROSSCUTS No.1 & 3	54	1700 MATERIAL HANDLING BAYS
25	400 ORE PASS DRIFT	55	NORTH DECLINE
26	350 CROSSCUT OVER SOUTH DECLINE	56	SOUTH DECLINE
27	350 DECLINE STATION	57	MAIN OFFICE STRUCTURE
28	500 SOUTH DRIFT	58	NORTH DECLINE HEADFRAME & PORTAL
29	500/400 ACCESS RAMP	59	SOUTH DECLINE PORTAL
30	500/250 ACCESS RAMP	60	HOIST HOUSE
30-A	1100 D.D STATION No.2	61	600/550 VENT BY-PASS
30-B	1100 REFUGE STATION	62	500 No.9 HOLE CROSSCUT
30-C	No.1 EXTRACTION VENT CROSSCUT	63	950 POWDER MAGAZINE
30-D	No.2 " "	64	950 MUCK BAY
30-E	500 SUB STATION	65	1100 No.1 S. DRIFT

COLOR CODE

735	DECLINES, DECLINE STATIONS & SUMP SYSTEM
745	500 LEVEL DEVELOPMENT
7385	1100 " "
7405	ORE HANDLING SYSTEM
747	VENT SHAFTS & RAISES

ISOMETRIC OF FINAL UNDERGROUND DEVELOPMENT

HECLA MINING COMPANY

LAKESHORE MINE

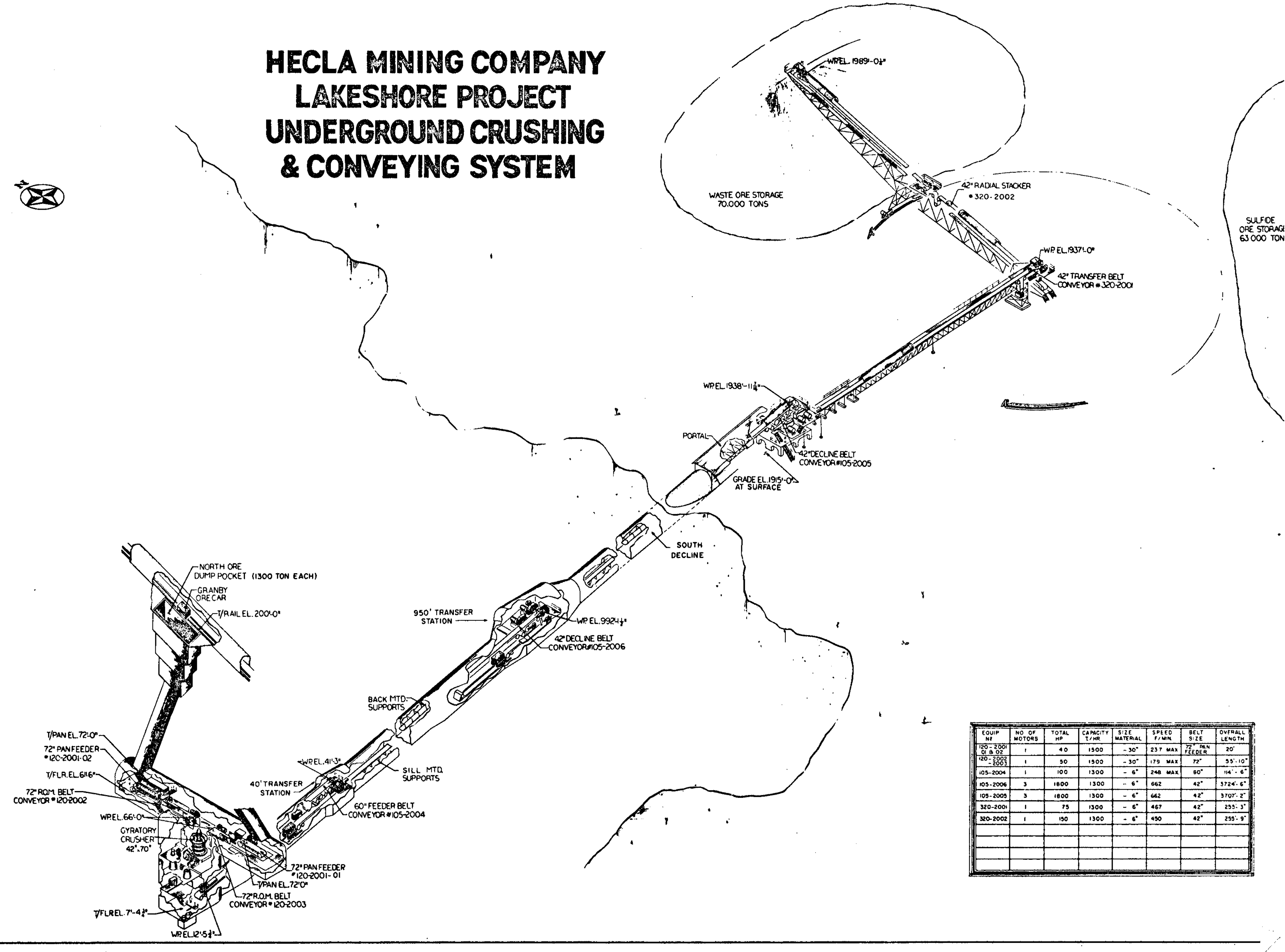
DWG. BY: Y.M. Blochanski DATE: 5/1/73

SCALE 1" = 324'

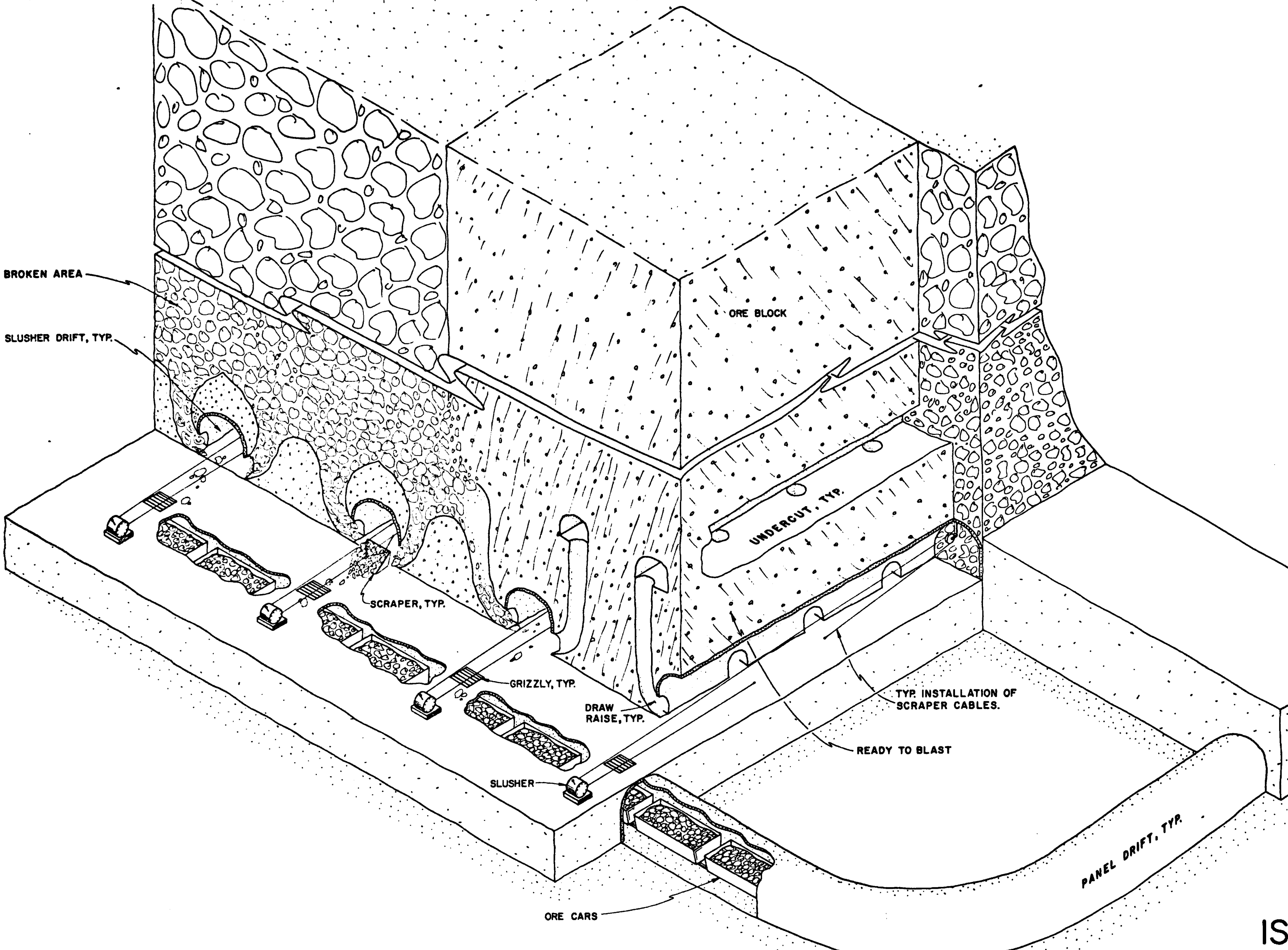
REV. L 1/19/74

DWG. No: 002-B

HECLA MINING COMPANY
LAKESHORE PROJECT
UNDERGROUND CRUSHING & CONVEYING SYSTEM



EQUIP No	NO. OF MOTORS	TOTAL HP	CAPACITY T/HR.	SIZE MATERIAL	SPEED F/MIN.	BELT SIZE	OVERALL LENGTH
120-2001 01 & 02	1	40	1500	-30"	237 MAX	72" PAN FEEDER	20'
120-2002 -2003	1	50	1500	-30"	179 MAX	72"	55'-10"
105-2004	1	100	1300	- 6"	248 MAX	60"	114'-6"
105-2006	3	1800	1300	- 6"	662	42"	3724'-6"
105-2005	3	1800	1300	- 6"	662	42"	3707'-2"
320-2001	1	75	1300	- 6"	467	42"	255'-3"
320-2002	1	150	1300	- 6"	450	42"	255'-9"



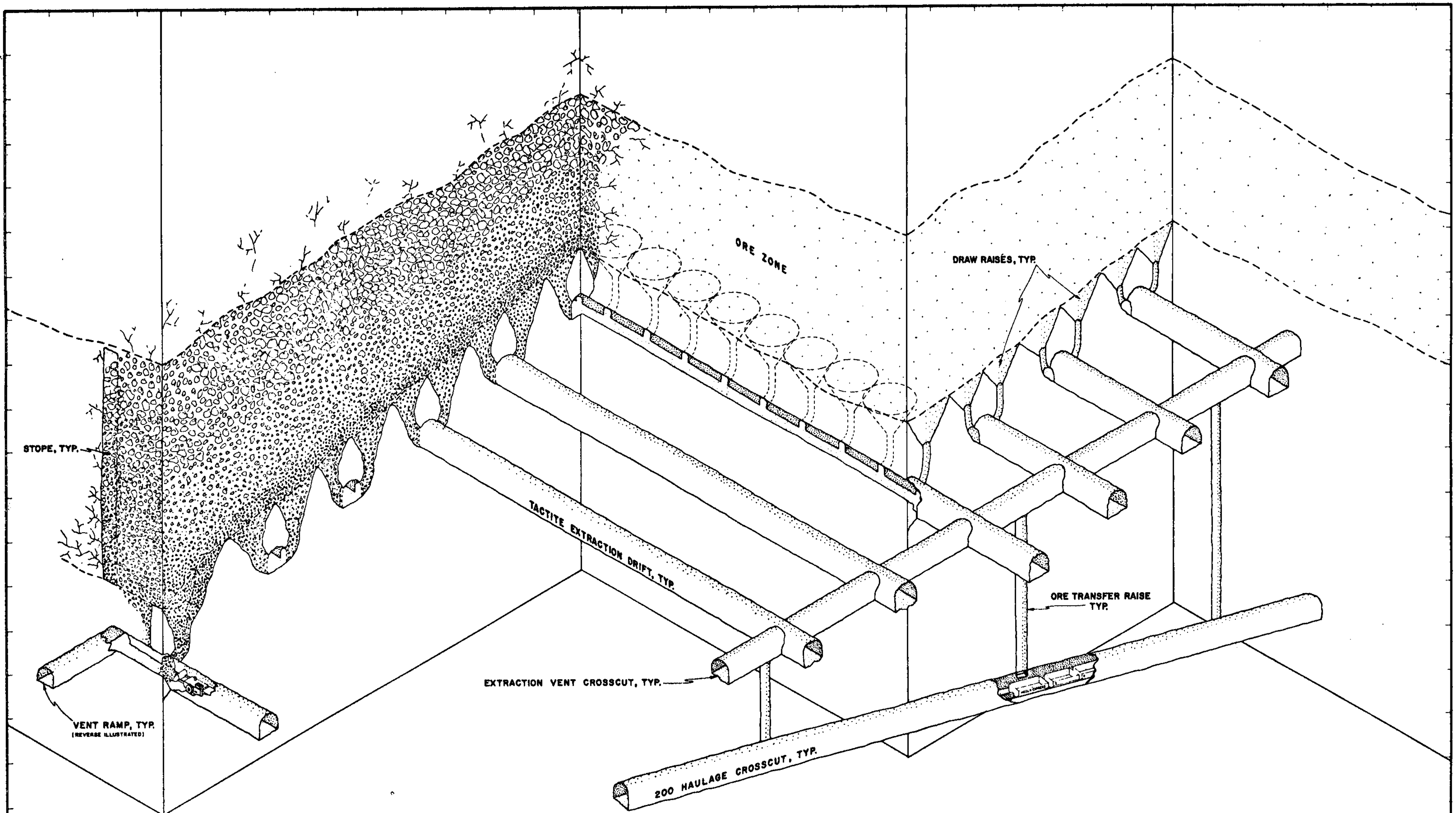
ISOMETRIC OF OXIDE CAVING SYSTEM

HECLA MINING COMPANY

LAKESHORE PROJECT

DWG. BY: J.M. Blachardi DATE: 12/6/73

DWG. 03-B



ISOMETRIC OF SULFIDE CAVING SYSTEM

HECLA MINING COMPANY

LAKESHORE PROJECT

DWG. BY: H.H. Biesbarski DATE: 4/23/74

DWG. 04-B

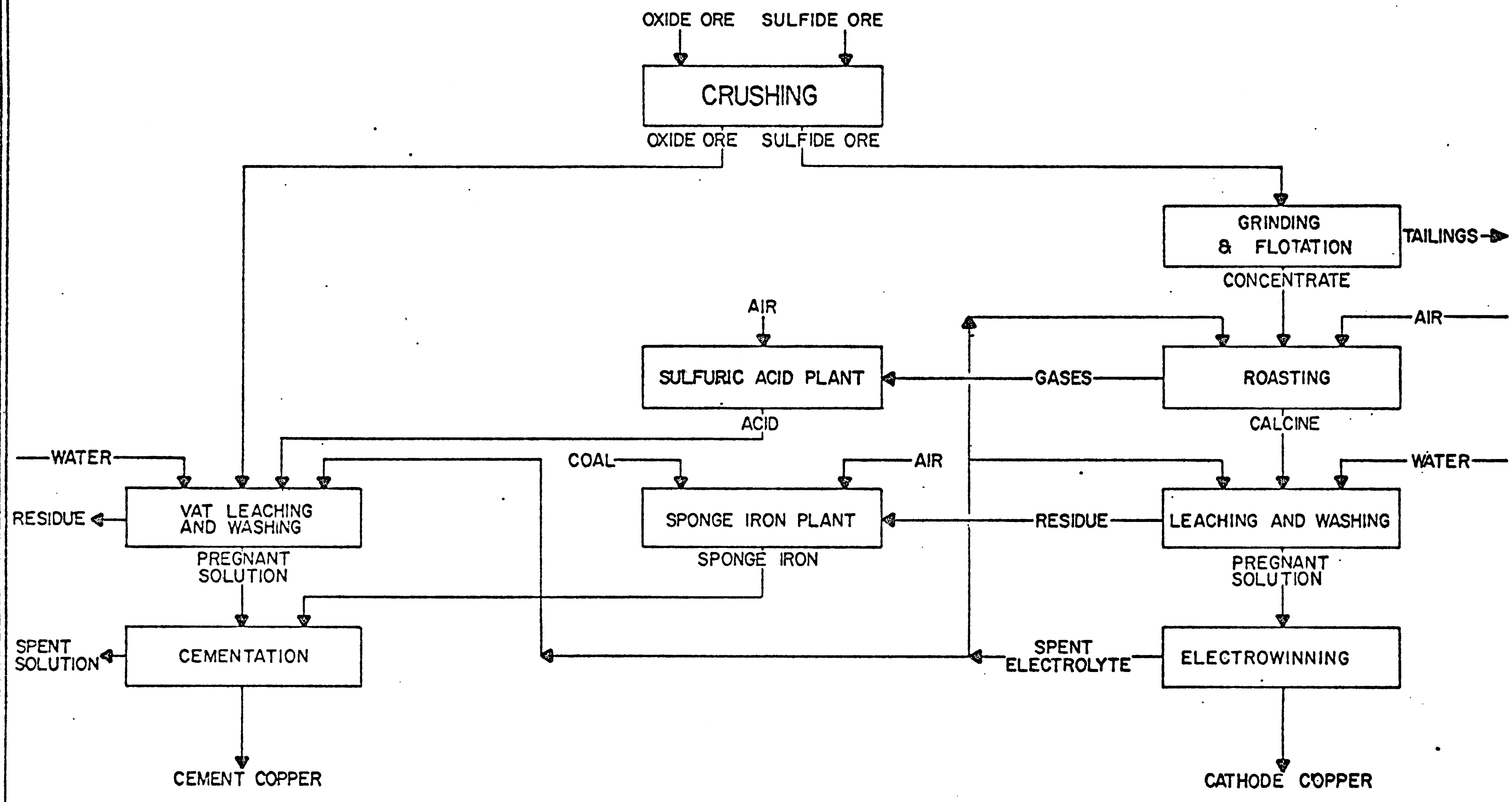
PROPOSED PLANT SURFACE FACILITIES

HECLA MINING COMPANY

LAKESHORE MINE

CASA GRANDE, ARIZONA

Lakeshore Project
Plant Flowsheet



3 copies

12/15/69

PBC

El Paso Natural Gas Company

El Paso, Texas 79999

November 28, 1969

Mr. E. Grover Heinrichs
Vice President
Heinrichs Geoexploration Company
P. O. Box 5671
Tucson, Arizona 85703

Dear Mr. Heinrichs:

In answer to your request I am enclosing a copy of the paper on exploration at Lakeshore that I prepared for the annual meeting of the New Mexico Mining Association which was held in El Paso on November 16 - 19, 1969.

Thank you.

Sincerely,

Claude E. Barron

Claude E. Barron
Senior Mining Geologist
Mining Division

CEB:mp

EXPLORATION AT LAKESHORE MINE

Pinal County, Arizona

By

Claude E. Barron
Senior Mining Geologist
El Paso Natural Gas Company

ABSTRACT

As the result of a general reconnaissance of the Slate Mountain area, an interpretation of the geology was made that assumed (1) the oxide tactite ore body in the Lakeshore Pit had been overturned by tilting to the northwest, (2) that these metasediments would be in place underlying the andesite west of the pit and would trend generally northwest parallel to the trend of the Slate Mountains, and (3) that the strong northwest and north-south fault and fracture system which was exposed in the pit would offer channels for migrating mineralized solutions permitting the deposition of sulphides at depth.

A proposed correlation of this interpretation with Induced Polarization anomalies involved an area that extended to the south and northwest of the Lakeshore Pit. This area was recommended for deep drilling to test the weak I. P. anomalies for sulphide mineralization.

Contour maps based on assay and geological data from gyroscopically surveyed drill holes offered control for delineation and computer evaluation of the discovered ore body.

EXPLORATION AT LAKESHORE MINE

Pinal County, Arizona

Claude E. Barron

Senior Mining Geologist

El Paso Natural Gas Company

INTRODUCTION

The Lakeshore mineral deposit outcrops on the southwest piedmont of the Slate Mountains in Section 25, T10S, R4E, Pinal County, Arizona. This location is in the Papago Indian Reservation, approximately 30 miles south of Casa Grande, Arizona.

In the Basin and Range Province of southwest Arizona, the Slate Mountains form an arcing outcrop that trends from northwest to north, and reaches an elevation of 3330 feet at Prieta Peak near the center of the range. The Lakeshore Mine, about 2 miles south of Prieta Peak, is at an elevation of approximately 1800 feet. Vegetation in the valley is of the desert variety, capable of surviving in the hot summer temperature and the few inches of annual precipitation.

PREVIOUS WORK

Rocks in the Slate Mountains were described in an unpublished thesis by Hogue (1) in 1940. The Lakeshore copper deposits were investigated by the U. S. Bureau of Mines (2) in 1950. Precambrian and Paleozoic sedimentary rocks of the area were described by McClymonds (3) in 1959. Geologic maps prepared by the Arizona Bureau of Mines (4) in 1960 show rocks in the Slate Mountain area range in age from Precambrian to Quaternary. Sedimentary rocks of the northern Slate Mountains have been described in detail in an unpublished thesis by Hammer (5) in 1961. Other work describing surface geology and sub-surface data obtained from shallow drilling is contained in several unpublished reports made by consultants for Transarizona.

HISTORY

The mineral outcrop, consisting primarily of copper silicates and iron oxides, was located by Trout and Atchison in the early 1880's. Abandoned in 1884, the property was relocated by B. S. Wilson in 1905. In 1914 Wilson sold the property to Frank M. and Charles Leonard.

The Leonards, who developed the ore body on three levels while working through a 225 foot vertical shaft, leased the property in 1917. This lease was terminated in 1919. The next noteworthy work to be conducted was an examination of the property by the U. S. Bureau of Mines in 1942 which initiated an investigation that started in 1948 and concluded with a report in 1950.

In November 1955, the three patented claims of the Lakeshore property and the Drake claims, consisting of three patented and 19 unpatented claims, were obtained by George Freeman under a lease-option agreement from Treasure State Mining Company. In 1956, a 580 acre lease surrounding these claims was obtained from the Bureau of Indian Affairs by Dwight McClure and George Freeman. In 1960 the Bureau of Indian Affairs approved an assignment of the lease to Transarizona Resources Inc.

El Paso Natural Gas Company's interest in the property was initiated by an invitation to examine the property in September 1962. At that time, the writer made an examination of the mine and plant. Transarizona had developed the mine as a small open pit. Exploration drilling on a closely-spaced drill pattern indicated $\pm$ 1.5 million tons of $\pm$ 1.75% copper oxide. Level maps and cross-sections prepared from the drill data indicated the mineral deposit formed a V-shaped trough that plunged to the southwest, and was controlled by faults.

The Plant had been designed for a copper segregation process that was followed by flotation.

As a result of the examination, a recommendation for a more complete evaluation of the property was made but the request was not approved. However, in June 1963, a limited amount of drilling was conducted in the open pit and a feasibility study of the segregation process was made.

In August 1966, under the direction of the Mining Division of El Paso Natural Gas Company, an induced Polarization survey was conducted on the Lakeshore property by McPhar Geophysical Limited and, at the same time, the writer began a general geological survey of the area.

In September 1966 a core drilling program was initiated to investigate the I. P. anomalies that were discovered on the property.

In February 1969, El Paso Natural Gas Company announced an agreement with Hecla Mining Company for development of a major new copper discovery made by the Mining Division on the Lakeshore property.

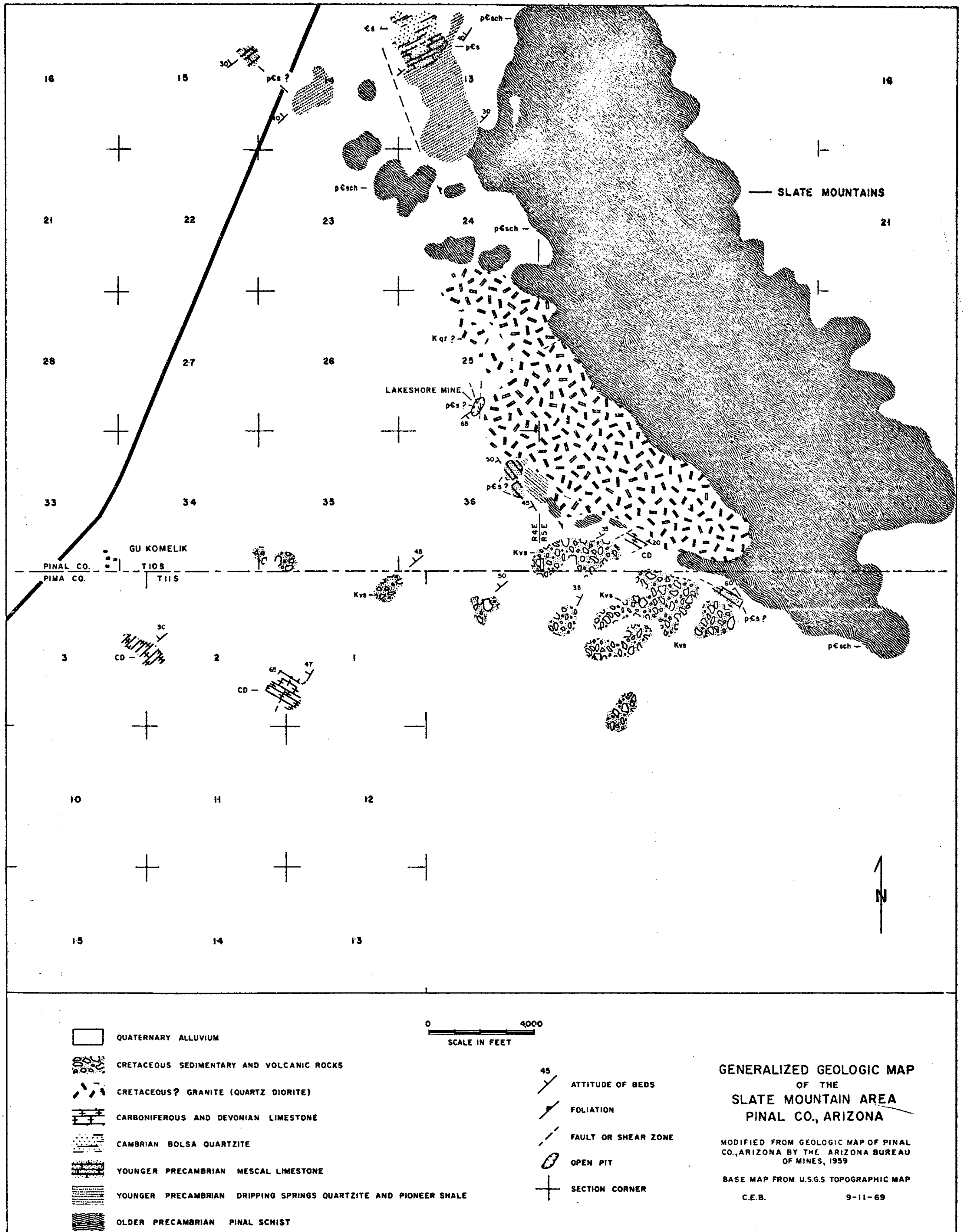
GENERAL GEOLOGY

Reconnaissance of the Slate Mountain Area

The Slate Mountains (Fig. 1), composed primarily of the Pinal Schist formation of Precambrian age (4), strike N ± 45W and dip ± 50° NE. Near the center of the mountains, an elongated mass of quartz diorite has intruded the schist. This intrusive mass tends to parallel the foliation of the schist and was identified as being Precambrian in age (4). However, recent work by P. E. Damon and R. L. Mauger (6) has dated this intrusive by the potassium-argon process as Laramide (Cretaceous-Tertiary). Along the northeast slopes of the mountains, the schist dips under the alluvium and fanglomerates at the edge of the valley.

At the north end of the Slate Mountains, the Pioneer Shale, the Dripping Springs Quartzite, and the Mescal Limestone of the Precambrian Apache Group (4) strike N ± 40° E and dip ± 45° NW. These northwest dipping metasediments overlie the northwest trending Pinal Schist with angular unconformity. Overlying the Apache Group is the Abrigo Limestone and Troy Quartzite of Early Cambrian age (4) and the limestone, quartzite and shales of Devonian and Carboniferous age (4). Along the southwest slope of the Slate Mountains and to the southeast, outcrops of these formations generally dip to the southwest and strike parallel with the trend of the mountains.

Around the southwest periphery of the Slate Mountains and protruding through the valley fill, are outlying hills of Devonian and Carboniferous limestone, Cretaceous volcanic and sedimentary rocks and Tertiary andesite and breccia (4). The Devonian



SLATE MOUNTAINS
LAKESHORE MINE
GU KOMELIK
PINAL CO.
PIMA CO.
T10S
T11S
R4E
R5E
p€sch
p€s
€s
Kqr ?
Kvs
CD
QUATERNARY ALLUVIUM
CRETACEOUS SEDIMENTARY AND VOLCANIC ROCKS
CRETACEOUS? GRANITE (QUARTZ DIORITE)
CARBONIFEROUS AND DEVONIAN LIMESTONE
CAMBRIAN BOLSA QUARTZITE
YOUNGER PRECAMBRIAN MESCAL LIMESTONE
YOUNGER PRECAMBRIAN DRIPPING SPRINGS QUARTZITE AND PIONEER SHALE
OLDER PRECAMBRIAN PINAL SCHIST
0 4000
SCALE IN FEET
ATTITUDE OF BEDS
FOLIATION
FAULT OR SHEAR ZONE
OPEN PIT
SECTION CORNER
N
GENERALIZED GEOLOGIC MAP
OF THE
SLATE MOUNTAIN AREA
PINAL CO., ARIZONA
MODIFIED FROM GEOLOGIC MAP OF PINAL CO., ARIZONA BY THE ARIZONA BUREAU OF MINES, 1959
BASE MAP FROM U.S.G.S. TOPOGRAPHIC MAP
C.E.B. 9-11-69

Fig. 1

and Carboniferous limestone and dolomite have been folded along an apparent northwest trending axis and then tilted to the northwest. In the area southwest of the Lakeshore mine, the breccia and the underlying Cretaceous volcanic and sedimentary rock strikes N $\pm$ 50° E and dips $\pm$ 45° NW.

Small faults have apparently displaced sedimentary bedding and igneous and sedimentary contacts in these outlying hills. However, any evidence of large faults has been covered by the alluvium. The poles of the measured attitudes of joints and fractures, plotted on a stereographic projection, indicates a preferred orientation of N 30° E with 45° SE dip, N 40° E with 45° NW dip, and N 65° E with 66° SE dip.

Geology of the Lakeshore Pit

At the Lakeshore Mine, a small open pit was excavated by Transarizona (Fig. 2). Near the center of the pit, mineralized banded tactite overlaid by a fine-grained quartzite, striking N $\pm$ 50 E and dipping $\pm$ 60° SE, was exposed. These metasediments terminate on the east side of the pit where they are in contact with diorite along a very strong oblique slip dip fault that strikes NW and dips 65° SW. Merging with this fault is a strong north-south fault that dips 74° W.

Along the west wall of the pit, altered and fractured andesite occurs on the footwall of an andesite and metasediment contact which shows slickensides. This contact, striking N $\pm$ 40° E and dipping $\pm$ 50° SE,forms the footwall of the oxide ore body.

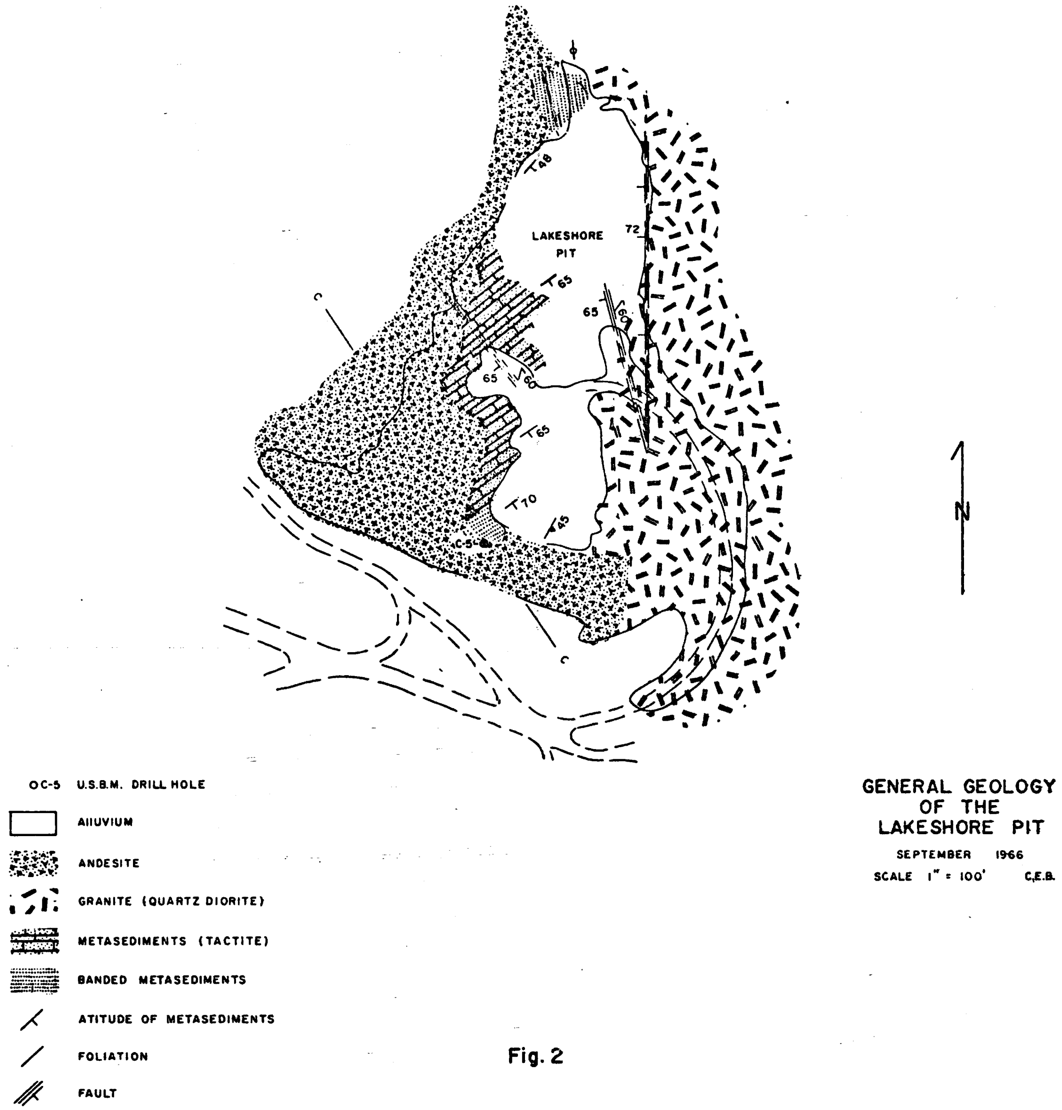

LAKESHORE PIT
N
GENERAL GEOLOGY
OF THE
LAKESHORE PIT
SEPTEMBER 1966
SCALE 1" = 100' C.E.B.
OC-5 U.S.B.M. DRILL HOLE
AIIUVIUM
ANDESITE
GRANITE (QUARTZ DIORITE)
METASEDIMENTS (TACTITE)
BANDED METASEDIMENTS
ATITUDE OF METASEDIMENTS
FOLIATION
FAULT

Fig. 2

At the north end of the pit, a fine-grained, banded quartzite, striking N $\pm$ 10° W with vertical dip, has been exposed in contact with the diorite on the footwall side of the NW striking fault zone.

The south end of the pit has been cut through highly altered and fractured andesite with foliation striking N $\pm$ 30° E and dipping $\pm$ 45° SE. This andesite overlays the metasedimentary rock and forms the hanging wall of the oxide ore body.

Drill hole data from close space drilling, conducted by Transarizona, indicated that the northeast end of the ore body had been offset to the northwest on the footwall side of the NW striking fault zone.

Drilling conducted by the U. S. Bureau of Mines (2) in 1948 had encountered quartzite underlying andesite at 460 feet in hole C-2, and at 270 feet in hole C-4. In hole C-5, from 455 feet to 545 feet, copper oxides were encountered in a section described by the Bureau as a shear zone (Fig. 3).

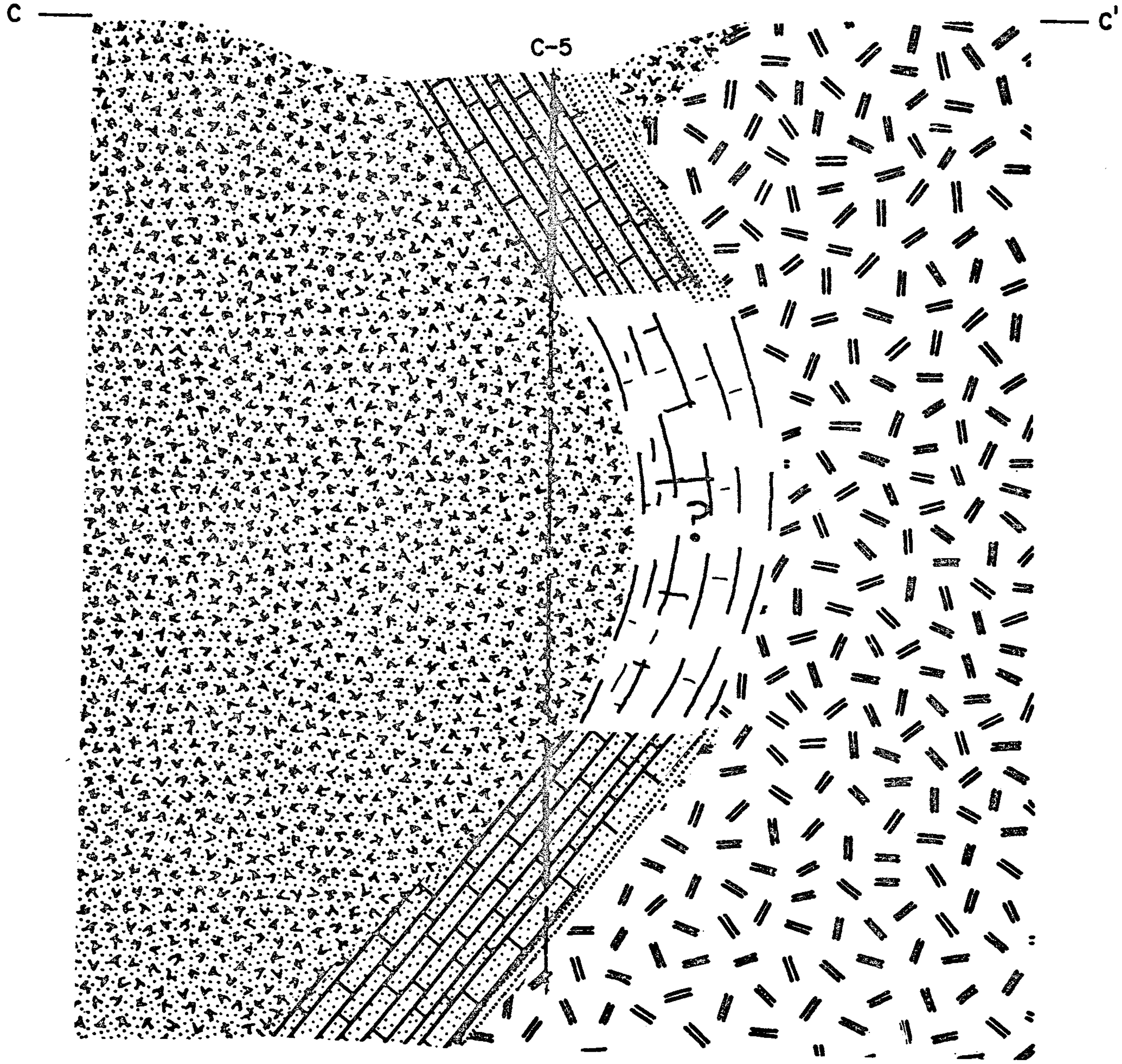
GEOPHYSICAL SURVEY

Induced Polarization Survey

During August and September of 1966, a combined resistivity and induced polarization survey was conducted on the mineral lease and the claims southwest of the Slate Mountains (Fig. 4).

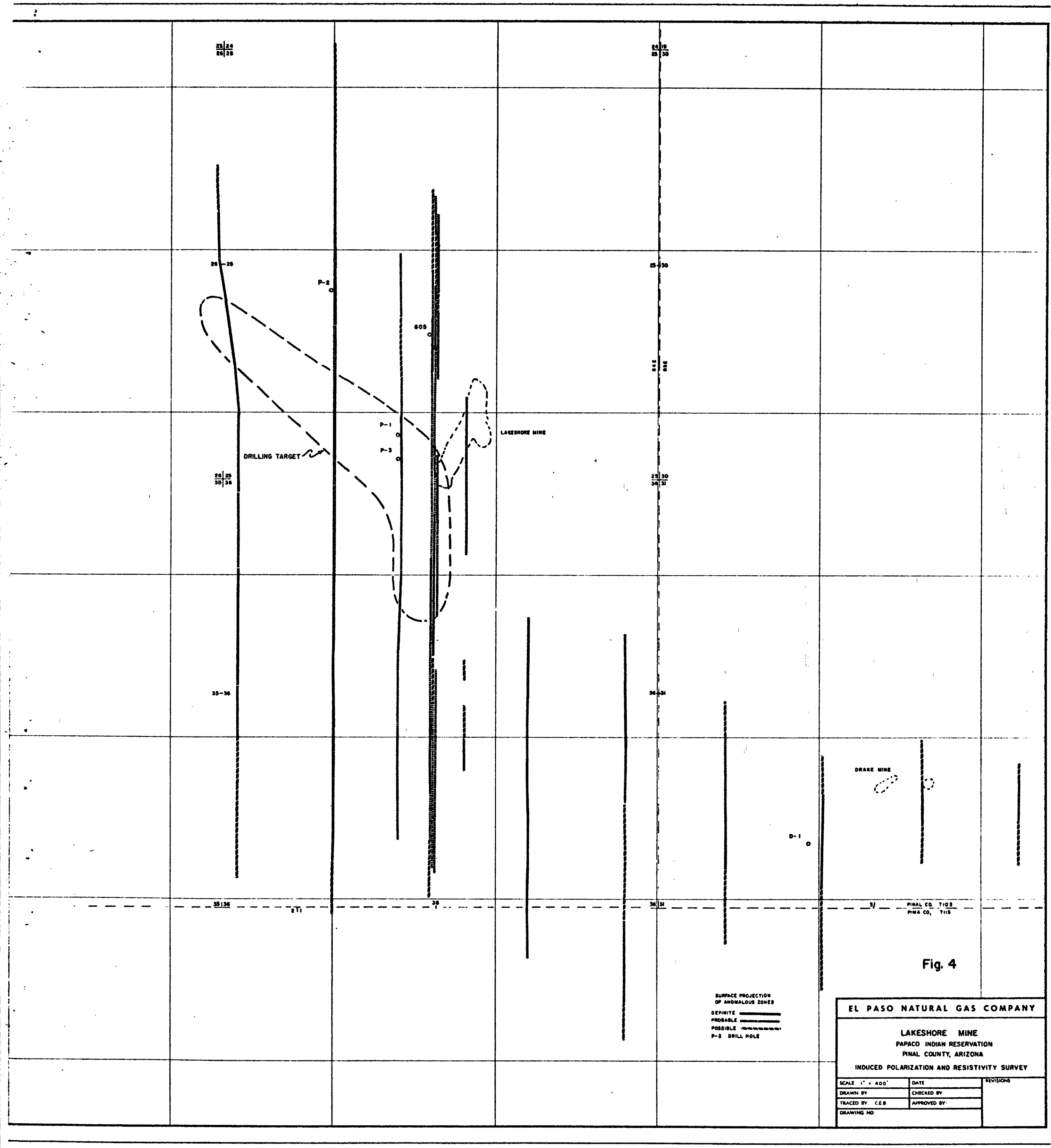
A dipole-dipole electrode configuration, with 500 foot electrode spread length, was used to apply current and measure potential along parallel north-south lines, with $\pm$ 1200 foot east-west separations. Alternating current of 0. 3 and 5 cycles per second were used to determine the I. P. effect. In addition to the north-south survey, an east-west survey, using shorter electrode spread lengths, was made over the Lakeshore fault system.

Fig. 3



CROSS-SECTION C-C'
LOOKING N 55 E
SCALE 1" = 100'

INTERPRETATION, BY THE WRITER, OF THE MINERALIZATION ENCOUNTERED BY THE U.S.B.M. IN CHURN DRILL HOLE No. C-5



P-2
605
P-1
P-3
LAKESHORE MINE
DRILLING TARGET
DRAKE MINE
D-1
PINAL CO. T10S
PIMA CO. T11S
SURFACE PROJECTION
OF ANOMALOUS ZONES
DEFINITE
PROBABLE
POSSIBLE
P-2 DRILL HOLE
EL PASO NATURAL GAS COMPANY
LAKESHORE MINE
PAPACO INDIAN RESERVATION
PINAL COUNTY, ARIZONA
INDUCED POLARIZATION AND RESISTIVITY SURVEY
SCALE 1" = 400'
DATE
REVISIONS
DRAWN BY
CHECKED BY
TRACED BY C.E.B
APPROVED BY
DRAWING NO.

Fig. 4

Testing I. P. Anomalies

Several I. P. anomalies were recorded along the north-south survey lines. To test the anomalies, core drilling began at locations D-1 and 605 (Fig. 4). Core hole D-1 was located in the area of a reported anomaly ± 1200 feet southwest of the Drake oxide pit. This test hole was cored for 500 feet through andesite breccia without encountering sulphide mineralization and then abandoned. Hole 605 was an old rotary drill hole which had been terminated in a weakly mineralized porphyry at a drill depth of ± 288 feet. This location was on an I. P. anomaly ± 750 feet north of the Lakeshore pit. Core drilling began at 288 feet and copper oxide mineralization was encountered along fractures in an altered biotite porphyry and in and near the contacts of the biotite porphyry and sections of altered andesite of varying thickness. This hole was anandoned at 790 feet because of drilling conditions without encountering sulphide mineralization.

With the completion of D-1 and 605, the testing of two additional I. P. anomalies began at locations P-1 and P-2 (Fig. 4). Drill hole P-2 was located on an I. P. anomaly ± 1500 feet northwest of hole 605. Core drilling was conducted through 800 feet of fanglomerate without encountering oxide or sulphide mineralization, and the hole was abandoned. The fanglomerate consisted of angular to sub-angular fragments of sedimentary and volcanic rock that was weakly cemented but did not display the prominent high-angle slickenside fracture system that had been encountered in hole 605.

At Hole P-1, located on an I. P. anomaly ± 700 feet west of the Lakeshore pit, low grade copper oxide mineralization was encountered in a fractured and altered andesite and andesite breccia. These andesites had been intruded by a few thin sill-like masses of biotite porphyry. At a drill depth of 750 feet where the drill was still in oxides, a re-evaluation of the I. P. data and a review of the geology was made.

INTERPRETATION OF GEOLOGY

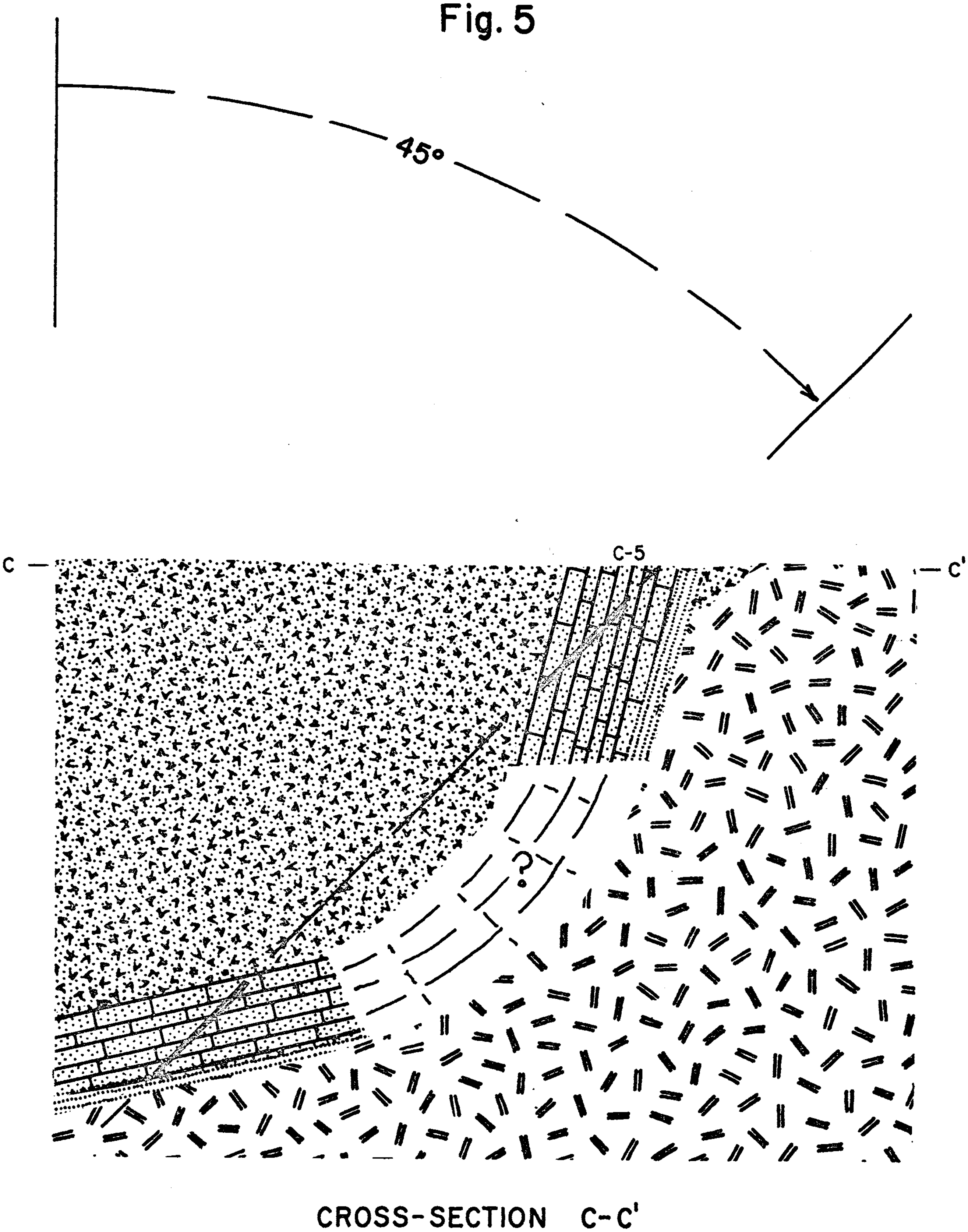
In an attempt to correlate surface geology with subsurface data obtained from core holes, the writer assumed:

(1) The andesite and breccia encountered in drill hole P-1 are extrusive and the biotite porphyry encountered in hole 605 and P-1 is younger than the andesite and younger than the biotite hornblende porphyry that has intruded the Pinal Schist to the east;

(2) The high angle slickenside fracture system encountered in hole P-1 and 605 is parallel to the fault and fracture system observed in the Lakeshore pit;

(3) The present attitude of the Cretaceous volcanic and sedimentary rocks cropping out southwest of the Slate Mountains represents the youngest structural trend in the area, and that this trend, striking N ± 50° E and dipping ± 45° NW, has been superimposed on the older structural system in the area;

Fig. 5



CROSS-SECTION C-C'
LOOKING N 55 E
SCALE 1" = 100'

ASSUMED ATITUDE OF THE METASEDIMENTS
PRIOR TO TILTING TO THE NORTHWEST

(4) If the metasediments outcropping in the Lakeshore pit were rotated about a horizontal axis trending N 50° E to a pre-45° tilt attitude, the metasediments would then be dipping steeply to the northwest and be overlaid by the andesite (Fig. 5).

(5) The mineralization, encountered by the U. S. Bureau of Mines (2) in churn drill hole C-5 at a drill depth of 455 feet to 545 feet, is the continuation down dip of the mineralized metasediments and these metasediments would continue to the northwest to underlie the andesite (Fig. 3).

In summation then, this interpretation requires that the metasedi[...] tend down dip from the oxide outcrop and lie under the andesite to the no[...] The trend of the metasediments is controlled by the northwest trend of th[...] Mountains, the strong northwest and north-south fault and fracture syste[...] intrusive. Movement of mineralized solutions were controlled by this ph[...] vironment and sulphide mineralization should be encountered at depth.

RECOMMENDED DRILLING TARGET

To try to correlate this interpretation with the indicated I. P. ano[...] plotted anomalies extending to the south of the Lakeshore pit and the ano[...] echelon to the northwest of the pit were encircled. This enclosed an are[...] wide extending from near the center of Section 36 north to Section 25, th[...] to the west line of Section 25 (Fig. 4). This area offered the best possib[...] of projected geology and plotted I. P. anomalies. The enclosed area was as the drilling target for the Lakeshore project.

DELINEATION OF MINERALIZATION

Drilling and Recording of Data

With the encounter of sulphide mineralization in metasediments, an accelerated drilling program began. Rotary drilling was used to penetrate the andesites and breccias. When the rotary hole was completed to a pre-determined depth, casing was set and a wire line diamond drill was then moved onto the prepared location. NX size tools (2-1/8 inch core diameter) were used until drill depth or drilling conditions required the hole diameter to be reduced; then BX size tools (1-5/8 inch core diameter) were used. Average recovery of core was over 90%.

From the recovered core, the following data and observations were recorded and sketched on the logs: rock type, alterations, mineralization, amount of fracturing, angle of fracturing and pitch of the slickensides, fault breccia and gouge, and contacts of major rock type changes.

When core holes were completed, they were surveyed for drift and inclination with a multiple-shot gyroscopic survey instrument. Degree of inclination and bearing of drift were recorded on 100 foot intervals and at major contacts.

With this drill hole survey data, the assay and geological data could be plotted in both vertical and horizontal positions with a high degree of accuracy (Fig. 6).

Subsurface Mapping

To maintain control of drilling and indicate attitude and limits of assay and geological data, the following subsurface contour maps were prepared:

(1) The andesite-tactite contact

(2) The tactite-quartzite contact

(3) The quartzite-diorite contact

(4) The top and bottom of mineralization within the tactite

(5) The upper contact of the mineralized biotite porphyry

(6) The top and the lower drilling cut off of sulphide

(7) The top and bottom of oxide

(8) Base of the fanglomerate

With the above contoured data, isopach maps were drawn indicating direction and thickness of high grade oxides, sulphides, tactite, and mineralization within the tactite.

With the same contour maps, cross-sections could be drawn in any direction without regard to drift or alignment of core holes.

Interpretation of Subsurface Data

From the subsurface data, the following interpretations were made:

(1) The contours of the andesite-tactite contact form a subsurface that strikes ± north and dips ± 30° W (Fig. 7).

(2) The contours at the tactite-quartzite contact form a subsurface that strikes N ± 20° W and dips ± 20° SW, then turns to the northeast and dips to the northwest (Fig. 8). The curving contours

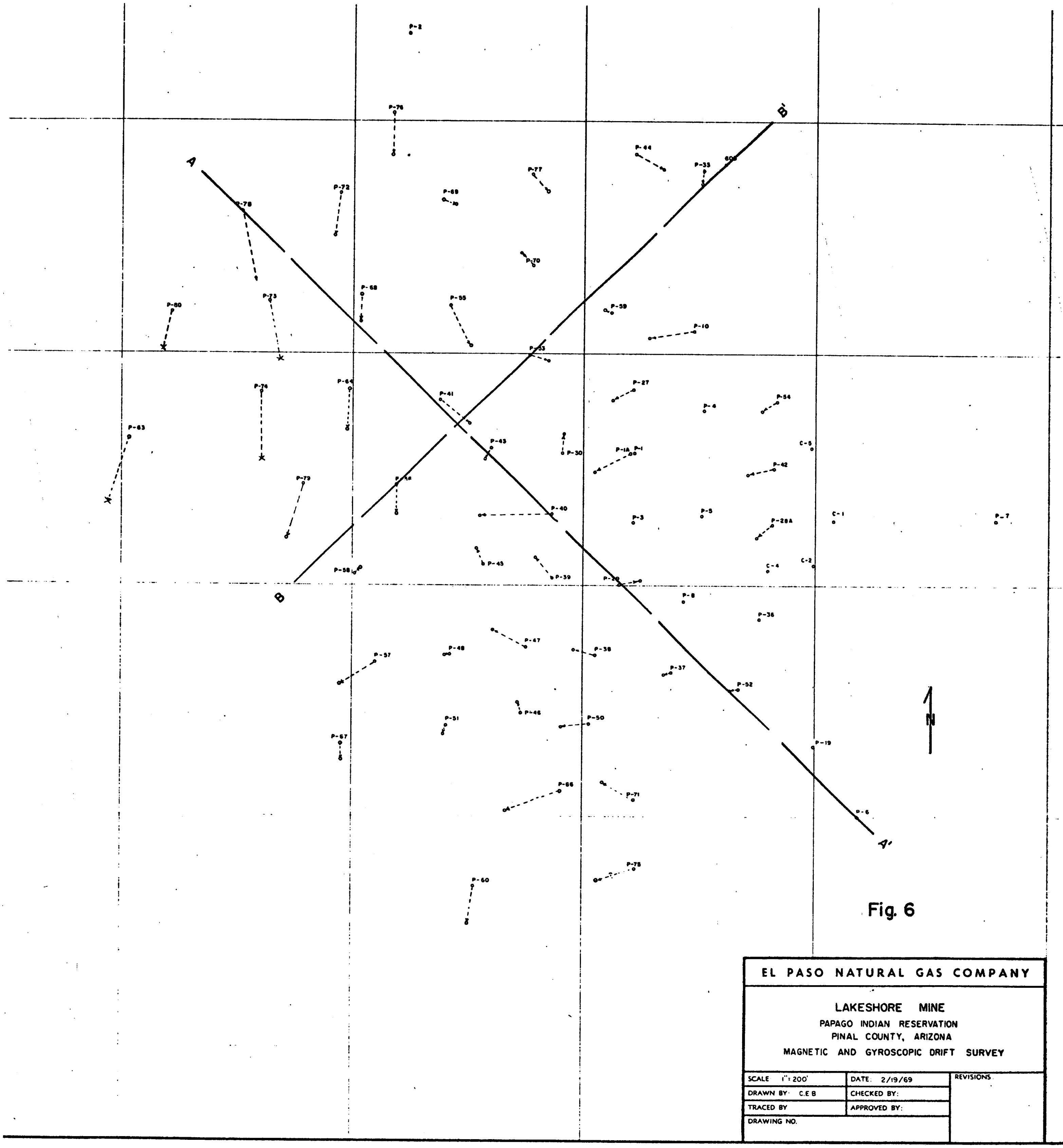


Fig. 6

EL PASO NATURAL GAS COMPANY

LAKESHORE MINE

PAPAGO INDIAN RESERVATION

PINAL COUNTY, ARIZONA

MAGNETIC AND GYROSCOPIC DRIFT SURVEY

SCALE 1" = 200'	DATE: 2/19/69	REVISIONS
DRAWN BY: C.E.B.	CHECKED BY:	
TRACED BY	APPROVED BY:	
DRAWING NO.		

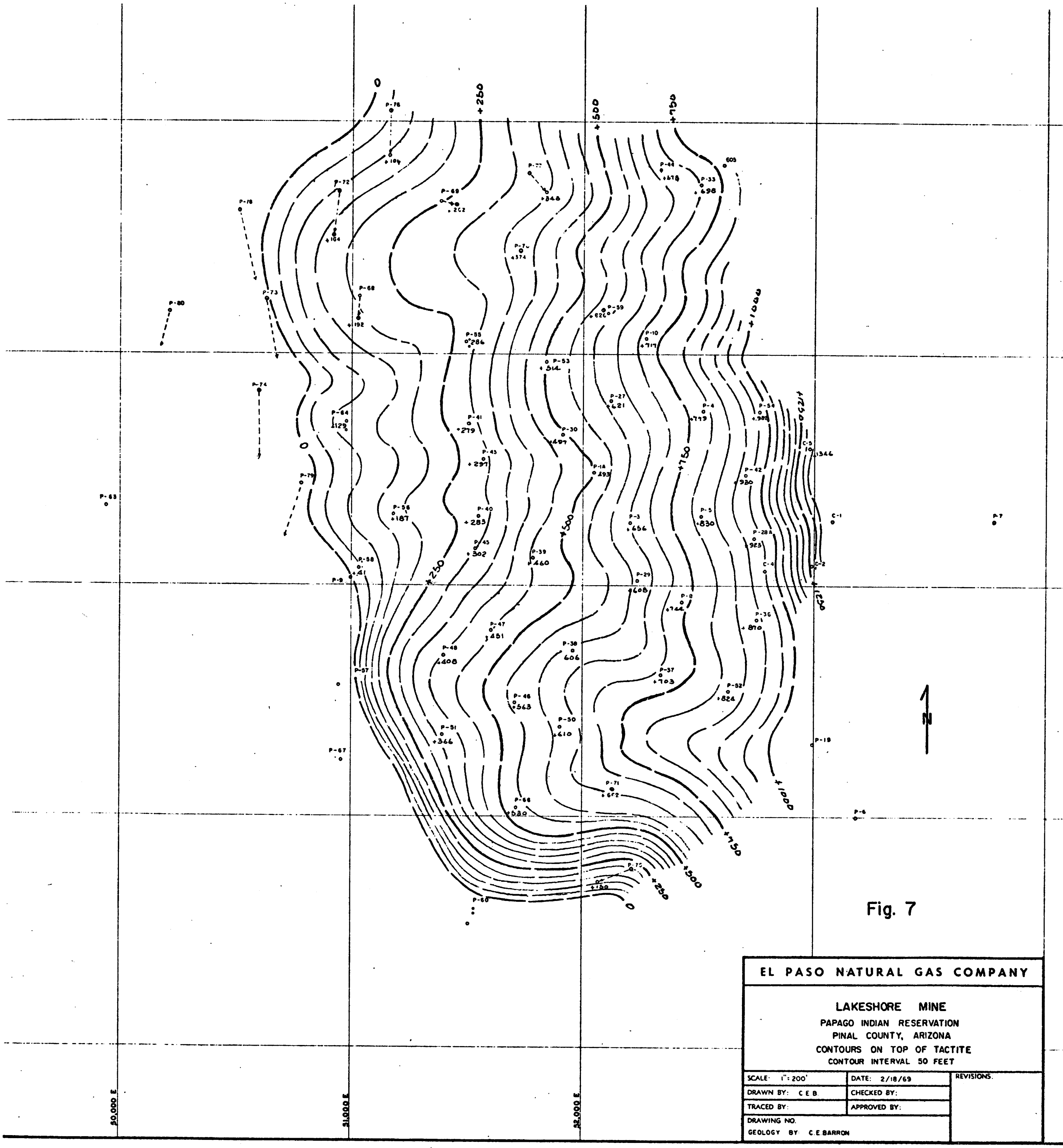


Fig. 7

EL PASO NATURAL GAS COMPANY

LAKESHORE MINE
PAPAGO INDIAN RESERVATION
PINAL COUNTY, ARIZONA
CONTOURS ON TOP OF TACTITE
CONTOUR INTERVAL 50 FEET

SCALE: 1" = 200'	DATE: 2/18/69	REVISIONS.
DRAWN BY: C.E.B.	CHECKED BY:	
TRACED BY:	APPROVED BY:	
DRAWING NO.		
GEOLOGY BY C.E. BARRON		

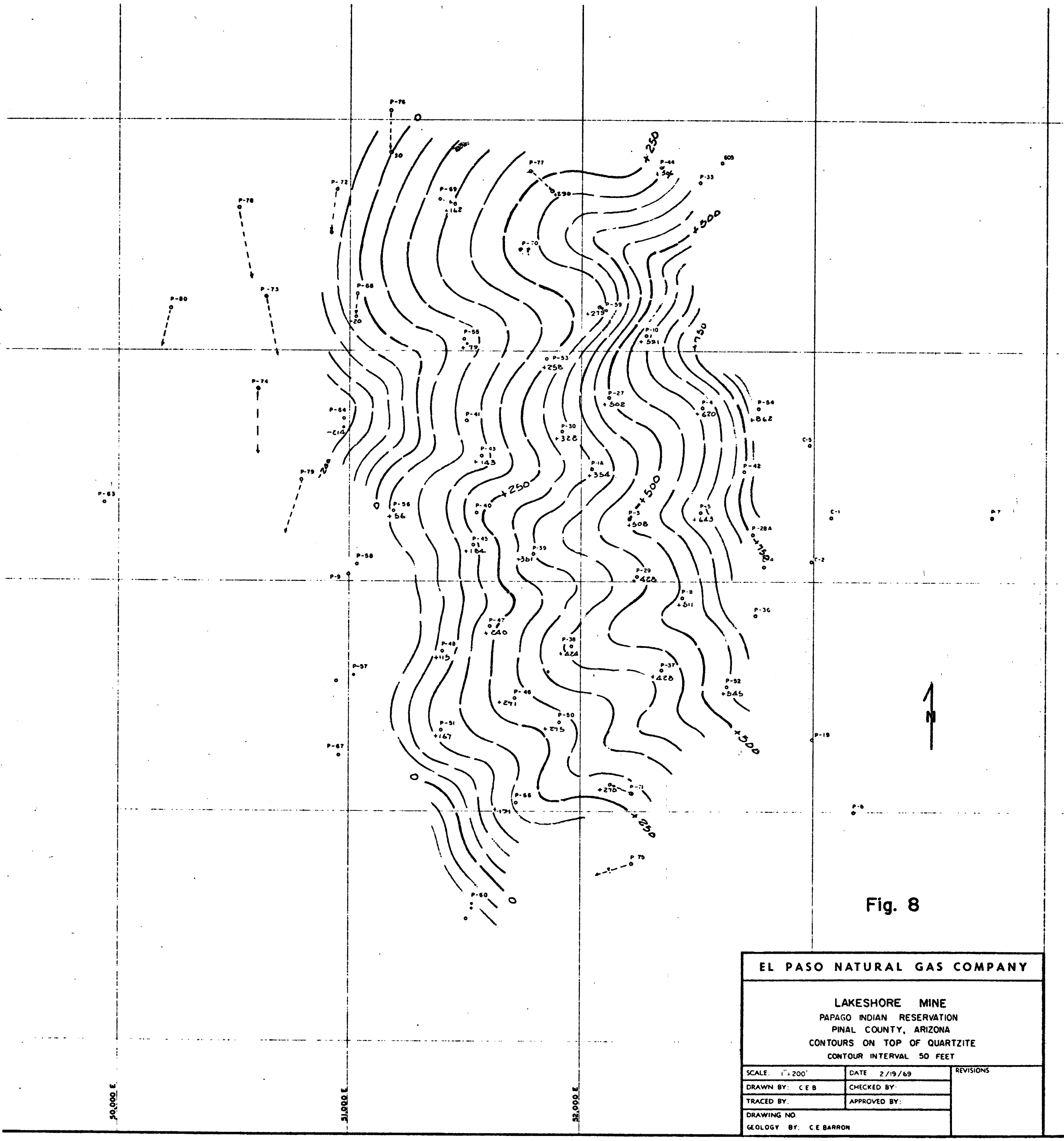


Fig. 8

EL PASO NATURAL GAS COMPANY

LAKESHORE MINE
PAPAGO INDIAN RESERVATION
PINAL COUNTY, ARIZONA
CONTOURS ON TOP OF QUARTZITE
CONTOUR INTERVAL 50 FEET

SCALE: 1" = 200'	DATE 2/19/69	REVISIONS
DRAWN BY: C E B	CHECKED BY:	
TRACED BY:	APPROVED BY:	
DRAWING NO.		
GEOLOGY BY: C.E. BARRON		

form a weakly nosing subsurface structure that plunges to the southwest. As the overlying andesite-tactite contact approaches this plunging structure, a thinning of the tactite occurs along a northeast trend and wedge-like thicknesses of tactite occur to the northwest and southeast of this zone of thinning. This thickening and thinning is best illustrated by an isopach of the tactite (Fig. 15).

(3) The more consistent thickness of mineralization, within the tactite, occurs in the wedge-like thickness southeast of the zone of thinning. Contours on the top and bottom of this mineralized thickness conform with the N 20 W strike and 20° SW dip of the underlying quartzite. The line of intersection of this mineralization with the overlying andesite trends NE and plunges SW, and terminates this thickness of mineralization in the zone of thinning. To the south and southeast of the zone of thinning, an increasing thickness of massive garnet and epidote occurs over the mineralization, and the mineralized horizon is divided into an upper and lower mineral thickness by an interbedded, fine-grained quartzite. Underlying this sulphide mineralization, a black and gray banded tactite is in contact with the underlying quartzite. This sequence of metasediments, which has been intruded by diabase and biotite porphyry, continues to the south and southeast until it has apparently been displaced by a major fault that trends N $\pm$ 20 W.

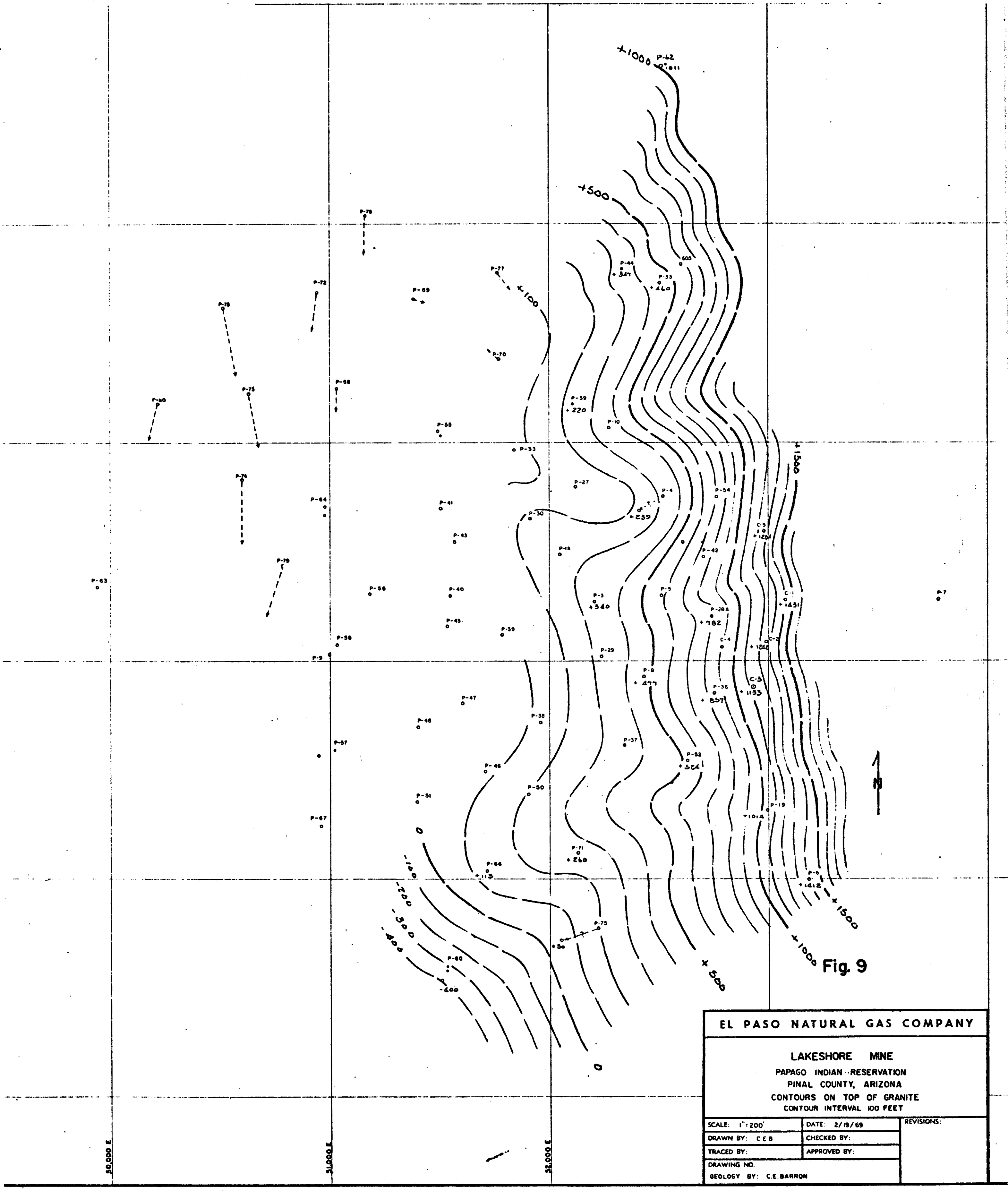
(4) To the east the metasediments are in contact with the diorite. Contours on this contact form a north trending subsurface that dips $\pm$ 60° W (Fig. 9).

(5) To the west the metasediments have been intruded by the biotite porphyry along a northeast trending contact zone. Along this contact zone the intrusive forms sills of irregular masses that occur in both the metasediments and the andesite. Better grade mineralization occurs along this zone of multiple sills (Fig. 16).

(6) Northwest of this contact zone the stock-like intrusive forms a more homogenous emplacement within the andesite but continues to form sills within the metasediments. Further to the northwest, the intrusive again forms a contact zone of multiple sills within the andesite (Fig. 16).

(7) Contours on top of the oxidized intrusive trend N 55 E and form a $\pm$ 40° slope along the northwest side (Fig. 10). On the southeast side the contours indicate a much steeper slope, and to the southwest, the intrusive apparently has been displaced in this horizon by a high angle normal fault that strikes $\pm$ N 20 W. Limits of the intrusive have not been determined to the north and northeast.

(8) Contours on top of the oxide mineralization form an irregular horizon in the subsurface west of the Lakeshore pit; then this horizon forms a northwestern dip and passes through the top of the mineralized intrusive. As the oxide zone passes through the



EL PASO NATURAL GAS COMPANY
LAKESHORE MINE
PAPAGO INDIAN RESERVATION
PINAL COUNTY, ARIZONA
CONTOURS ON TOP OF GRANITE
CONTOUR INTERVAL 100 FEET
SCALE: 1" = 200'
DATE: 2/19/69
REVISIONS:
DRAWN BY: C E B
CHECKED BY:
TRACED BY:
APPROVED BY:
DRAWING NO.
GEOLOGY BY: C.E. BARRON
30,000 E
31,000 E
32,000 E
N
+1000
+500
+100
+1500
0
-100
-200
-300
-400
P-62
P-44
P-33
P-77
P-69
P-72
P-78
P-70
P-68
P-75
P-60
P-59
P-10
P-55
P-53
P-74
P-64
P-41
P-27
P-4
P-54
P-30
P-43
P-42
P-14
P-63
P-56
P-40
P-3
P-5
P-28A
P-45
P-39
P-58
P-9
P-29
C-4
C-2
C-1
C-3
C-5
P-8
P-36
P-47
P-48
P-38
P-57
P-37
P-52
P-46
P-50
P-51
P-67
P-19
P-71
P-66
P-6
P-7
+220
+347
+460
+239
+540
+782
+477
+857
+1153
+1431
+1251
+584
+1014
+260
+113
+1612

Fig. 9

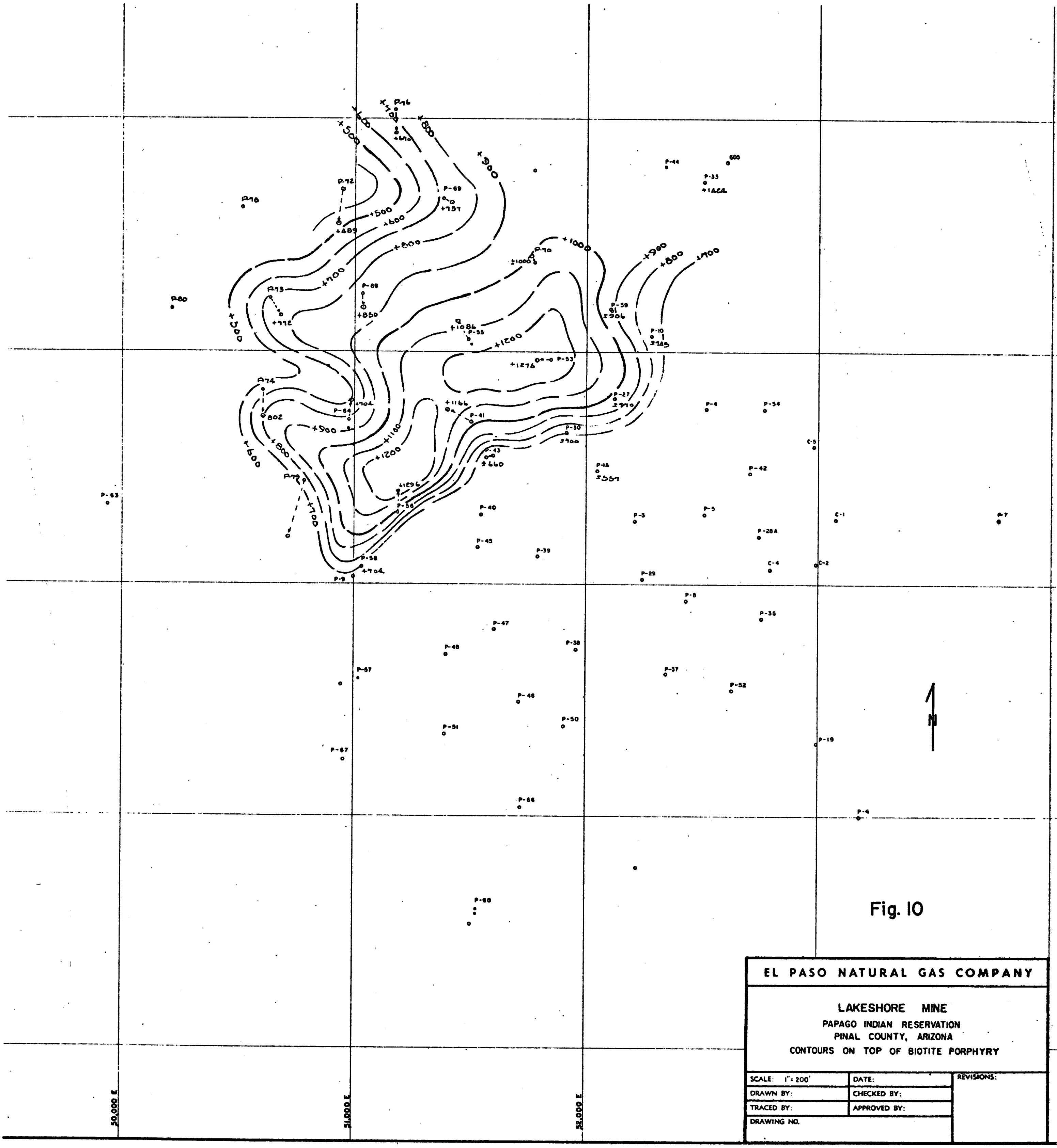


Fig. 10

EL PASO NATURAL GAS COMPANY

LAKESHORE MINE

PAPAGO INDIAN RESERVATION
PINAL COUNTY, ARIZONA
CONTOURS ON TOP OF BIOTITE PORPHYRY

SCALE: 1" = 200'	DATE:	REVISIONS:
DRAWN BY:	CHECKED BY:	
TRACED BY:	APPROVED BY:	
DRAWING NO.		

upper part of the intrusive, a ± 100 foot thick blanket of ± 1.5% copper oxide mineralization occurs at the base of the oxides. This mineralization trends to the northeast along the top of the intrusive and dips to the northwest. As the dip of the oxide mineralization increases to the northwest, the high grade oxide mineralization thins and a zone of chalcocite has formed an enriched upper thickness of sulphide mineralization (Fig. 11).

(9) Contours at the top of sulphide mineralization form a low trough that plunges to the southwest along the southeast flank of the biotite porphyry intrusive. This oxide-sulphide transition horizon then climbs to its highest elevation within the top of the intrusive and forms a northeast trend that dips to the NW. To the southwest the contours turn sharply to the northwest or southeast and form a N ± 20° W trending horizon that dips ± 70° SW (Fig. 12).

(10) The isopach of the sulphides indicates a wedge-like thickness of mineralization. The thin edge, ± 300 feet thick, occurs along the northeast trending contact zone of the intrusive and the metasediments. To the northwest of this contact zone and along the apparent fault zone, the mineralized zone thickens to over 1000 feet. Some core holes in this zone have an average assay value of .85% copper for 1000 feet of recovered core. The limits of mineralization to the northwest and north of this area have not been determined (Fig. 14).

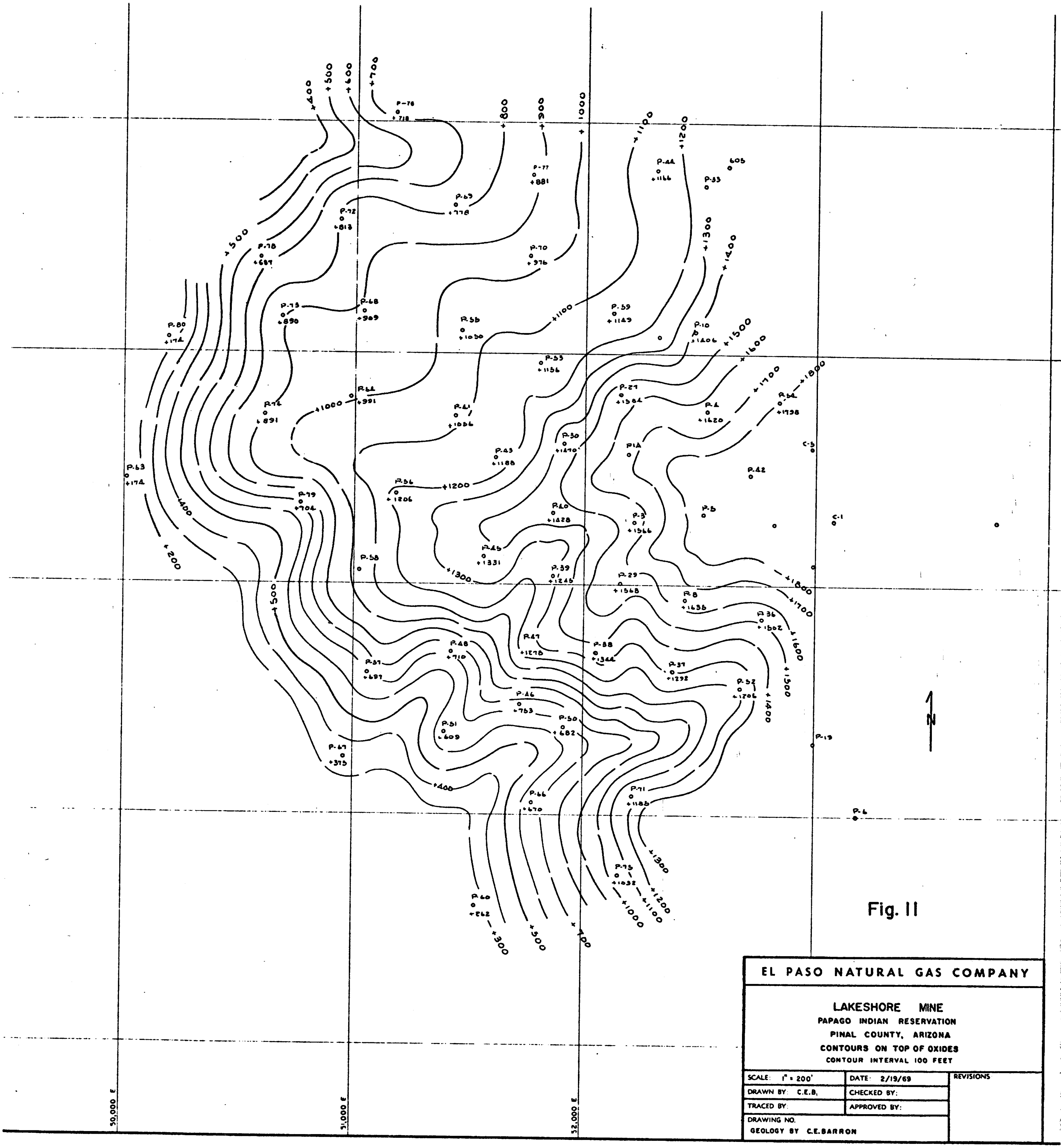


Fig. II

EL PASO NATURAL GAS COMPANY		
LAKESHORE MINE PAPAGO INDIAN RESERVATION PINAL COUNTY, ARIZONA CONTOURS ON TOP OF OXIDES CONTOUR INTERVAL 100 FEET		
SCALE: 1" = 200'	DATE: 2/19/69	REVISIONS
DRAWN BY: C.E.B.	CHECKED BY:	
TRACED BY:	APPROVED BY:	
DRAWING NO.		
GEOLOGY BY C.E.BARRON		

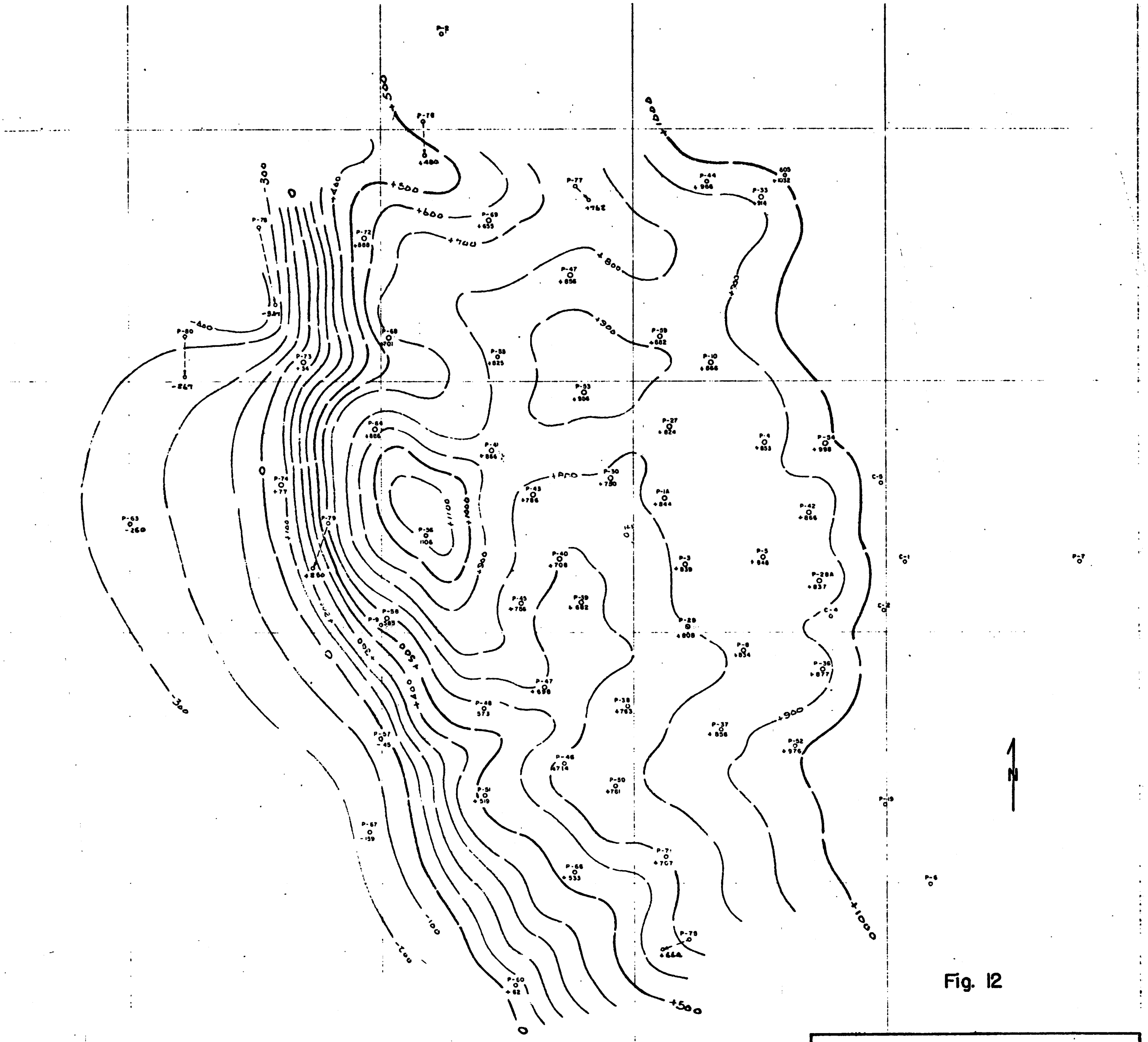


Fig. 12

EL PASO NATURAL GAS COMPANY

LAKESHORE MINE

PAPAGO INDIAN RESERVATION

PINAL COUNTY, ARIZONA

CONTOURS ON TOP OF SULPHIDES

CONTOUR INTERVAL 100 FEET

SCALE: 1" = 200'	DATE: 2/19/69	REVISIONS.
DRAWN BY: C.E.B.	CHECKED BY:	
TRACED BY:	APPROVED BY:	
DRAWING NO.		
GEOLOGY BY: C.E. BARRON		

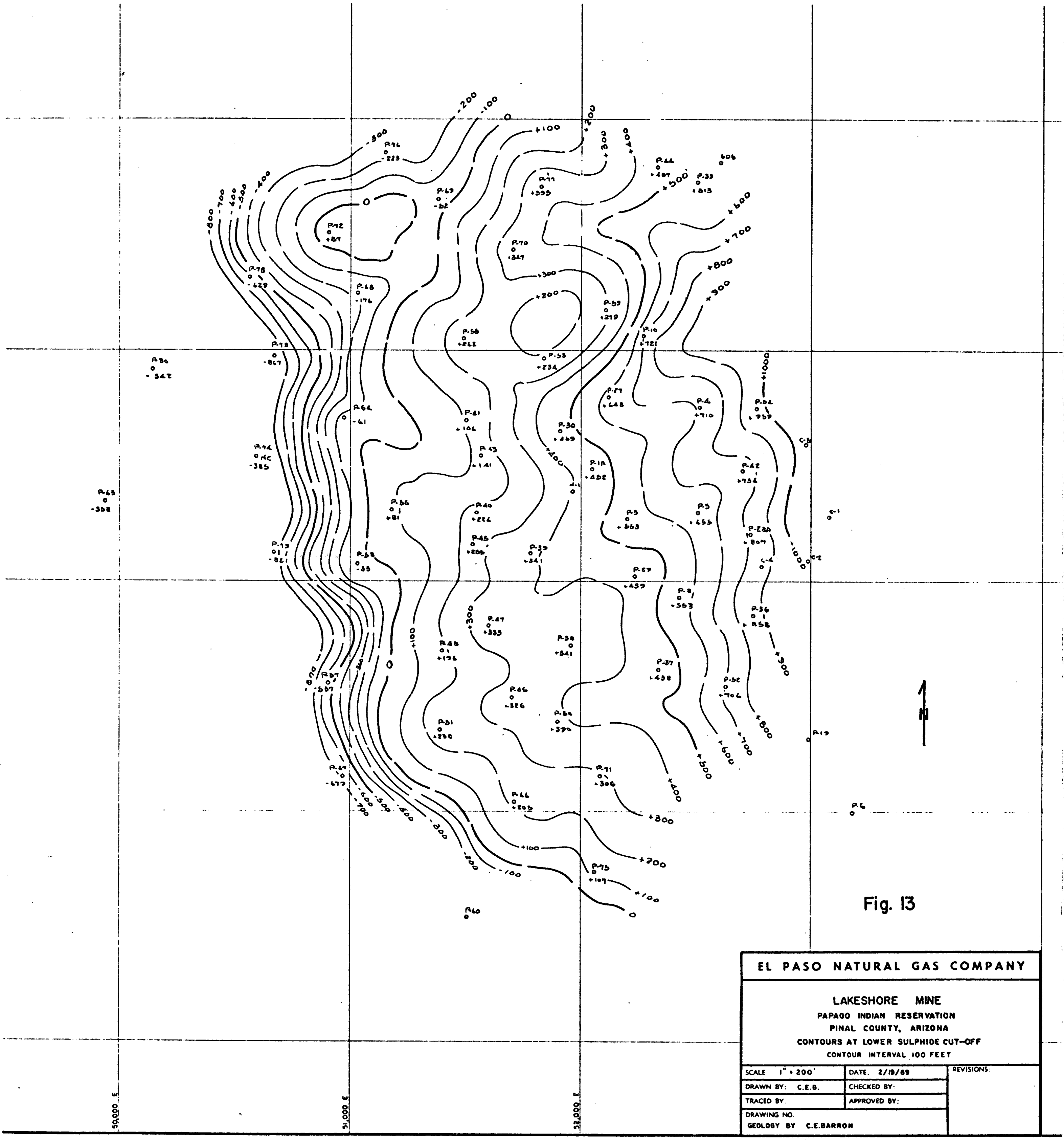


Fig. 13

EL PASO NATURAL GAS COMPANY

LAKESHORE MINE

PAPAGO INDIAN RESERVATION

PINAL COUNTY, ARIZONA

CONTOURS AT LOWER SULPHIDE CUT-OFF

CONTOUR INTERVAL 100 FEET

SCALE 1" = 200'	DATE: 2/19/69	REVISIONS:
DRAWN BY: C.E.B.	CHECKED BY:	
TRACED BY	APPROVED BY:	
DRAWING NO.		
GEOLOGY BY C.E.BARRON		

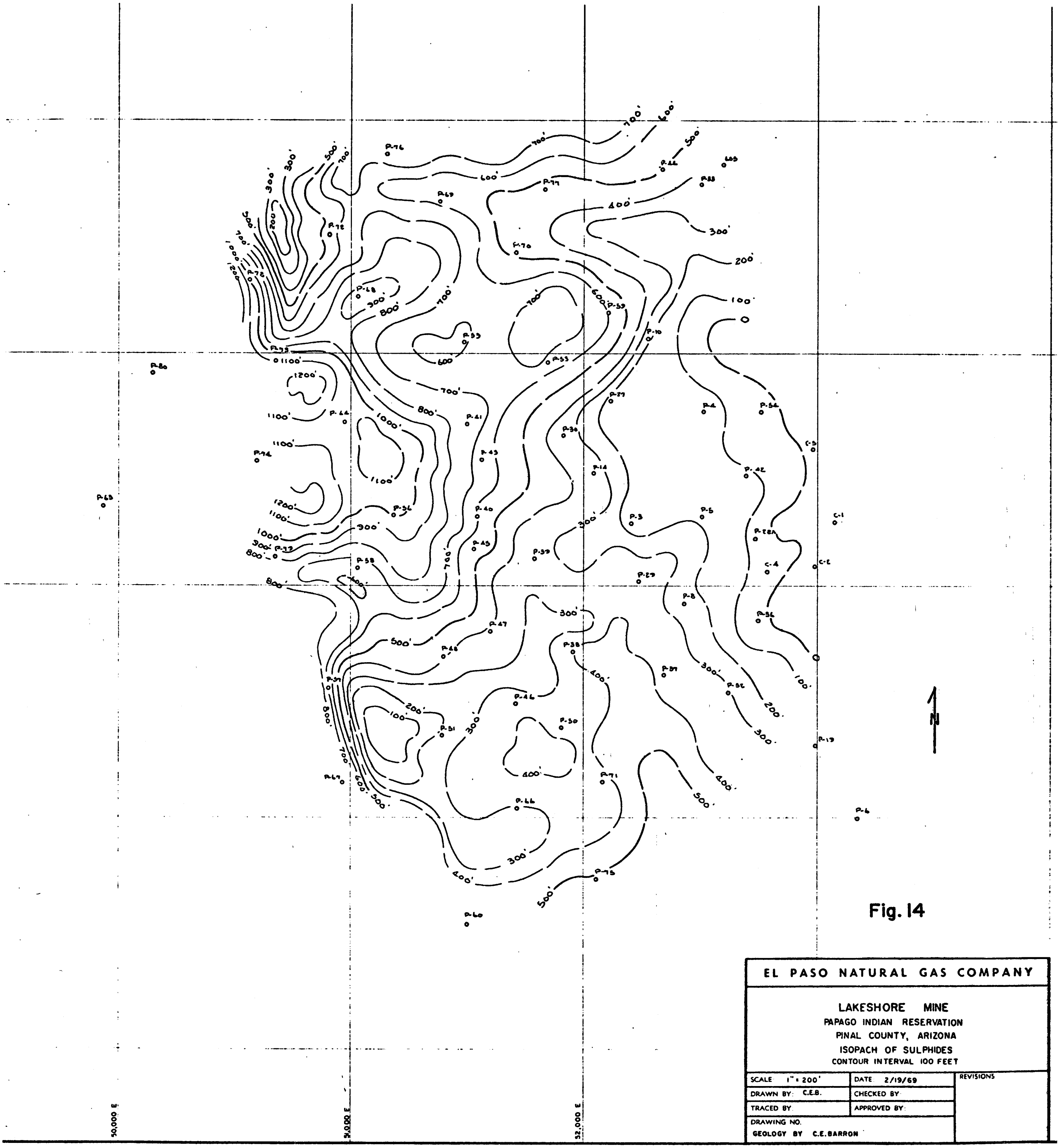


Fig. 14

EL PASO NATURAL GAS COMPANY		
LAKESHORE MINE PAPAGO INDIAN RESERVATION PINAL COUNTY, ARIZONA ISOPACH OF SULPHIDES CONTOUR INTERVAL 100 FEET		
SCALE 1" = 200'	DATE 2/19/69	REVISIONS
DRAWN BY: C.E.B.	CHECKED BY:	
TRACED BY:	APPROVED BY:	
DRAWING NO.		
GEOLOGY BY C.E.BARRON		

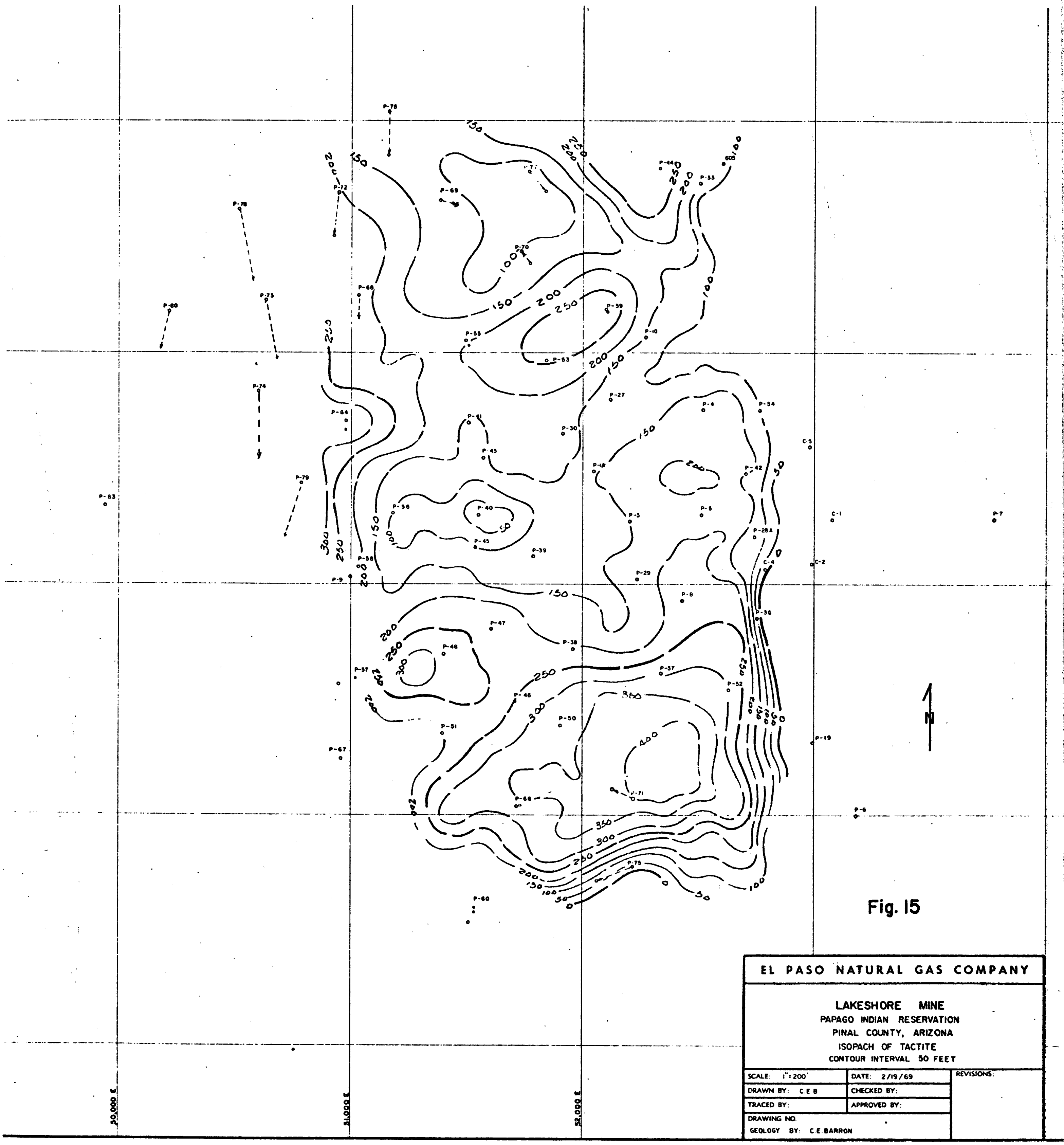
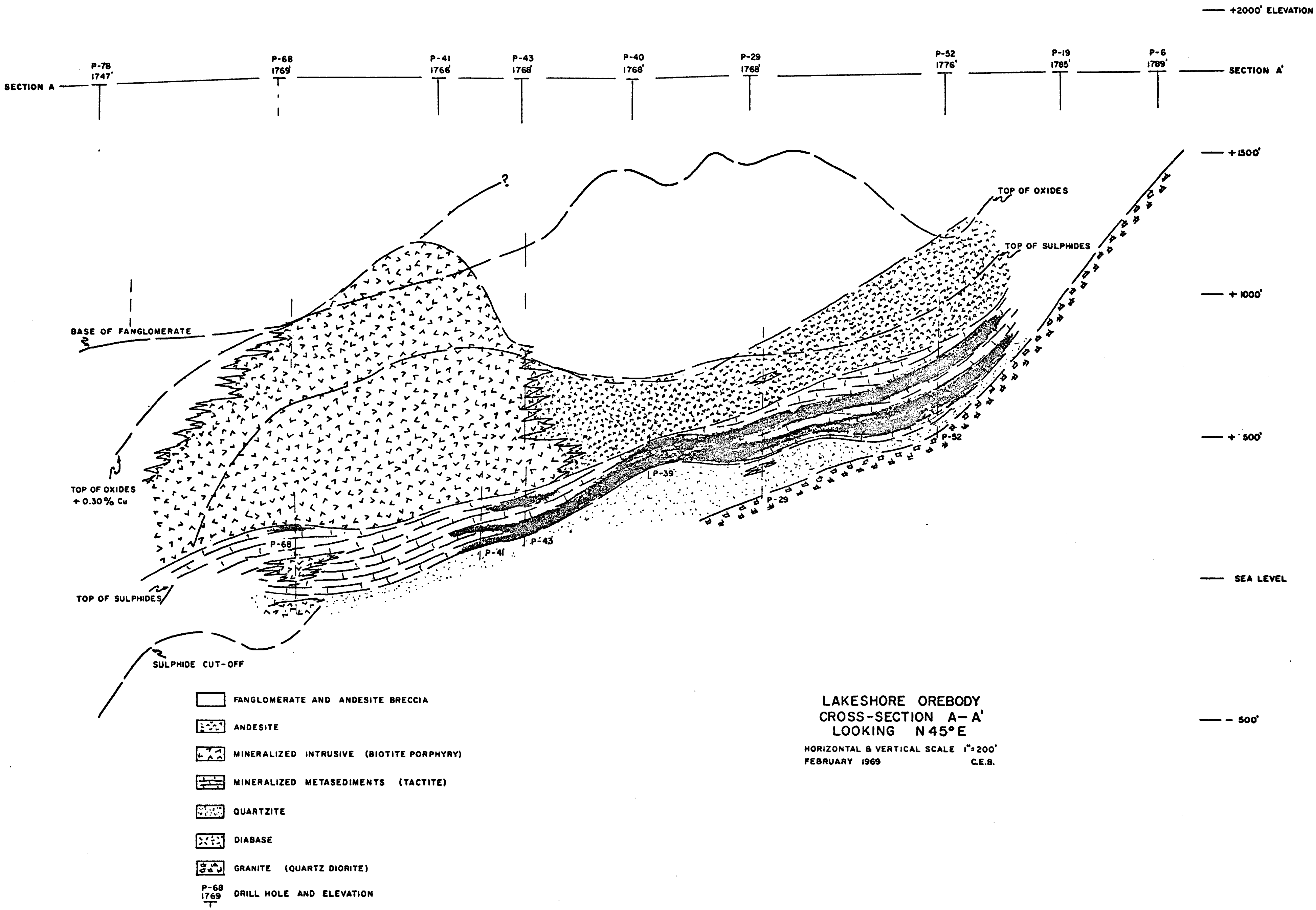


Fig. 15

EL PASO NATURAL GAS COMPANY

LAKESHORE MINE
PAPAGO INDIAN RESERVATION
PINAL COUNTY, ARIZONA
ISOPACH OF TACTITE
CONTOUR INTERVAL 50 FEET

SCALE: 1" = 200'	DATE: 2/19/69	REVISIONS:
DRAWN BY: C.E.B.	CHECKED BY:	
TRACED BY:	APPROVED BY:	
DRAWING NO.		
GEOLOGY BY: C.E. BARRON		



+2000' ELEVATION
SECTION A
SECTION A'
P-78 1747'
P-68 1769'
P-41 1766'
P-43 1768'
P-40 1768'
P-29 1768'
P-52 1776'
P-19 1785'
P-6 1789'
+1500'
+1000'
+500'
SEA LEVEL
-500'
TOP OF OXIDES
TOP OF SULPHIDES
BASE OF FANGLOMERATE
TOP OF OXIDES + 0.30% Cu
TOP OF SULPHIDES
SULPHIDE CUT-OFF
P-39
P-29
P-52
P-68
P-41
P-43
?
FANGLOMERATE AND ANDESITE BRECCIA
ANDESITE
MINERALIZED INTRUSIVE (BIOTITE PORPHYRY)
MINERALIZED METASEDIMENTS (TACTITE)
QUARTZITE
DIABASE
GRANITE (QUARTZ DIORITE)
P-68 1769 DRILL HOLE AND ELEVATION
LAKESHORE OREBODY
CROSS-SECTION A-A'
LOOKING N 45° E
HORIZONTAL & VERTICAL SCALE 1" = 200'
FEBRUARY 1969
C.E.B.

Fig. 16

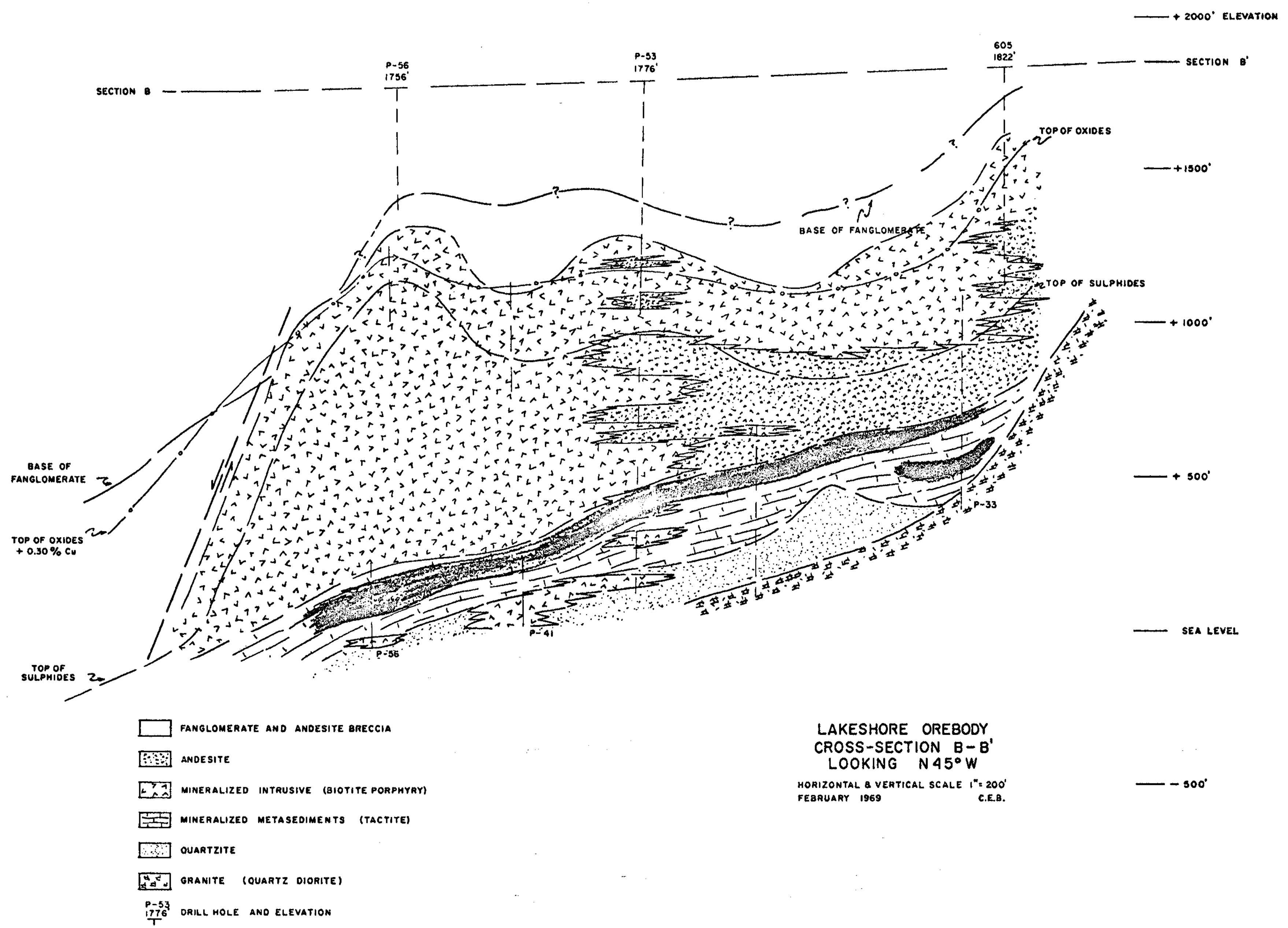

+ 2000' ELEVATION
SECTION B
SECTION B'
P-56
1756'
P-53
1776'
605
1822'
TOP OF OXIDES
+1500'
BASE OF FANGLOMERATE
TOP OF SULPHIDES
+ 1000'
+ 500'
SEA LEVEL
- 500'
P-33
P-41
P-56
BASE OF FANGLOMERATE
TOP OF OXIDES + 0.30 % Cu
TOP OF SULPHIDES
FANGLOMERATE AND ANDESITE BRECCIA
ANDESITE
MINERALIZED INTRUSIVE (BIOTITE PORPHYRY)
MINERALIZED METASEDIMENTS (TACTITE)
QUARTZITE
GRANITE (QUARTZ DIORITE)
P-53 1776' DRILL HOLE AND ELEVATION
LAKESHORE OREBODY
CROSS-SECTION B-B'
LOOKING N45°W
HORIZONTAL & VERTICAL SCALE 1" = 200'
FEBRUARY 1969
C.E.B.

Fig. 17

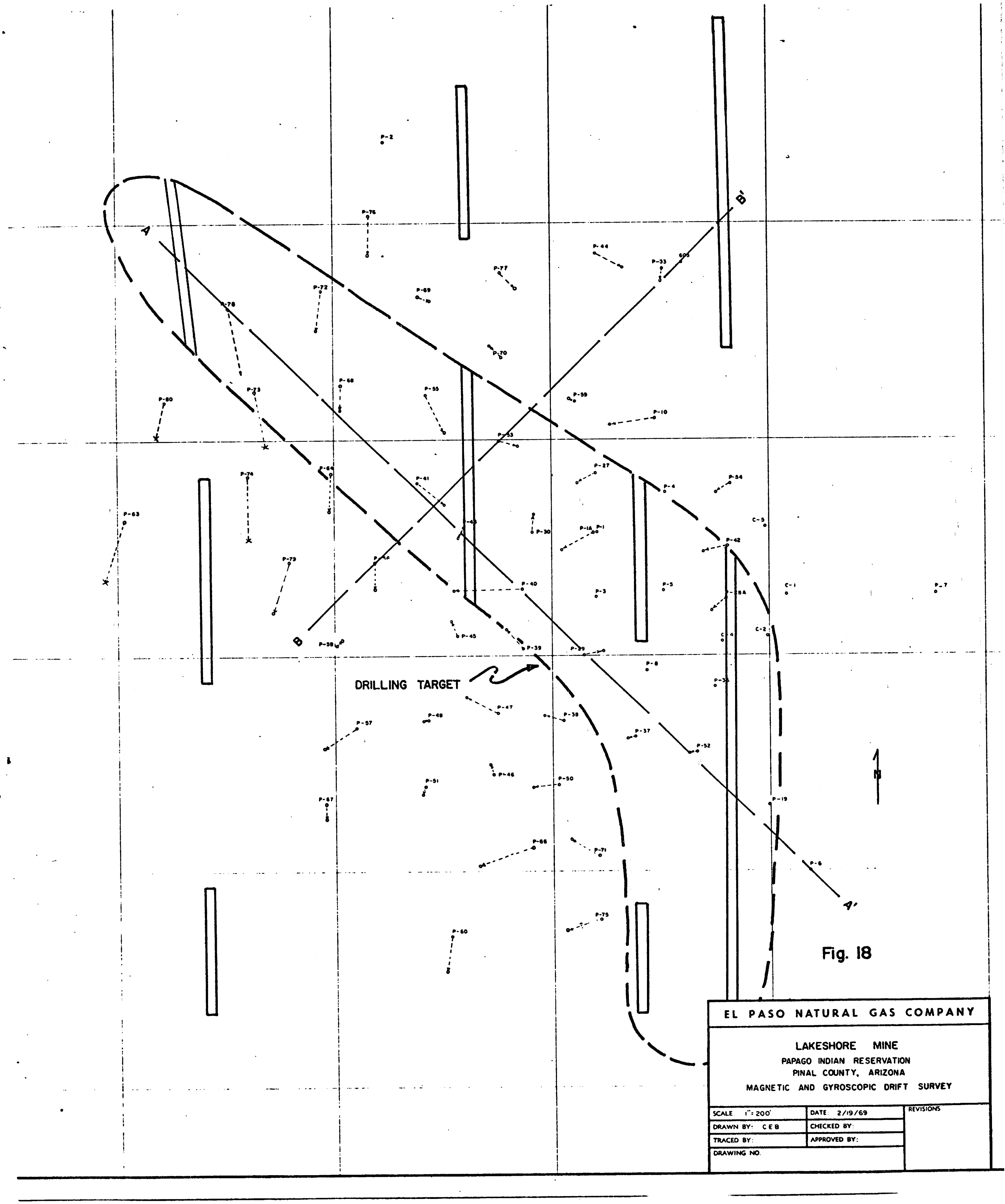

A
A'
B
B'
DRILLING TARGET
EL PASO NATURAL GAS COMPANY
LAKESHORE MINE
PAPAGO INDIAN RESERVATION
PINAL COUNTY, ARIZONA
MAGNETIC AND GYROSCOPIC DRIFT SURVEY
SCALE 1" = 200'
DATE 2/19/69
REVISIONS
DRAWN BY: CEB
CHECKED BY:
TRACED BY:
APPROVED BY:
DRAWING NO.

Fig. 18

(11) Overlying the highly fractured and altered andesite, biotite porphyry and tactite is a relatively unfractured, weakly cemented fanglomerate that thickens from ± 100 feet at the edge of the valley to ± 1500 feet around the southwest end of the biotite porphyry and is apparently in contact with the altered and oxidized top of this intrusive.

In summation, the geological data indicates the occurrence of mineralization at Lakeshore to be the result of the emplacement of a weakly mineralized biotite porphyry. This stock-like mass formed a multiple sill contact with eroded and deformed metasediments and the overlying andesites and breccia. The processes of contact metamorphism formed tactite or skarn in the metasediments and a higher grade of sulphide mineralization was deposited in the more favorable carbonates. Post-mineral faulting and fracturing formed channels for erosion, leaching, and enrichment of mineralization. This mineral deposit was tilted to the northwest and underwent a second period of erosion and oxidization. This oxidized and fractured surface was then buried by the present overlying fanglomerate (Fig. 17).

COMPUTER EVALUATION

During March and April of 1968, a computer evaluation of the assay and geological data from 23 core holes was performed by an independent consultant (7). This evaluation provided the following information:

(1) Ore reserves, tonnage and grade of the sulphide and oxide mineralization for various cut-off grades and thicknesses;

(2) Level plans at various vertical intervals showing contours of sulphide copper values;

(3) Vertical cross-sections of the sulphide copper values;

(4) A confidence interval analysis to determine future drilling requirements; and

(5) A financial analysis based on ore reserves of varying cut off grades, and the following parameters - mining cost and mining methods, concentrator capacity and recovery, metal prices, capital requirements and financing, royalty, sales agreements, and taxation.

In May 1968, ore reserves based on assay and geological data from 23 holes was reported as follows:

1. Tactite reserves, based on a cut-off grade of 0.75% copper, were 13.7 million tons with an average grade of 1.84% copper.
2. Porphyry reserves including tactite, based on a cut-off grade of 0.50% copper, were 59 million tons with an average grade of 0.99% copper.

During September 1968, the assay and geological data was again submitted to an independent consultant (8) for computer evaluation. The following reserves were reported:

1. Porphyry reserves based on mineralization with a thickness greater than 200 feet and a cut-off grade of 0.50% copper were 86 million tons with an average grade of 0.81% copper. This included tactite material lying under the porphyry.

2. Tactite reserves, outside the porphyry area and with a cut-off grade of 1.00% copper, were 10 million tons with an average grade of 1.73% copper.

In November 1968, with the data from 42 core holes, the following up-dated ore reserves, classified as a total of proved and probable, were reported:

1. Porphyry reserves based on mineralization with a thickness greater than 200 feet and a cut-off grade of 0.50% copper, were 132.0 million tons with an average grade of 0.81% copper. This included 9 million tons of tactite material lying under the porphyry.
2. Tactite reserves, outside the porphyry area and with a cut-off grade of 1.00% copper, were 10 million tons with an average grade of 1.73% copper.
3. Oxide reserves, based on a cut-off grade of 0.50% copper, were 85 million tons with an average grade of 0.81% copper.

On February 7, 1969, with data from 51 core holes, the following ore reserves classified as a total of proved and probable, were reported:

1. Porphyry reserves, based on a cut-off grade of 0.40% copper, were 241 million tons with an average grade of 0.70% copper.
2. Tactite reserves, based on a cut-off grade of 1.00% copper, were 24 million tons with an average grade of 1.69% copper.
3. Oxide reserves, based on a cut-off grade of 0.40% copper, were 207 million tons with an average grade of 0.71% copper.

CONCLUSION

In the opinion of the writer, the discovery of sulphide mineralization at Lakeshore was the result of a successful interpretation of combined geologic and geophysical data. The rotation of the mineralized metasediments to an assumed pre-tilt attitude gave a reason for projecting these metasediments to the northwest. The I. P. anomalies were correlated with this assumed northwest projection.

At the end of this phase of the exploration program, the majority of mineralized core holes have been collared within or near the limits of the proposed drilling target (Fig. 18). The interpretation that assumed overturning of metasediments by tilting to the northwest has been strengthened by three core holes which were collared in the oxide ore body and again entered mineralized metasediments at depth after penetrating the andesites. The discovery of the mineralized tactite led to the discovery of sulphide mineralization in the biotite porphyry intrusive and a "porphyry copper" deposit.

The gyroscopic drift survey of drill holes accurately located the subsurface position of the assay and geologic data that was obtained from the diamond drill cores, and gave the necessary vertical and horizontal control for the preparation of subsurface maps and cross sections and for computer evaluation of the mineral deposit.

Computer evaluation proved to be an efficient and rapid method of obtaining and updating grade and tonnage estimates during the exploration program.

ACKNOWLEDGMENTS

The author wishes to thank the members of the Mining Division of El Paso Natural Gas Company for helpful comments and criticism on the paper; and is grateful to Doctors W. S. Strain and Earl M. P. Lovejoy of the Geology Department, University of Texas at El Paso, for reading the paper and suggesting improvements.

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A GEOPHYSICAL CASE HISTORY OF THE LAKESHORE OREBODY

by

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and

Emil Winniski.

THIS IS AN UNEDITED PREPRINT – SUBJECT TO CORRECTION
Presented at the S.E.G. Annual Meeting
New Orleans, Louisiana, November 1970

ABSTRACT

The Lakeshore Orebody occurs in Pinal County, Arizona about 30 miles south of Casa Grande. In February 1969, when the latest figures were published, the ore reserves were reported at 241 million tons of disseminated sulphide ore (0.7% Cu) and 24 million tons of concentrated metallic ore (1.69% Cu).

The first hole intersected primary ore (magnetite, pyrite, chalcopyrite) in the metasediments (tactite) at a depth of 1147 feet in early 1967. The successful conclusion of this exploration program by El Paso Natural Gas Company is an excellent example of an integrated exploration approach. The application of regional geological planning, geophysical methods and detailed geological reasoning resulted in the discovery of a major copper orebody.

Due to the depth of the ore zone, and the less than massive character of the ore, the only geophysical technique that was useful in the direct detection of the ore mineralization was the induced polarization method. Variable frequency induced polarization measurements, made using the dipole-dipole electrode configuration and electrode intervals from 300' to 1,000', successfully indicated the presence of the metallic mineralization at depth, and gave some indication of its extent.

Comparisons of the induced polarization data and the appropriate geological sections give information concerning the usefulness of the method.

Natural Gas Co. was accomplished by the application of integrated exploration techniques. All of the available geological and geophysical data was considered; not just once, but repeatedly. The success of the program was due in large part to the patient re-evaluation of geophysical and geological data by the Geologic Staff of El Paso Natural Gas Co.

Our thanks are due to the Management of El Paso Natural Gas Co. for permission to publish the data presented. We are greatly indebted to Mr. John R. Reynolds, Manager of Exploration, and Claude E. Barron, Senior Geologist, of El Paso Natural Gas Co. for their help in the preparation of the geological aspects of the paper. Mr. H.E. Harper of Hecla Mining Co., who are Managers of the current development at Lakeshore, was kind enough to review the paper and gave permission for its presentation.

References

1) Barron, Claude E. " Exploration at the Lakeshore Mine". Presented at the Annual Meeting of the New Mexico Mining Association November 1969.

2) Harper, H.E. and Reynolds, J.R. "The Lakeshore Copper Deposit". Presented at the 1969 Mining Congress, San Francisco, California October 1969.

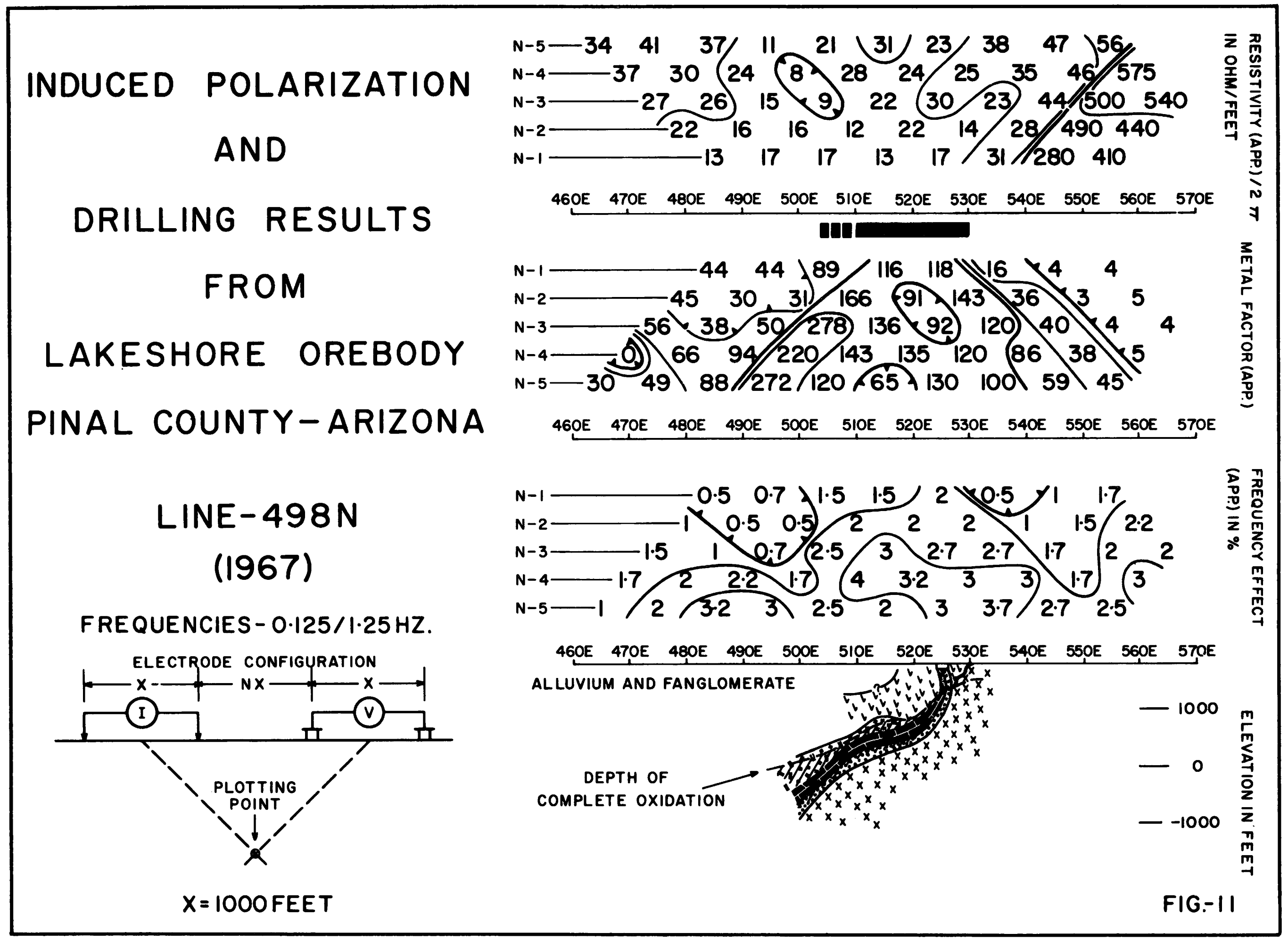


FIG.-11

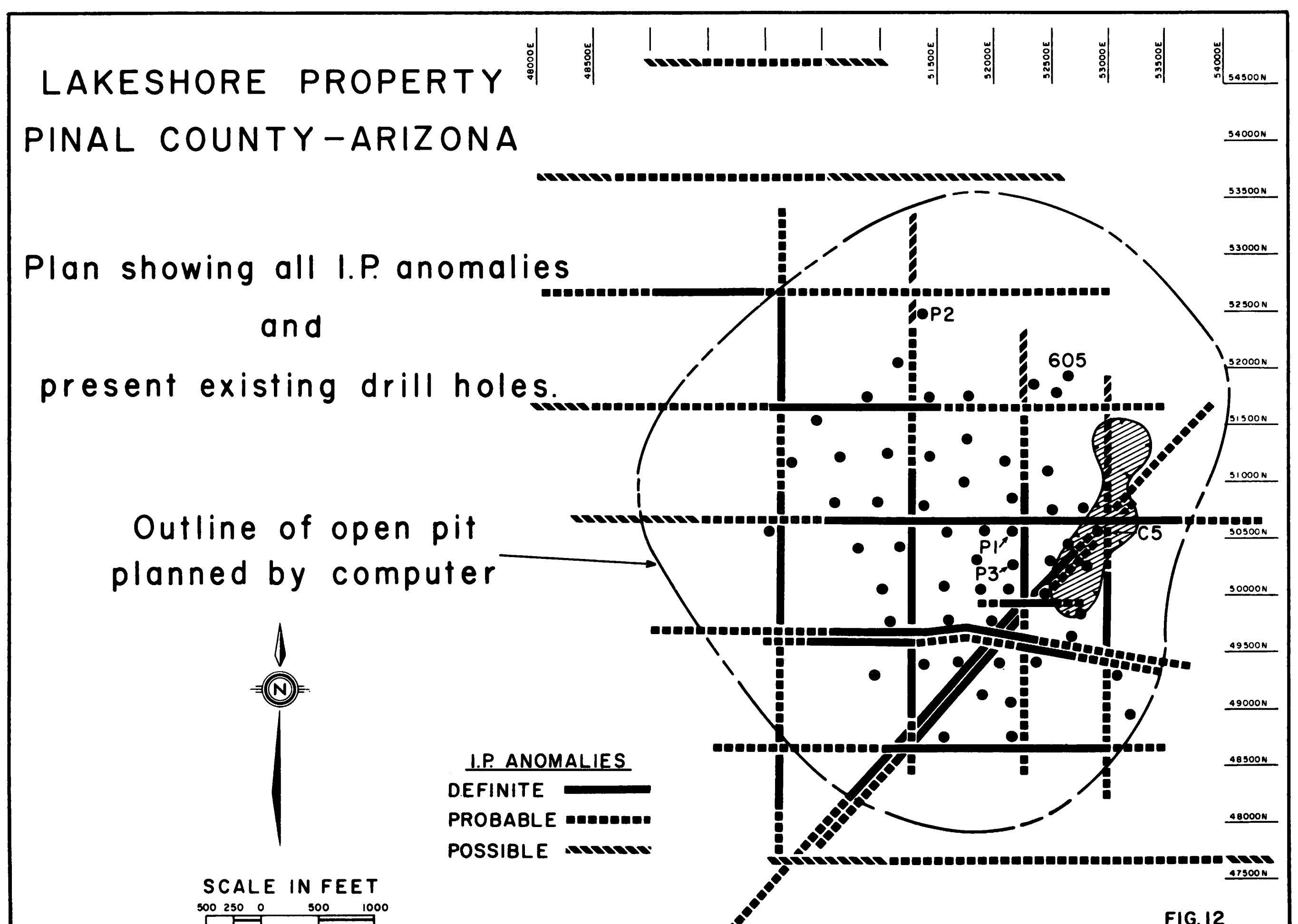


FIG. 12

Introduction

On February 7, 1969 an announcement was made by El Paso Natural Gas Co. that the latest calculations for the Lakeshore Orebody gave 241 million tons of disseminated sulphide ore averaging 0.70% copper and 24 million tons of concentrated (tactite) metallic ore containing 1.69% copper. This was the latest announcement that has been made. The orebody is currently being developed jointly by El Paso Natural Gas Co. and Hecla Mining Co.

The discovery of this major copper deposit by the Mineral Division of El Paso Natural Gas Co. was the result of a well planned, integrated exploration program. The application of regional geological studies, modern geophysical techniques and detailed geological reasoning all contributed to the success of the program.

The Lakeshore Orebody lies under the southwest pediment of the Slate Mountains in Section 25, T10S, R4E, Pinal County, Arizona. (Fig. 1). This location is in the Papago Indian Reservation, about 30 miles south of Casa Grande, Arizona and 70 miles northwest of Tucson. The surface elevation in this area is about 1,800 feet.

Interest in the area dates back to the early 1880's. The mineralized outcrop consisted primarily of copper silicates and iron oxides. Between 1917 and 1919, a shaft was sunk to a depth of 225 feet. An excellent history of the Lakeshore Property is given in the paper by Harper and Reynolds (1969).

El Paso Natural Gas Co. first examined the area in 1962, but the mineral rights to the Lakeshore Property were not acquired until mid-1966. Investigations were begun into processes to recover the copper in the copper silicates exposed in the old Lakeshore Pit. At the same time, regional exploration was initiated. After preliminary geologic studies, a reconnaissance induced polarization survey was completed by McPhar

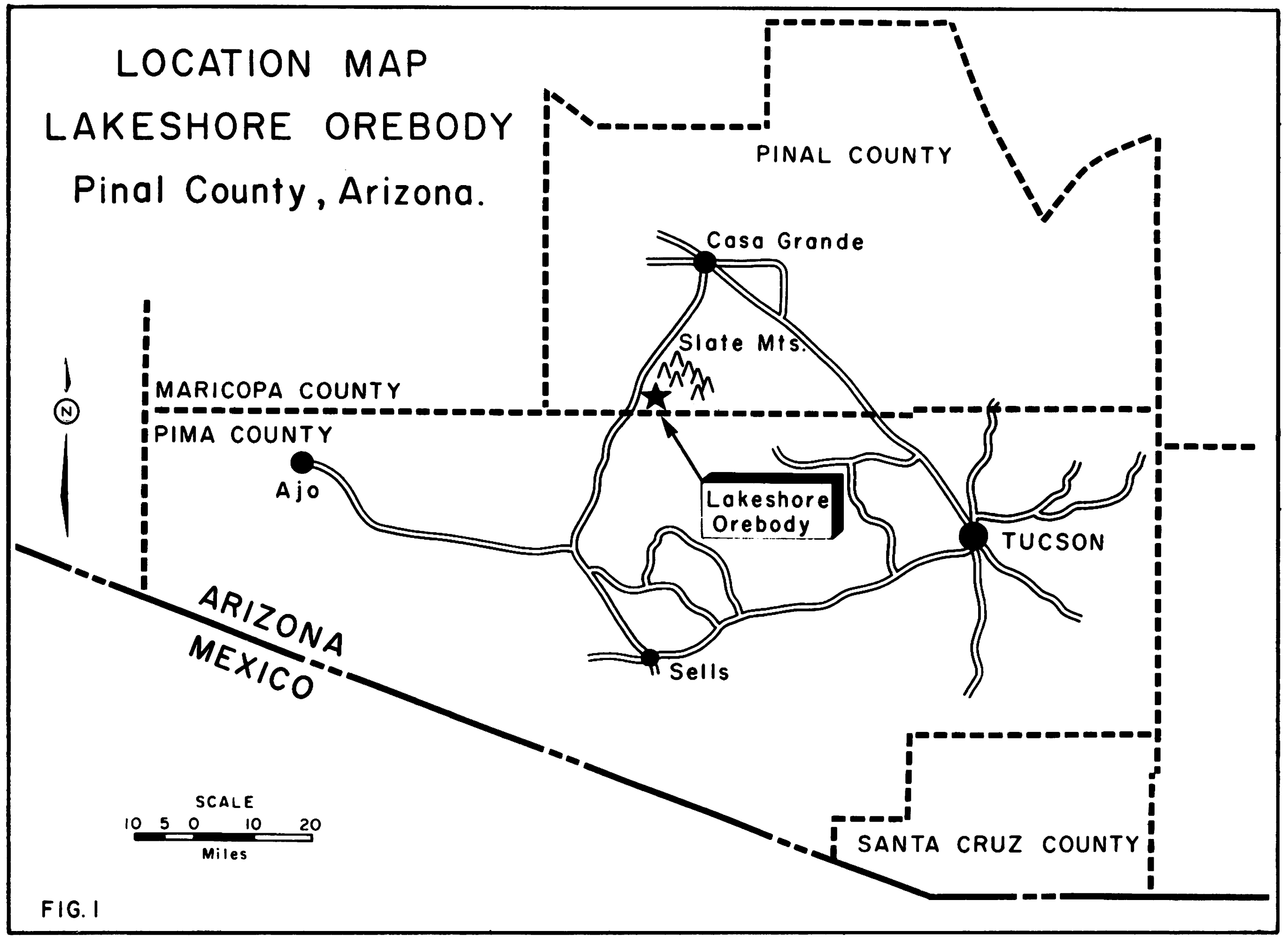


FIG. 1

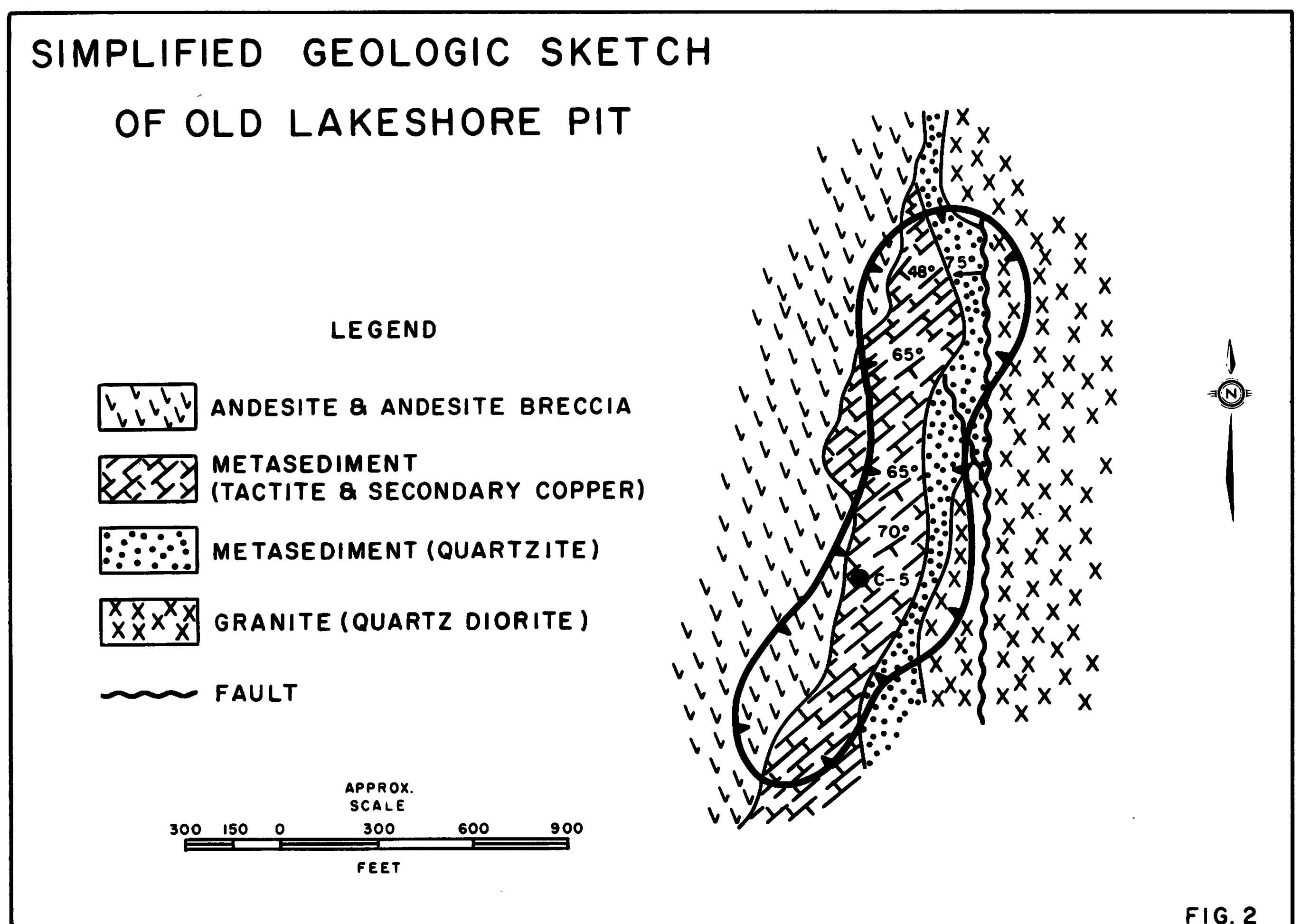


FIG. 2

shown on Figure 11. The IP anomaly centred at 520E correlates with the centre of the Lakeshore Orebody. The apparent frequency effect values and the apparent Metal Factor values are definitely anomalous. With 1000' electrode intervals, it is probable that the IP anomaly is due to the entire volume of metallic mineralization rather than just the near-vertical, up-dip end of the tactite zone that gave rise to anomalies when shorter electrode intervals were used.

Conclusions

The variable frequency IP results described above were chosen to demonstrate the role played by geophysics in the discovery and evaluation of the major copper deposit at the Lakeshore Property. The IP measurements at Lakeshore were made at irregular intervals over a period of three years. Some of the results contributed to the eventual discovery of the ore; in other cases the results were misleading. Now that more complete geological data is available, it is, of course, possible to explain all of the effects measured.

On Figure 12, we have shown all of the anomalies interpreted during the various IP surveys at Lakeshore. Also shown are all of the drill holes completed prior to November 1969. The line surrounding all of the IP anomalies is the surface outline of a sample open pit prepared as the result of one, of several, computer analyses of the drill hole data. The correlation is quite specific.

Acknowledgements

The authors feel that there is a lesson for all exploration people in the history of the discovery of the Lakeshore Orebody. The successful conclusion of the Exploration Program by the Mineral Division of El Paso

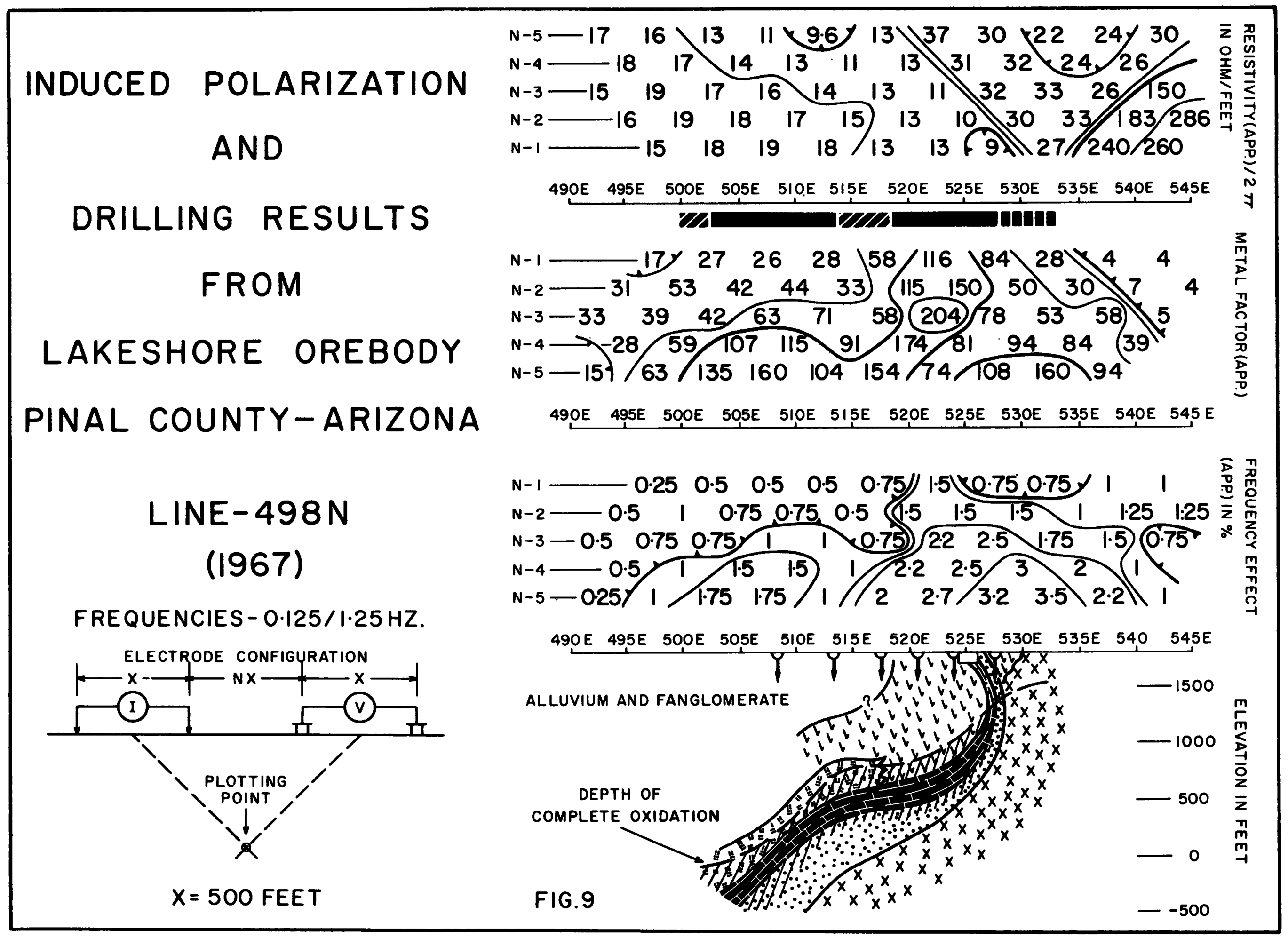


FIG.9

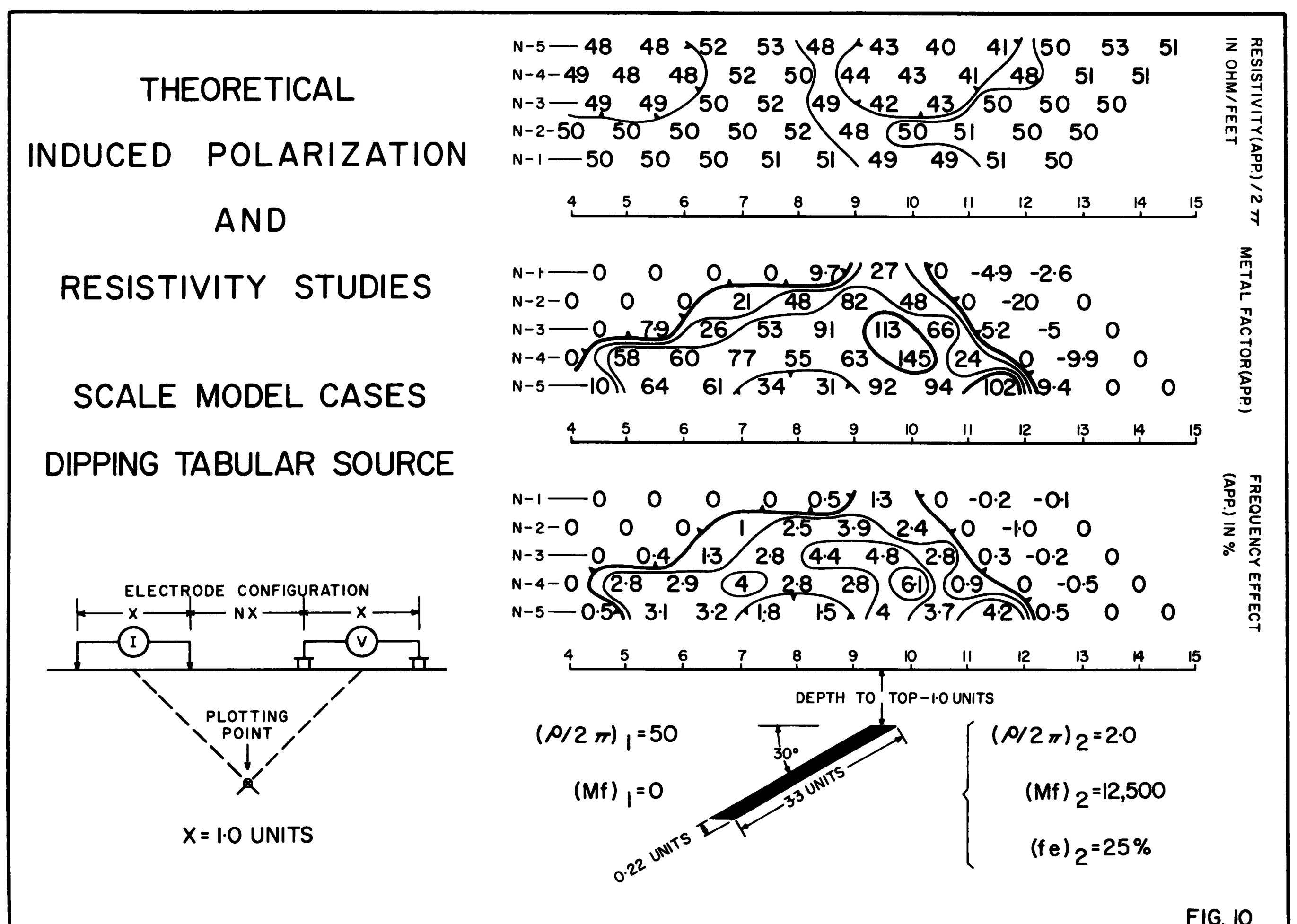


FIG. 10

Geophysics Inc. in August - September 1966. The IP survey was planned to locate any zones of metallic mineralization that might be associated with the surface zone.

Geology

The general geology of the area is described briefly by Harper and Reynolds (1969). A complete geologic description is given by Barron (1969). The mass of the Slate Mountains (about 2.0 miles northeast of the Lakeshore Property) is primarily Precambrian Pinal Schist. Near the centre of the mountains, an elongated body of Laramide age quartz-diorite (granite) has intruded the schist. Around the southwest edge of the Slate Mountains, and outcropping through the valley fill, are outlying hills of Devonian and Carboniferous limestone, Cretaceous volcanic and sedimentary rocks and Tertiary andesite and andesite breccia.

At the Lakeshore Property, the geology has been exposed in the old Lakeshore Pit. (Fig. 2). In the centre of the pit, mineralized, banded tactite (metasediment) overlaid by a fine-grained quartzite, striking N50E and dipping 60^{o}SE, is exposed. These metasediments are terminated on the east side of the pit by a very strong fault that strikes northwest and dips 65^{o}SW.

Along the west wall of the pit, altered and fractured andesite occurs on the footwall of an andesite and metasediment contact. This contact, striking N40^{o}E and dipping 50^{o}SE, forms the footwall of the oxide orebody in the wedge-shaped block of metasediment (tactite).

The drilling recently completed at the Lakeshore Property has obviously added a great deal to information about the subsurface geology. The simplified geological section shown in Figure 3 shows the main features, as presently known. The correlations from the drill hole sections have resulted in a completely unexpected picture !

Hole C-5 is one of several churn drill holes completed in 1948 by the U.S. Bureau of Mines. The hole penetrated the oxide mineralization in the pit and then entered fractured andesite. At a depth of 455 feet, the hole penetrated 90 feet of secondary copper mineralization. A proper interpretation of these results in 1966-67, gave added importance to IP anomalies, at depth, to the west.

The picture in Fig. 3 is much simplified. For instance, the tactite is not completely mineralized and the concentrated mineralization (magnetite, pyrite, chalcopyrite) extends into the surrounding rock units at some points. The overturned position of the oxidized tactite at the surface is shown as a result of simple folding; in fact, complex faulting may be a part of the structure !

The biotite porphyry (quartz monzonite) intrusive which contains much of the disseminated mineralization intrudes the Cretaceous andesitic breccia and the late Precambrian metasediments. It was not known to reach the surface in the vicinity of the Lakeshore Property, at the time of this exploration program.

The andesites, porphyry, metasediments and the upper portions of the underlying intrusive have been extensively shattered and are moderately to strongly altered. The principal host rocks are the andesite, porphyry and the tactite. Chalcopyrite and pyrite are the principal sulphide minerals. They are disseminated throughout the shattered porphyry and andesite; they are present in greater concentration with the near-massive magnetite in the metasomatic replacement in the tactite.

The copper mineralization is younger than the intrusive porphyry, but may be associated with it. The granite (quartz-diorite) stock has been dated as Laramide in age; the porphyry, and the copper mineralization, are probably related to later phases of the same magmatic period. The complete picture is that of a typical southwestern U.S., "porphyry copper" deposit that reaches the present surface at only one, very small, outcrop area.

definite anomaly, at depth, centred at 525E. The anomalous pattern suggests a near-vertical, tabular source that has a width less than the electrode interval (300').

The results on Line 500N show clearly that if the Lakeshore Orebody is to be detected using 200' or 300' electrode intervals, it is necessary to use the dipole-dipole configuration and make accurate measurements for $n = 4$ and $n = 5$.

d) Line 498N ($X = 500'$ and $X = 1000'$)

As mentioned above, the deep IP anomaly at Lakeshore was confirmed using east-west lines and larger electrode intervals after the first drilling had not intersected significant sulphide mineralization to depths of 700 to 800 feet. Measurements using $X = 500'$ and $X = 1000'$ were made on Line 498N. This line is close enough to Line 500N, that the data can be considered to be from the same survey line.

The measurements with 500' electrode intervals can be seen on Figure 9. The most distinctive resistivity feature is the high resistivity level east of 530E to 535E. There is only a very slight resistivity low associated with the orebody.

The IP anomaly is quite definite when 500' electrode intervals are used. The apparent frequency effect values and the apparent Metal Factor values are both definitely anomalous. The largest effects are measured for $n = 4$ and $n = 5$.

The anomalous pattern suggests an asymmetric source and the pattern is complex. The source of the IP effects could be approximated by a tabular source dipping to the west. The theoretical scale modelling results shown in Figure 10 show a typical pattern for a source dipping at 30^{o}. The pattern is not unlike that measured over the Lakeshore Orebody using 500' electrode intervals.

The results of measurements with $X = 1000'$ on Line 498N are

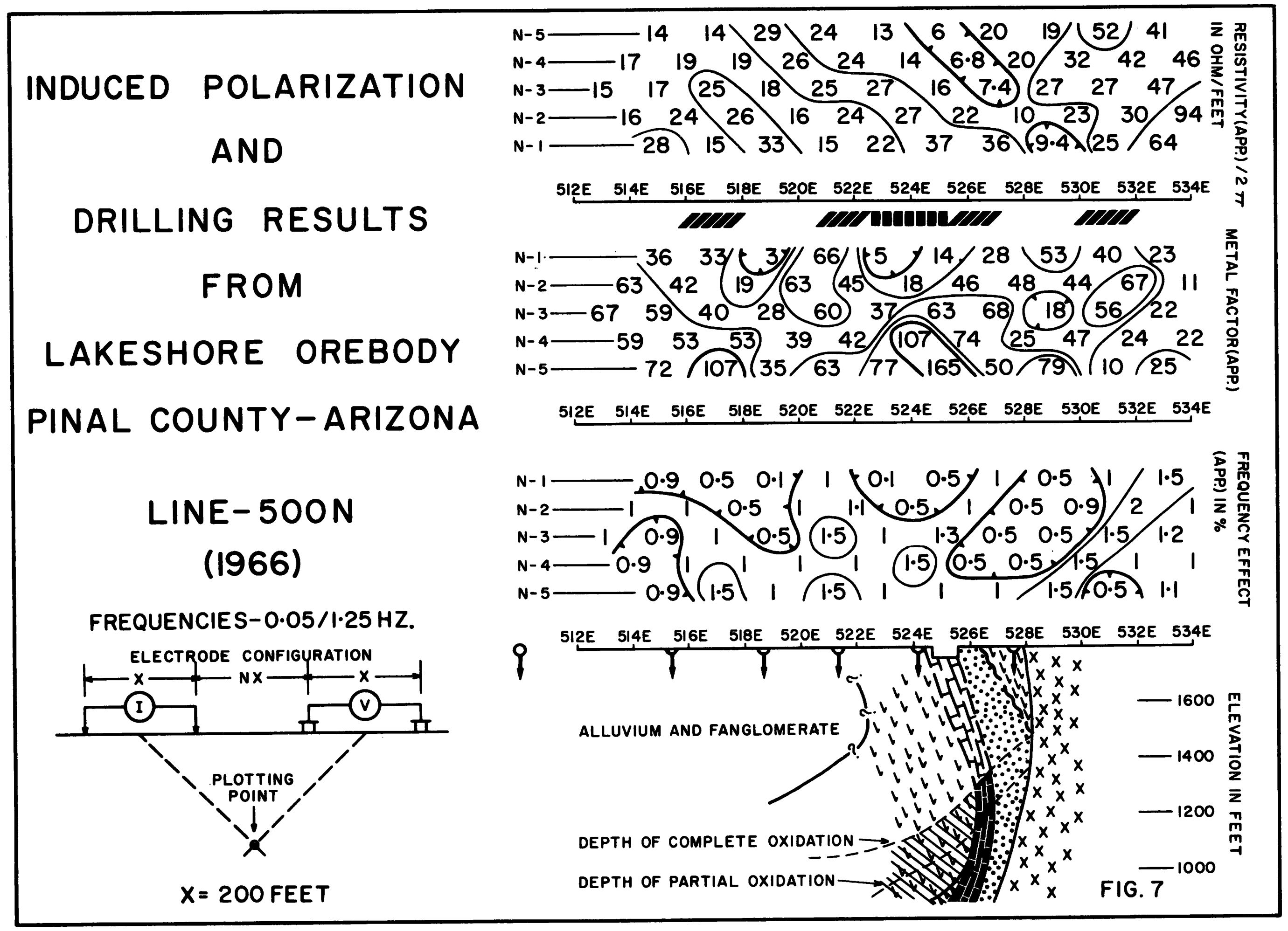


FIG. 7

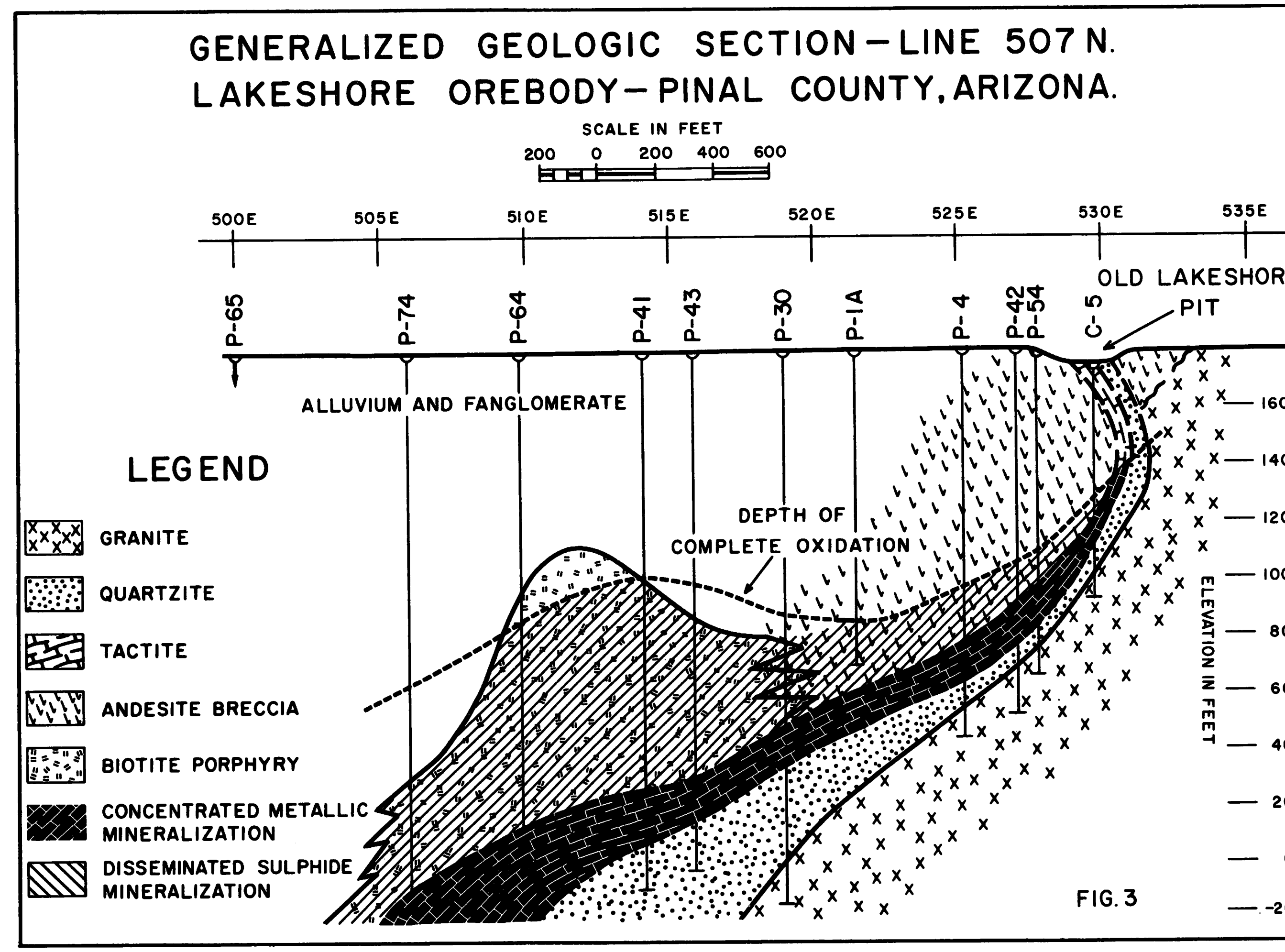


FIG. 3

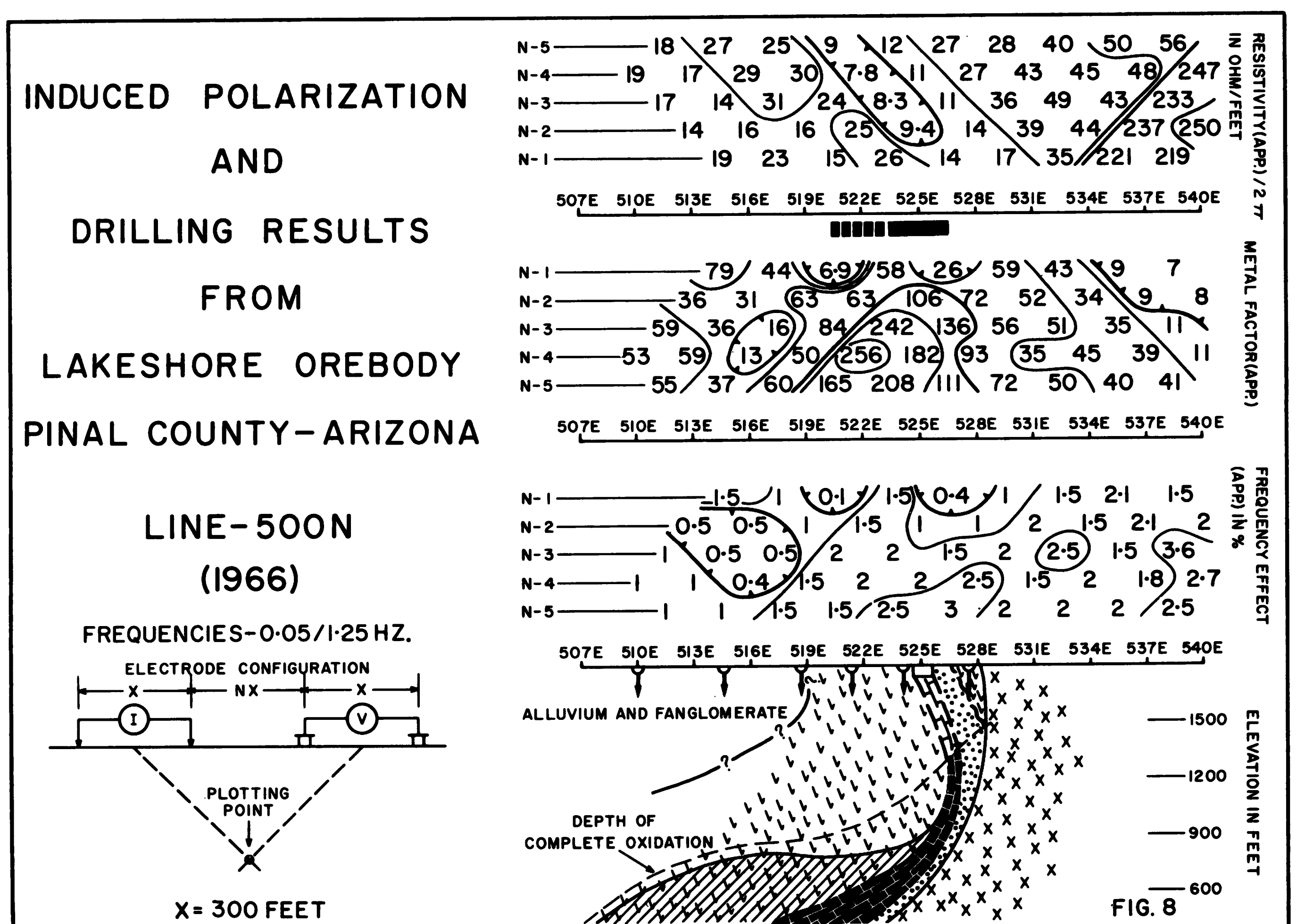


FIG. 8

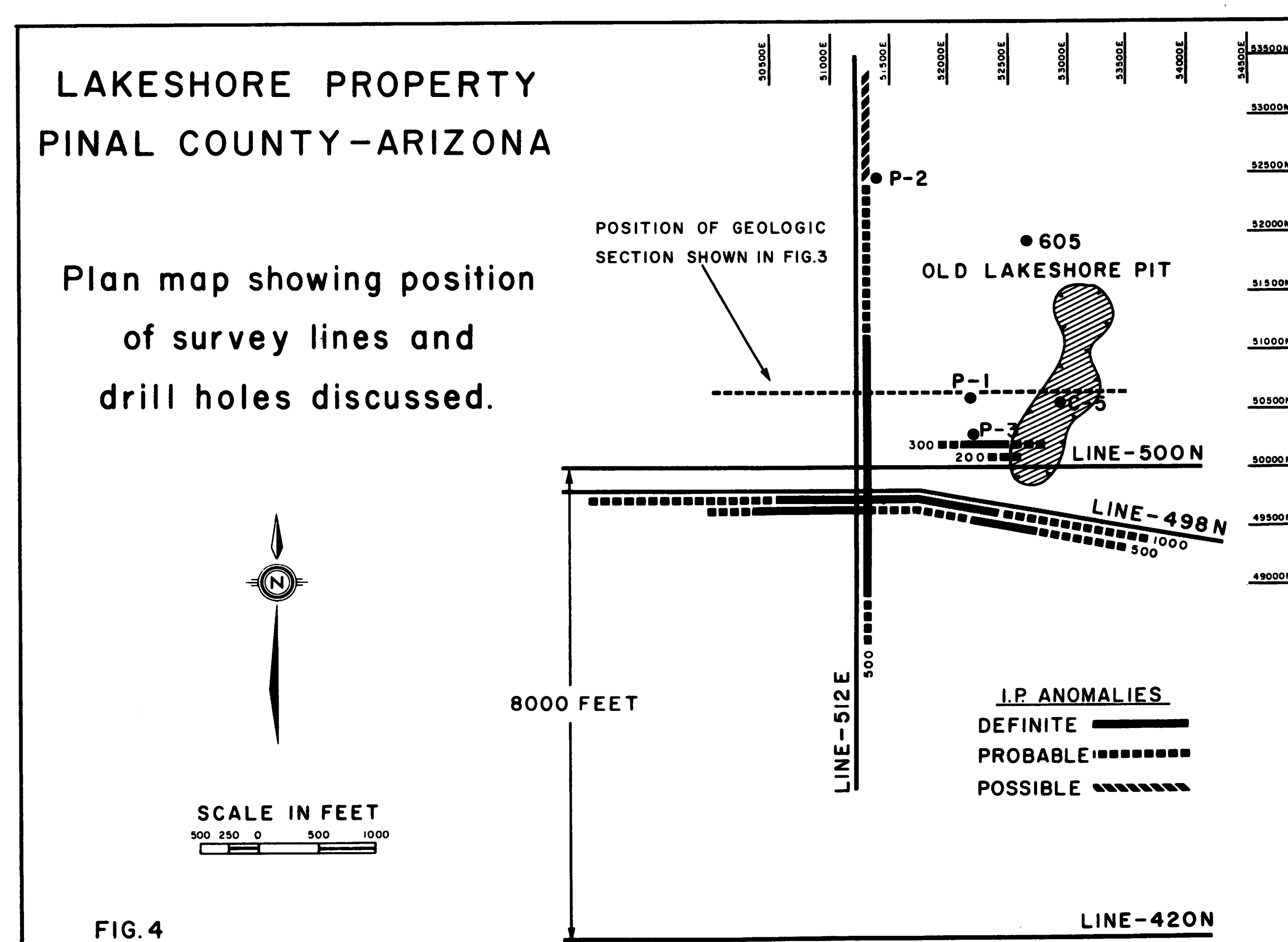


FIG. 4

Drilling Sequence For First Holes

The reconnaissance IP survey completed in August - September 1966 was made on north-south lines, at approximately one-quarter mile intervals. The dipole-dipole electrode configuration was used, with X = 500'. A few east-west lines were surveyed over the old Lakeshore Pit mineralization using X = 200' and X = 300'. The reconnaissance results indicated a moderate magnitude anomaly, at depth, to the west of the known mineralization in the old Lakeshore Pit. The depth to the top of the source was interpreted to be 1.0 - 2.0 electrode intervals (i.e. 500' to 1,000').

In Figure 4 we have shown the drill holes and surveyed lines that will be discussed. The first drilling done after the IP survey, was a deepening of Hole #605. This old rotary hole lay at the edge of the anomalous zone. It had been stopped at 288 feet in a porphyry, weakly mineralized with secondary copper minerals. Core drilling was completed to 790 feet, before the hole was lost due to poor drilling conditions. Fractured and altered porphyry and andesite breccia were encountered, with secondary copper minerals. No sulphide mineralization was encountered.

At this point, Hole P-1 and Hole P-2 were begun at widely separated points within the IP anomaly. Hole P-2 was drilled through 800 feet of cemented fanglomerate and abandoned due to poor conditions. No oxide or sulphide mineralization was encountered. Hole P-1 was continued to a depth of 750 feet in fractured and altered andesite and andesite breccia; a few, sill-like, masses of biotite porphyry were encountered. At 750 feet the hole was still in weak copper oxide mineralization. At this point in time, drilling was discontinued while all of the geological and geophysical data was re-evaluated.

Laboratory measurements were made on core samples of all of the rock types encountered. The samples were of relatively low resistivity (25 - 250) due to porosity from fracturing, alteration, etc.; a few of the frequency effects measured were 1.0% to 1.25% (using 0.31 - 5.0 cps),

This is the most definite anomaly located on the reconnaissance survey, probably because of the decrease in the depth to the top, at this point.

c) Line 500N (X = 200' and X = 300')

At the end of the reconnaissance survey in 1966, a few east-west lines were surveyed in the vicinity of the old Lakeshore Pit. For this work X = 200', n = 1,2,3,4,5 were used. The data shown on Figure 7 is from Line 500N. This line passes over the south end of the old Lakeshore Pit.

No anomalous frequency effects were measured. The apparent Metal Factor results show a weak anomaly, at considerable depth, centred at 524E. As shown by the geological section, constructed using later drill holes, this deep anomaly correlates with the up-dip edge of the metallic mineralization, beneath the depth of oxidation.

Definite information about the depth of oxidation is sparse. However, the available data suggests that no fresh sulphide mineralization could be present above a depth of 400' to 500'. There would certainly be some interval of partial oxidation, in which some metallic minerals might be present. The metallic mineralization present is at the extreme limit of the depth at which X = 200' measurements would be expected to detect it.

Because of the great depth of the anomaly detected using X = 200', the measurements on Line 500N were repeated using X = 300'. (Figure 8). The 50% increase in electrode interval gave rise to a much more definite anomaly.

The resistivity pattern centred between 531E and 534E is a typical pattern indicating a near-vertical contact between high resistivity rocks to the east and lower resistivity rocks to the west. There is a slight resistivity low associated with the anomaly.

There is a slight increase in the apparent frequency effects for n = 4,5 but the increase is less than the increased frequency effects to the east in the high resistivity rocks. The Metal Factor parameter shows a

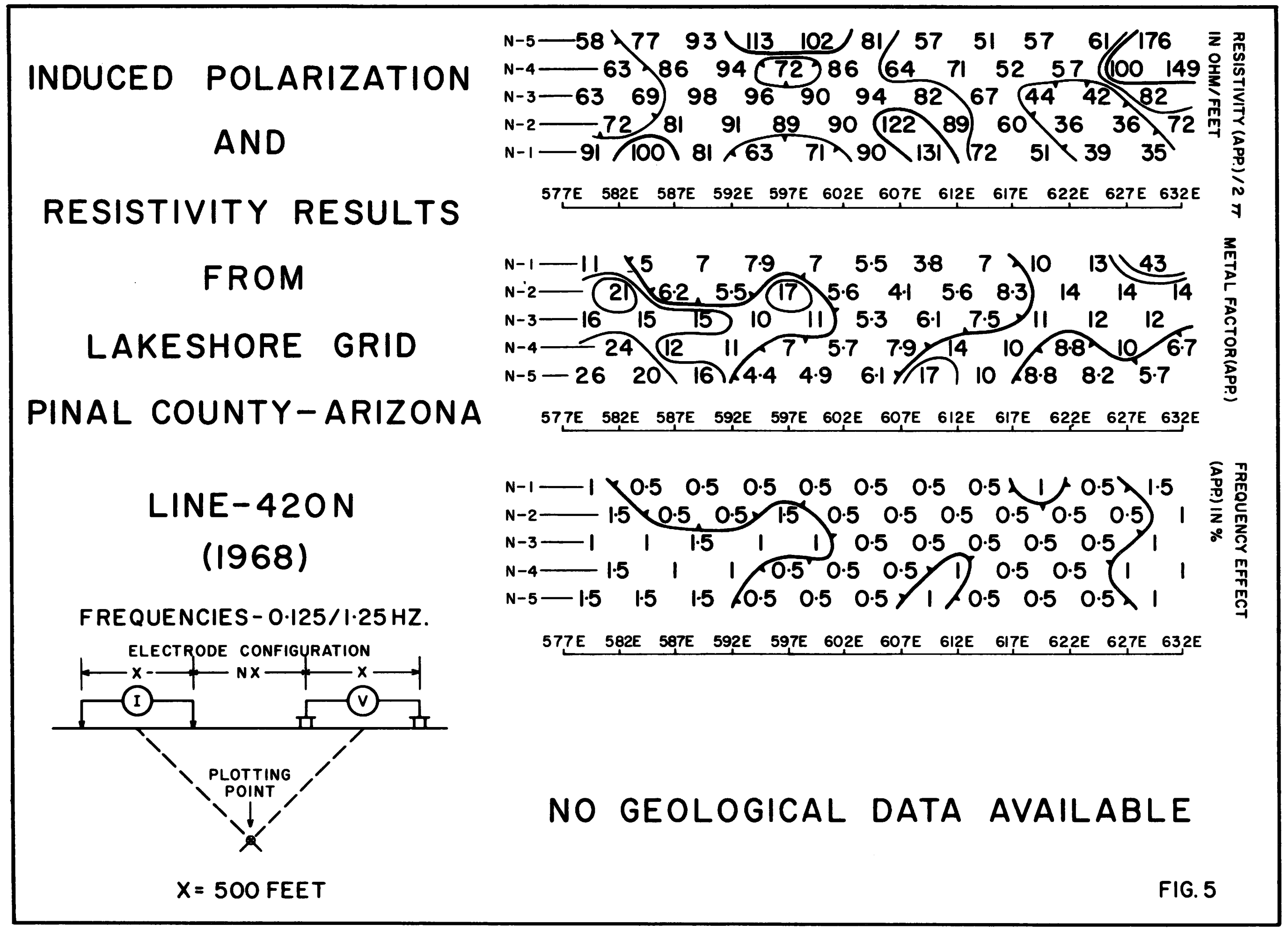


FIG. 5

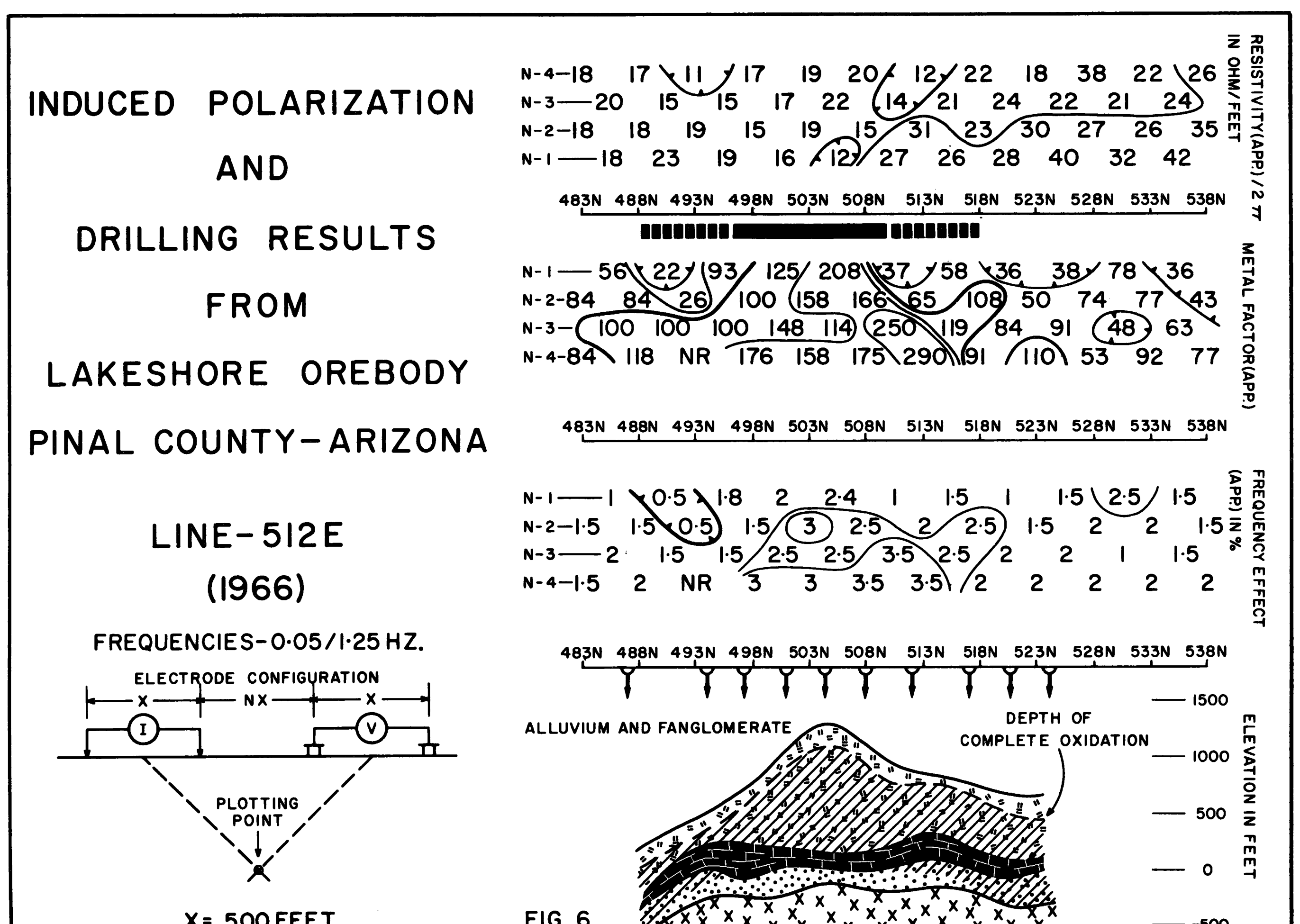


FIG. 6

but most were less than 1.0%. These true IP effects were not large enough in magnitude to be the source of the apparent effects previously measured. The anomaly was then confirmed using 500' electrode intervals on a few east-west lines.

At the same time a complete review of all of the geological information available was being completed by the Mineral Division of El Paso Natural Gas Co. This work was done by Claude E. Barron, Senior Mining Geologist, under the supervision of John R. Reynolds, Chief Geologist of the Minerals Division.

The major result of this review was the decision that the last structural event effecting the Lakeshore geology has been a 45° rotation about a horizontal axis trending N50°E. The interpretation was made that before this event the mineralized metasediments outcropping in the old Lakeshore Pit had been dipping steeply to the northwest, and overlain by the andesite and andesite breccia. This interpretation was confirmed by the two intersections of secondary copper mineralization in the old churn drill hole, Hole C-5; it also suggested that the mineralized tactite should be, at depth, in the area of the deep IP anomaly.

With the review completed, the possible importance of the IP anomalies was confirmed. It was decided to continue Hole P-1, in an attempt to intersect metallic mineralization that could be the source of the IP effects. At 850 feet, the hole encountered weak copper sulphide mineralization in the andesite breccia. Hole P-1 was lost at about 1,100 feet, due to poor drilling conditions.

Meanwhile, Hole P-3 had been started about 300' south of Hole P-1. The fractured and altered andesite and andesite breccia were difficult to drill; however, careful drilling gave consistently high core recovery. Some secondary copper mineralization was encountered, but little or no sulphides ! The hole passed from altered volcanics to altered sediments (limestone and dolomite) at 1,080 feet. At 1,147 feet the hole penetrated 90 feet of mineralized, banded tactite with massive magnetite, pyrite, and chalcopyrite. The interval assayed 1.75% copper.

This intersection (in mid-1967) marked the discovery of sulphide mineralization in the metasediments (tactite). The drilling program was accelerated, and in early 1968 an announcement was made that a major copper deposit had been discovered.

Geophysical Results

The only geophysical technique used in the direct detection of the metallic mineralization at Lakeshore was the induced polarization method. Ground and airborne magnetic data does exist for the area, but this data has not been released for publication here. The surface magnetic results show a weak anomaly associated with the mineralized tactite in the old Lakeshore Pit; these effects are interpreted to be due to small quantities of remnant magnetite in the weathered zone. There are variable, and sometimes large, concentrations of magnetite in the andesites. The surface expressions from these features effectively mask any interpretable anomaly from the approximately flat-lying magnetite zone in the tactite at depth.

Before Hecla Mining Co. joined El Paso Natural Gas Co. in the development of the Lakeshore Orebody, several other major mining companies reviewed the drilling and geophysical data. As part of their review, several of these companies carried out induced polarization surveys over the mineralized zone. These IP measurements were made in both the frequency domain and the time domain, with many different electrode configurations. If these measurements were made with the proper electrode interval, and electrode configuration, they usually confirmed the IP anomaly at depth. None of this data has been released for inclusion in this paper.

The variable frequency induced polarization surveys completed by McPhar Geophysics Inc., for El Paso Natural Gas Co., were done using the dipole-dipole electrode configuration. We will present enough of the

data here to confirm the usefulness of the method in detecting and delimiting the Lakeshore Orebody.

a) Line 420N (Background)

The results shown on Figure 5 are from a portion of Line 420N, which passes approximately two miles south of the centre of the ore zone. These results were chosen to show typical background levels on the pediment, southwest of the Slate Mountains. The resistivity level is moderate and the apparent frequency effects are variable, but low in magnitude.

b) Line 512E (Discovery Line)

The results shown on Figure 6 are part of the original 1966 reconnaissance survey done on north-south lines, about one-quarter mile apart. The survey was done using 500' electrode intervals and 0.05 - 1.25 cps.

There is almost no resistivity expression of the anomaly. The apparent frequency effect and apparent Metal Factor results both show a definite anomaly centred at 503N. There is some depth indicated to the source, but the depth to the top was not interpreted to be much more than one electrode interval (i.e. 500' - 600').

The geological section shown at the bottom of Figure 6 is drawn to the same vertical and horizontal scale as the IP data plots. The locations of the holes that have been drilled since 1966 are also shown. The rock-type symbols used are those identified in Figure 2 and Figure 3. The geologic section shows that the IP anomaly correlates with the shallowest portion of the mineralized porphyry. At about 503N on Line 512E, the disseminated mineralization is about 600' to 700' nearer the surface than it is for several thousand feet in all directions.

Under Line 512E, the more concentrated metallic mineralization in the tactite is at a depth of 1,800 feet. This mineralization would not be expected to influence the measurements using 500' electrode intervals.

ABSTRACT

An economic study of the Lake Shore Project was performed using Risk Analysis and the Wealth Growth Rate concept. For the analysis a large tonnage underground block caving operation was assumed using the cost figures from a currently operating mine (San Manuel). Results indicated the following: (@ 57¢ - 63¢ copper and 5% royalty)

1. 40,000 TPD -- most likely WGR = 10.6%
2. 50,000 TPD -- most likely WGR = 11.2%
3. 60,000 TPD -- most likely WGR = 11.2%

The minimum WGR was 10% at 40,000 TPD and the maximum was 11.6% at 50,000 TPD.

Results indicate the project may be attractive if all figures used in the analysis are accurate and the property can be acquired at a reasonable cost. The royalty paid to the Indians does not seem to be a large factor in the WGR; causing a reduction of about ½% at 10% royalty.

INTERIUM REPORT: LAKESHORE EVALUATIONS

BY: W. N. Hoskins

BACKGROUND

The Lakeshore property is located about thirty-one miles southeast of Casa Grande, Arizona, within the Papago Indian Reservation and Casa Grande mining district, Pinal County. (Sections 25, 26, 35, 36; T10S, R4E, Silver Reef Quandrangle). The Lakeshore deposit is situated on the southwest piedmont of the Slate Mountains at an elevation of about 1800 feet.

Work first began in this area in the early 1880's; however, after a shallow shaft and some horizontal drifting had been done, the copper market failed and the claims were abandoned. In 1905 the property was again relocated and a small quantity of ore from the old mine dumps was shipped to nearby smelters. In 1914 the property changed hands and the new owners, Frank and Charles Leonard, sank a new shaft to 225 feet and began mining the high grade portion of the ore body. In 1917 the Atlas Development Compny leased the mine and shipped 850 tons of 5.2% copper ore. Two years later, after Atlas Development Company terminated the lease, the owners did more exploration and mined a total of about 12 tons of high grade (15%) copper and in 1929 production ceased.

In 1949 the United States Bureau of Mines (USBM) investigated the Lakeshore property by performing geologic and topographic mapping, exploratory drilling (one diamond drill hole and 5 churn drill holes for a total of 2,872 feet) and metallurgical test work. Shortly after the USBM investigation was completed, the property was acquired by Transarizona Resources, Inc. From 1956 to 1962 Trans~~america~~ arizona Resources developed a small oxide open pit mine on the copper deposit and, jointly with the USBM, designed a special benification process to separate the copper from the host rock. Metallurgical and technical problems could not be satisfactorily solved and Transarizona Resources went into receivership.

During 1962 - 1966 Transarizona Resources tried to interest several large mining companies in the properties. El Paso Natural Gas Company examined the property in 1962 and started a small drilling program in 1963. In 1966 the Narragansett Wire Company acquired the outstanding stock of Transarizona Resources, cured the receivership, and in 1967 became a wholly owned subsidary of El Paso Natural Gas.

During 1967, El Paso Natural Gas started extensive geological and geophysical investigations of the operating property and adjacent land which culminated in discovery of the large copper deposit concealed beneath alluvium to the west of the small open pit mine. In 1968 they opened their exploration records for inspection by a number of major mining companies and is known to have received several offers of participation. Finially, in February 1969 an agreement was concluded with Hecla Mining Company in which Hecla relinquished 16.8% of its stock to El Paso National Gas for a 50% interest and operating control of the property.

RESERVES AND GRADE

Harper and Reynolds, at the 1969 Mining Congress meeting, reported that in February 1969, with a total of 77 drill holes located in an area 3000' by 4000', spaced at 350' to 400' apart, and ranging in depth from 700' to 3200' (total footage: 127,000'), reserves and grade were:

241×10^6	tons sulfides	@ 0.70% Cu
207×10^6	tons oxides	@ 0.71% Cu
23.6×10^6	tons tactite	@ 1.69% Cu
472×10^6	tons total ore.	

with minor values of Mo S_2, Au, and Ag.

At the November 1969 New Mexico Mining Association annual meeting, C. E. Barron, senior mining geologist with El Paso Natural Gas reported the same figures.

An earlier report, completed January 14, 1969 by R. F. Hewlett of Computech Research, Ltd. reported the following reserves based on 22 drill holes: 322, 319, 280 tons @ 0.81% Cu.

Several personal communications between Ken Jones (Essex) and unnamed parties cast doubt on the validity of some portions of the ore reserve information. Careful review of the raw data would be desirable in order to confirm the reserves and grade.

FINANCIAL ANALYSIS

The financial analysis of the Lakeshore property was based on information obtained from previously mentioned reports and second hand information. At best, the final answer is in the "ball park". Due to the variability of data it was decided to use an analysis based on business risk and a computer program developed especially for economic evaluation of mining properties.

Risk analysis is a comprimise between conventional and theoretical analytic procedures. Conventional analysis involves cash flow computations based on deterministic variables (those variables for which one value only is used) from which the output is used to determine capital investments. In conventional analysis no attempt is made to incorporate the variability of input data. Risk analysis provides management with information on the extent of risk involved in an investment by using data in the form of probability distributions. In other words, the grade of ore is generally known between high and low limits and is indicated by a statistical weighted mean value. For example, a copper grade is known to be between 0.75% to 0.95% with a mean of 0.85%. Conventional methods use the 0.85% as the true grade, whereas, Risk analysis would use 0.85% as the mean with a standard deviation of 0.10%. In Risk analysis all variables, except those known to be constant, can be input with their probable variation and the final result is an answer that gives the probability of acheiving a certain net present value of investment or return on investment.

As an additional modification, the program calculates the financial feasibility of the property using the wealth growth rate concept. Wealth growth rate involves using as input data, the rate of interest on capital, and using this rate as the growth rate of all positive cash flow monies. Conventional discounted cash flow-return on investment methods use the return on investment as the growth rate of positive cash flows. If the rate of return for the investment is large then the final result is inflated, because the method assumes that all incoming money is reinvested at the same rate.

The following is a list of the input data used in calculating the wealth growth rate on investment for a hypothetical Essex - El Paso Natural Gas joint venture. The values are approximations based on the combined knowledge of the Essex Metallurgy and Mining staff. It has been assumed that Essex will gain control of Hecla by some means and El Paso Natural Gas will write off their capital expenditures at the to date.

A. Mining Method: Underground block caving

B. Fixed Variables:

1.	Federal tax rate	48.0%
2.	State and Local tax rate	1.5%
3.	Depletion rate	15.0%
4.	Operating days per year	350
5.	Rate of capital	10.0%
6.	Pre production period - years	4.0
7.	Mill concentrate grade (% Cu)	26.0%
8.	Mill recovery	93.0%

C. Stochastic Variables ~~(values uncertain~~

1.	Mine capacity	a. 40,000 TPD b. 50,000 TPD c. 60,000 TPD
2.	Water and land acquisition	$50,000,000 max $40,000,000 mean $30,000,000 min
3.	Reserves (tons)	472,000,000 max 370,000,000 mean 320,000,000 min
4.	Grade (constant)	0.80% Cu
5.	Exploration costs	$2,500,000 max $2,000,000 mean $1,500,000 min
6.	Royalty (on production only)* *also determined at a constant rate of 5%	10% max 7% mean 5% min
7.	Mining recovery	92% max 90% mean 88% Min
8.	Smelting and refining costs standard deviation	$67.60/ton conc = $5.00/ton

9.	Copper price (per pound cu)	$0.60
	standard deviation	= $0.03
10.	Mining costs (per ton of ore)	$1.60
	standard deviation	= $0.10
11.	Development costs (per ton of ore)	$1.00
	standard deviation	= $0.10
12.	Milling costs (per ton of ore)	$0.85
	standard deviation	= $0.05
13.	Capital investment costs for replacement of equipment	$6,000,000
14.	Salvage value of equipment	$5,000,000
15.	Capital investment	$150,000,000
	a. 40,000 TPD	
	standard deviation	= $10,000,000
	b. 50,000 TPD	$160,000,000
	standard deviation	= $10,000,000
	c. 60,000 TPD	$180,000,000
	standard deviation	= $10,000,000
16.	Development costs	
	a. 40,000 TPD	$15,000,000
	standard deviation	= $2,000,000
	b. 50,000 TPD	$17,000,000
	standard deviation	= $2,000,000
	c. 60,000 TPD	$20,000,000
	standard deviation	= $2,000,000
17.	Working capital for property	
	a. 40,000 TPD	$8,000,000
	b. 50,000 TPD	$9,000,000
	c. 60,000 TPD	$10,000,000

CAPACITY= 50000. TONS PER DAY

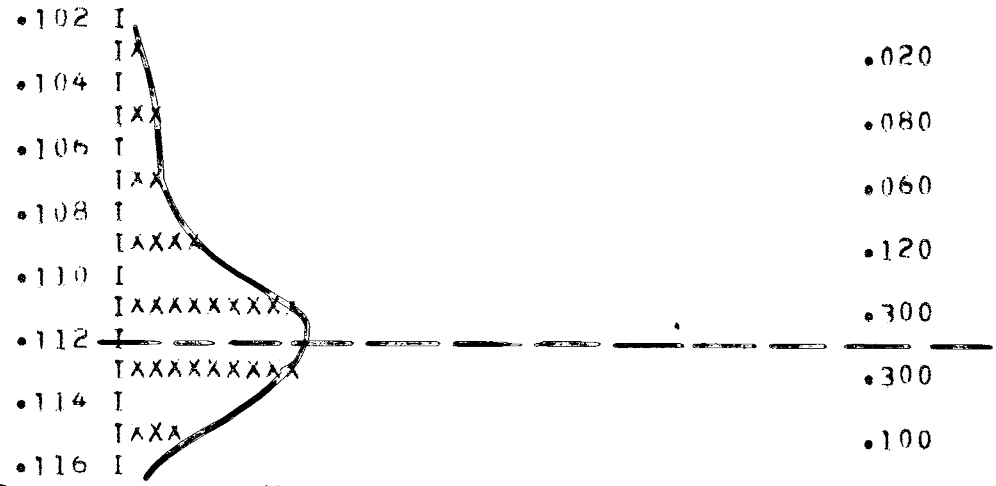
WEALTH GROWTH RATE AS INVESTMENT CRITERION
REQUIRED RATE OR COST OF CAPITAL = .10

MINIMUM	.103
MEAN	.111
MOST LIKELY	.112
MAXIMUM	.116
STANDARD DEVIATION	.003
COEFFICIENT OF VARIATION	.03

PROBABILITY CRITERION EXCEDES 0.00 = 1.00

CLASS LIMITS — PROBABILITY DISTRIBUTION SHAPE — PROBABILITY OF CLASS

(A)



CLASS LIMITS — CUMULATIVE PROBABILITY DISTRIBUTION SHAPE — CUMULATIVE PROBABILITY OF CLASS

(B)

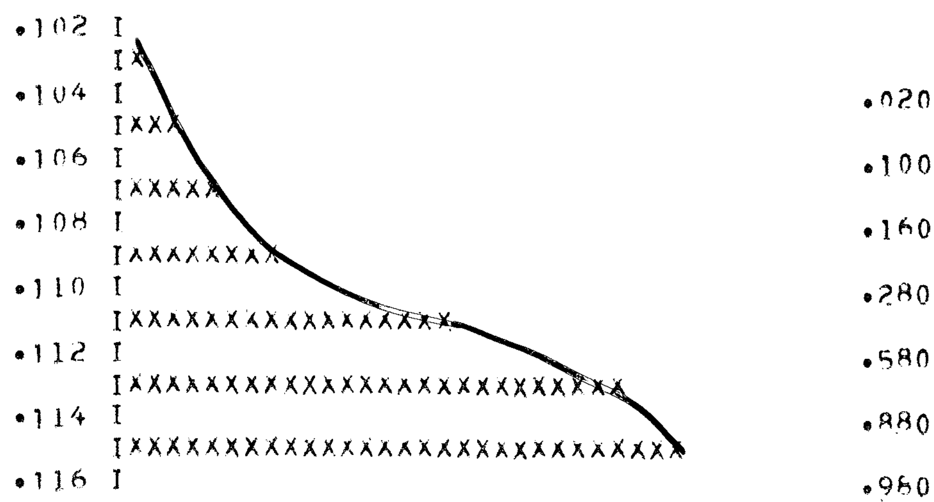


Figure 2 Probability Curves 50,000 TPD

CAPACITY= 40000. TONS PER DAY

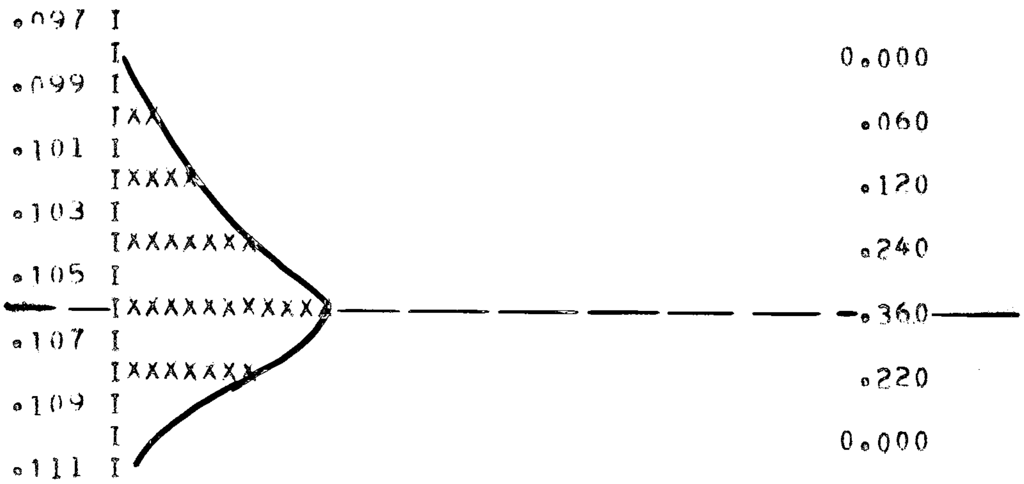
WEALTH GROWTH RATE AS INVESTMENT CRITERION
REQUIRED RATE OR COST OF CAPITAL = .10

MINIMUM	.100
MEAN	.105
MOST LIKELY	.106
MAXIMUM	.108
STANDARD DEVIATION	.002
COEFFICIENT OF VARIATION	.02

PROBABILITY CRITERION EXCEDES 0.00 = 1.00

CLASS LIMITS | PROBABILITY DISTRIBUTION SHAPE | PROBABILITY OF CLASS

(A)



CLASS LIMITS | CUMULATIVE PROBABILITY DISTRIBUTION SHAPE | CUMULATIVE PROBABILITY OF CLASS

(B)

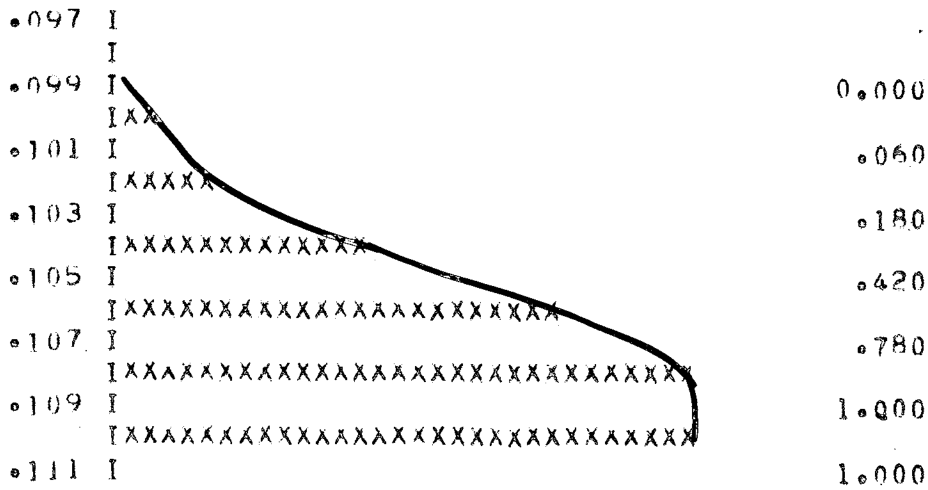


Figure 1 Probability Curves 40,000 TPD

```
                    CAPACITY=   60000. TONS PER DAY

              WEALTH GROWTH RATE AS INVESTMENT CRITERION
               REQUIRED RATE OR COST OF CAPITAL = .10
MINIMUM                                   .102
MEAN                                      .110
MOST LIKELY                               .112
MAXIMUM                                   .115
STANDARD DEVIATION                        .003
COEFFICIENT OF VARIATION                  .03

PROBABILITY CRITERION EXCEEDS                 0.00 = 1.00
    CLASS                 PROBABILITY                      PROBABILITY
    LIMITS             DISTRIBUTION SHAPE                   OF CLASS

        .101 I
             IX                                               .020
        .103 I
             IX                                               .020
        .105 I
             IX                                               .040
        .107 I
             IXXXXX                                           .180
        .109 I
             IXXXXXXX                                         .220
        .111 I
             IXXXXXXXX                                        .280
        .113 I
             IXXXXX                                           .160
        .115 I
    CLASS            CUMULATIVE PROBABILITY                CUMULATIVE
    LIMITS            DISTRIBUTION SHAPE             PROBABILITY OF CLASS

        .101 I
             IX
        .103 I                                                .020
             IX
        .105 I                                                .040
             IXX
        .107 I                                                .080
             IXXXXXXXX
        .109 I                                                .260
             IXXXXXXXXXXXXXX
        .111 I                                                .480
             IXXXXXXXXXXXXXXXXXXXXXXX
        .113 I                                                .760
             IXXXXXXXXXXXXXXXXXXXXXXXXXXXX
        .115 I                                                .920
```

Figure 3 Probability Curves 60,000 TPD

DISCUSSION OF RESULTS

Figures 1, 2, and 3 represent the final results of the economic analysis in graphical form. In each analysis at 40,000 TPD, 50,000 TPD, and 60,000 TPD, a total of 50 simulations were performed with each simulation having a random value for each stochastic variable and a given value for each deterministic variable. Figure 1(a) indicates that out of the 50 simulations performed at 40,000 TPD, 36% of the simulations performed had a wealth growth rate (WGR) of 10.5 - 10.7% on investment. Figure 1(b) indicates that out of the 50 simulations performed at 40,000 TPD, 78% of the time a WGR equal to or less than 10.5 - 10.7% was obtained.

Figure 2(a) indicates that at 50,000 TPD there is a 30% probability of obtaining from 11.0 - 11.2% WGR and a 30% probability of obtaining from 11.2 - 11.4% WGR. Figure 2(b) indicates an 88% probability that at least 11.2 - 11.4% WGR will be obtained.

Figure 3(a) indicates a 28% probability of obtaining from 11.1 - 11.3% WGR and a 76% probability of getting at least 11.1 - 11.3% WGR.

Summarizing all three graphs indicates that, with the given input data, the most likely rate of return at 40,000 TPD is 10.6%, at 50,000 TPD is 11.2% and at 60,000 TPD is also 11.2%. All this data was generated using a royalty of 5% on production for the Indians. Apparently from previous investigations a royalty of 10% will decrease the WGR about ¼ - ½%. Previous data indicates that less than 40,000 TPD in block caving at the scale being visualized may not be satisfactory.

List of References:

1. Barron, C.E., "Exploration at Lakeshore Mine", presented at annual meeting, New Mexico Mining Assoc., Nov. 16-19, 1969.

2. Hewlett, R.F., "El Paso Natural Gas Company, Lakeshore Property, Preliminary Report", January 14, 1969.

3. Hecla Mining Company, 1972 Annual Report.

4. Freeman, G.A., C. Rampacek, and L.G. Evans, "Copper Segregation at the Lakeshore Mine", AIME Annual meeting, St. Louis, Mo., 27 Feb. 1961.

5. Leech, W. D., "Documentation of a Computer Program using the Business Risk Analysis Technique Applied to Preliminary Economic Evaluation of Mining Properties", Term Report, U of Arizona, November 1972.

6. Hertz, D.B., "Risk Analysis in Capital Investment ", Harvard Business Review, Boston, Mass., about 1963.

7. Kim, Y.C., "The Risk Analysis Approach to Investment Decision Making", Kennecott Copper Corp., Scientific and Engineering Computer Center, S.L.C., Utah. 8 Dec. 1967.

8. Harper, H.E. and J.R. Reynolds, "The Lakeshore Copper Deposit", paper presented at 1969 Mining Congress in San Francisco.

9. Romslo, T.M., "Investigation of the Lakeshore Copper Deposits, Pinal County, Arizona" U.S.B.M. RI4706, July 1950.

```
                 CAPACITY=   50000. TONS PER DAY

             NET PRESENT VALUE AS INVESTMENT CRITERION
              REQUIRED RATE OR COST OF CAPITAL = .10
MINIMUM                       14320000.000
MEAN                          50970000.000
MOST LIKELY                   57645000.000
MAXIMUM                       81710000.000
STANDARD DEVIATION            15140000.000
COEFFICIENT OF VARIATION              .30

PROBABILITY CRITERION EXCEDES           0.00 = 1.00
     CLASS                PROBABILITY                   PROBABILITY
     LIMITS            DISTRIBUTION SHAPE                 OF CLASS

  14310000.000 I
               IX                                             .040
  23940000.000 I
               IXXX                                           .100
  33570000.000 I
               IXXXX                                          .140
  43200000.000 I
               IXXXXXX                                        .200
  52830000.000 I
               IXXXXXXXXXX                                    .320
  62460000.000 I
               IXXXX                                          .120
  72090000.000 I
               IXX                                            .080
  81720000.000 I
     CLASS             CUMULATIVE PROBABILITY              CUMULATIVE
     LIMITS              DISTRIBUTION SHAPE           PROBABILITY OF CLASS

  14310000.000 I
               IX
  23940000.000 I                                              .040
               IXXXX
  33570000.000 I                                              .140
               IXXXXXXXX
  43200000.000 I                                              .280
               IXXXXXXXXXXXXXX
  52830000.000 I                                              .480
               IXXXXXXXXXXXXXXXXXXXXXXXX
  62460000.000 I                                              .800
               IXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  72090000.000 I                                              .920
               IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  81720000.000 I                                             1.000
```

```
                    CAPACITY=   40000. TONS PER DAY

              WEALTH GROWTH RATE AS INVESTMENT CRITERION
                REQUIRED RATE OR COST OF CAPITAL = .10
MINIMUM                                    .100
MEAN                                       .105
MOST LIKELY                                .106
MAXIMUM                                    .108
STANDARD DEVIATION                         .002
COEFFICIENT OF VARIATION                    .02

PROBABILITY CRITERION EXCEDES              0.00 = 1.00
     CLASS                PROBABILITY                    PROBABILITY
     LIMITS            DISTRIBUTION SHAPE                 OF CLASS

          .097 I
               I                                           0.000
          .099 I
               IXX                                          .060
          .101 I
               IXXXX                                        .120
          .103 I
               IXXXXXXX                                     .240
          .105 I
               IXXXXXXXXXXX                                 .360
          .107 I
               IXXXXXXX                                     .220
          .109 I
               I                                           0.000
          .111 I
     CLASS             CUMULATIVE PROBABILITY             CUMULATIVE
     LIMITS              DISTRIBUTION SHAPE          PROBABILITY OF CLASS

          .097 I
               I
          .099 I                                           0.000
               IXX
          .101 I                                            .060
               IXXXXX
          .103 I                                            .180
               IXXXXXXXXXXXXX
          .105 I                                            .420
               IXXXXXXXXXXXXXXXXXXXXXXX
          .107 I                                            .780
               IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
          .109 I                                           1.000
               IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
          .111 I                                           1.000
```

```
                  CAPACITY=   40000. TONS PER DAY

              NET PRESENT VALUE AS INVESTMENT CRITERION
               REQUIRED RATE OR COST OF CAPITAL = .10
MINIMUM                        -1950000.000
MEAN                           25060000.000
MOST LIKELY                    24790000.000
MAXIMUM                        51520000.000
STANDARD DEVIATION             12110000.000
COEFFICIENT OF VARIATION               .48

PROBABILITY CRITERION EXCEDES           0.00 =  .96
     CLASS                PROBABILITY                  PROBABILITY
     LIMITS            DISTRIBUTION SHAPE               OF CLASS

  -1950000.000 I
               IXX                                       .060
   5690000.000 I
               IXXXX                                     .120
  13330000.000 I
               IXXXX                                     .120
  20970000.000 I
               IXXXXXXXXXX                               .320
  28610000.000 I
               IXXXXXXX                                  .220
  36250000.000 I
               IXXXX                                     .120
  43890000.000 I
               IX                                        .040
  51530000.000 I
     CLASS              CUMULATIVE PROBABILITY          CUMULATIVE
     LIMITS              DISTRIBUTION SHAPE        PROBABILITY OF CLASS

  -1950000.000 I
               IXX
   5690000.000 I                                         .060
               IXXXXX
  13330000.000 I                                         .180
               IXXXXXXXXX
  20970000.000 I                                         .300
               IXXXXXXXXXXXXXXXXXXX
  28610000.000 I                                         .620
               IXXXXXXXXXXXXXXXXXXXXXXXXX
  36250000.000 I                                         .840
               IXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  43890000.000 I                                         .960
               IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  51530000.000 I                                        1.000
```

INPUT DATA

CAP.INV. I = NORMAL

CAPACITY	EXPECTED VALUE	STANDARD DEVIATION
40000.	150000000.000	10000000.000
50000.	160000000.000	10000000.000
60000.	180000000.000	10000000.000

DEVEL.IN≠L = NORMAL

CAPACITY	EXPECTED VALUE	STANDARD DEVIATION
40000.	15000000.000	2000000.000
50000.	17000000.000	2000000.000
60000.	20000000.000	2000000.000

WORK.CAP≠L = NORMAL

CAPACITY	EXPECTED VALUE	STANDARD DEVIATION
40000.	8000000.000	0.000
50000.	9000000.000	0.000
60000.	10000000.000	0.000

MISCELLANE = CONSTANT

CAPACITY	EXPECTED VALUE	STANDARD DEVIATION
40000.	0.000	0.000
50000.	0.000	0.000
60000.	0.000	0.000

INPUT DATA

MIN≠G COST = NORMAL

CAPACITY	EXPECTED VALUE	STANDARD DEVIATION
40000.	1.600	.100
50000.	1.600	.100
60000.	1.600	.100

PROC≠SCOST = NORMAL

CAPACITY	EXPECTED VALUE	STANDARD DEVIATION
40000.	.850	.050
50000.	.850	.050
60000.	.850	.050

DEV.P COST = NORMAL

CAPACITY	EXPECTED VALUE	STANDARD DEVIATION
40000.	1.000	.100
50000.	1.000	.100
60000.	1.000	.100

OVERHEAD = CONSTANT

CAPACITY	EXPECTED VALUE	STANDARD DEVIATION
40000.	0.000	0.000
50000.	0.000	0.000
60000.	0.000	0.000

CAP.INV. R = CONSTANT

CAPACITY	EXPECTED VALUE	STANDARD DEVIATION
40000.	6000000.000	0.000
50000.	6500000.000	0.000
60000.	7000000.000	0.000

SALVAGE = CONSTANT

CAPACITY	EXPECTED VALUE	STANDARD DEVIATION
40000.	5000000.000	0.000
50000.	5500000.000	0.000
60000.	6000000.000	0.000

INPUT DATA

STOCHASTIC VARIABLES-

TONNAGE = TRIANGULAR

MINIMUM	MOST LIKELY	MAXIMUM
320000000.00000	370000000.00000	472000000.00000

GRADE = CONSTANT

EXPECTED VALUE	STANDARD DEVIATION
.00800	0.00000

WATER+LAND = TRIANGULAR

MINIMUM	MOST LIKELY	MAXIMUM
30000000.00000	40000000.00000	50000000.00000

EXPLORAT≠N = TRIANGULAR

MINIMUM	MOST LIKELY	MAXIMUM
1500000.00000	2000000.00000	2500000.00000

ROYALTY = CONSTANT

EXPECTED VALUE	STANDARD DEVIATION
.05000	0.00000

RECOVERY = TRIANGULAR

MINIMUM	MOST LIKELY	MAXIMUM
.88000	.90000	.92000

CONTRACT≠L = CONSTANT

EXPECTED VALUE	STANDARD DEVIATION
0.00000	0.00000

POST CONCT = NORMAL

EXPECTED VALUE	STANDARD DEVIATION
67.60000	5.00000

PRICE = NORMAL

EXPECTED VALUE	STANDARD DEVIATION
1200.00000	60.00000

INPUT DATA

CAPACITY 40000. TPD

FRACTION OF EXPENDITURE IN EACH PREPRODUCTION YEAR

	1	2	3	4	5
WATER+LAND AQUISITION	1.00	0.00	0.00	0.00	
EXPLORATION	.25	.25	.25	.25	
INITIAL CAPITAL INVESTMENT	.10	.30	.50	.10	
INITIAL DEVELOPMENT	.30	.40	.20	.10	

CAPACITY 50000. TPD

FRACTION OF EXPENDITURE IN EACH PREPRODUCTION YEAR

	1	2	3	4	5
WATER+LAND AQUISITION	1.00	0.00	0.00	0.00	
EXPLORATION	.25	.25	.25	.25	
INITIAL CAPITAL INVESTMENT	.10	.30	.50	.10	
INITIAL DEVELOPMENT	.30	.40	.20	.10	

CAPACITY 60000. TPD

FRACTION OF EXPENDITURE IN EACH PREPRODUCTION YEAR

	1	2	3	4	5
WATER+LAND AQUISITION	1.00	0.00	0.00	0.00	0.00
EXPLORATION	.25	.25	.25	.15	.10
INITIAL CAPITAL INVESTMENT	.10	.30	.40	.10	.10
INITIAL DEVELOPMENT	.20	.30	.20	.20	.10

INPUT DATA

FIXED VARIABLES-

FEDERAL TAX RATE	STATE AND LOCAL TAX RATE	DEPLETION RATE	OPERATING DAYS/YEAR
.48	.02	.15	350.
REQUIRED RATE OR COST OF CAPITAL	WEALTH GROWTH RATE BENCH	NET PRESENT VALUE BENCH	MINIMUM ROYALTY
.10	*00	0.	0.
CAPACITIES TESTED	SIMULATIONS PER CAPACITY	LONGEST PRE-PRODUCTION PERIOD	RANDOM NO. SEED
3	50	5	50.

SEC 617 TO DATE	CON GRADE	
0.	.260	.930

TIMIMG AND FRACTION OF CAPITAL EXPENDITURE FOR REPLACEMENT

CAPACITY TONS/DAY	PREPRODUCTION PERIOD IN YEARS	YR	FRAC	YR	FRAC	YR	FRAC	YR	FRAC	YR	FRAC
40000.	4	10	.500	20	.500	0	0.000	0	0.000	0	0.000
50000.	4	9	.500	18	.500	0	0.000	0	0.000	0	0.000
60000.	5	10	1.000	0	0.000	0	0.000	0	0.000	0	0.000

```
                  CAPACITY=   50000. TONS PER DAY

             WEALTH GROWTH RATE AS INVESTMENT CRITERION
               REQUIRED RATE OR COST OF CAPITAL = .10
MINIMUM                                    .103
MEAN                                       .111
MOST LIKELY                                .112
MAXIMUM                                    .116
STANDARD DEVIATION                         .003
COEFFICIENT OF VARIATION                    .03

PROBABILITY CRITERION EXCEDES               0.00 = 1.00
     CLASS                 PROBABILITY                      PROBABILITY
     LIMITS             DISTRIBUTION SHAPE                   OF CLASS

          .102 I
               IX                                             .020
          .104 I
               IXX                                            .080
          .106 I
               IXX                                            .060
          .108 I
               IXXXX                                          .120
          .110 I
               IXXXXXXXXX                                     .300
          .112 I
               IXXXXXXXXX                                     .300
          .114 I
               IXXX                                           .100
          .116 I
     CLASS              CUMULATIVE PROBABILITY              CUMULATIVE
     LIMITS               DISTRIBUTION SHAPE           PROBABILITY OF CLASS

          .102 I
               IX
          .104 I                                              .020
               IXXX
          .106 I                                              .100
               IXXXXX
          .108 I                                              .160
               IXXXXXXXX
          .110 I                                              .280
               IXXXXXXXXXXXXXXXXX
          .112 I                                              .580
               IXXXXXXXXXXXXXXXXXXXXXXXXXX
          .114 I                                              .880
               IXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
          .116 I                                              .980
```

CAPACITY=   60000. TONS PER DAY

NET PRESENT VALUE AS INVESTMENT CRITERION
REQUIRED RATE OR COST OF CAPITAL = .10

MINIMUM	9620000.000
MEAN	48860000.000
MOST LIKELY	44365000.000
MAXIMUM	79100000.000
STANDARD DEVIATION	14480000.000
COEFFICIENT OF VARIATION	.30

PROBABILITY CRITERION EXCEDES 0.00 = 1.00

```
     CLASS               PROBABILITY                    PROBABILITY
     LIMITS           DISTRIBUTION SHAPE                  OF CLASS

   9610000.000 I
               IX                                            .020
  19540000.000 I
               IXXX                                          .100
  29470000.000 I
               IXXX                                          .100
  39400000.000 I
               IXXXXXXXXXX                                   .320
  49330000.000 I
               IXXXXXXX                                      .220
  59260000.000 I
               IXXXX                                         .140
  69190000.000 I
               IXXX                                          .100
  79120000.000 I
     CLASS            CUMULATIVE PROBABILITY            CUMULATIVE
     LIMITS            DISTRIBUTION SHAPE          PROBABILITY OF CLASS

   9610000.000 I
               IX
  19540000.000 I                                             .020
               IXXXX
  29470000.000 I                                             .120
               IXXXXXXX
  39400000.000 I                                             .220
               IXXXXXXXXXXXXXXXX
  49330000.000 I                                             .540
               IXXXXXXXXXXXXXXXXXXXXXXX
  59260000.000 I                                             .760
               IXXXXXXXXXXXXXXXXXXXXXXXXXXX
  69190000.000 I                                             .900
               IXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
  79120000.000 I                                            1.000
```

```
                    CAPACITY=   60000. TONS PER DAY

              WEALTH GROWTH RATE AS INVESTMENT CRITERION
                REQUIRED RATE OR COST OF CAPITAL = .10
MINIMUM                                   .102
MEAN                                      .110
MOST LIKELY                               .112
MAXIMUM                                   .115
STANDARD DEVIATION                        .003
COEFFICIENT OF VARIATION                   .03

PROBABILITY CRITERION EXCEDES             0.00 = 1.00
     CLASS                PROBABILITY                  PROBABILITY
     LIMITS            DISTRIBUTION SHAPE               OF CLASS

          .101 I
               IX                                         .020
          .103 I
               IX                                         .020
          .105 I
               IX                                         .040
          .107 I
               IXXXXX                                     .180
          .109 I
               IXXXXXXX                                   .220
          .111 I
               IXXXXXXXX                                  .280
          .113 I
               IXXXXX                                     .160
          .115 I
     CLASS              CUMULATIVE PROBABILITY          CUMULATIVE
     LIMITS              DISTRIBUTION SHAPE       PROBABILITY OF CLASS

          .101 I
               IX
          .103 I                                          .020
               IX
          .105 I                                          .040
               IXX
          .107 I                                          .080
               IXXXXXXXX
          .109 I                                          .260
               IXXXXXXXXXXXXXX
          .111 I                                          .480
               IXXXXXXXXXXXXXXXXXXXXXXX
          .113 I                                          .760
               IXXXXXXXXXXXXXXXXXXXXXXXXXXXX
          .115 I                                          .920
```

ESSEX INTERNATIONAL

SUMMARY OF INVESTMENT CRITERION DATA BY CAPACITY

NET PRESENT VALUE AS INVESTMENT CRITERION
REQUIRED RATE OR COST OF CAPITAL = .10

CAPACITY TONS/DAY	EXPECTED VALUE	PROBABILITY CRITERION EXCEDES 0.00	MINIMUM	MOST LIKELY	MAXIMUM	STANDARD DEVIATION	COEFFICIENT OF VARIATION
40000.	25060000.00	.96	-1950000.00	24790000.00	51520000.00	12110000.00	.48
50000.	50970000.00	1.00	14320000.00	57645000.00	81710000.00	15140000.00	.30
60000.	48860000.00	1.00	9620000.00	44365000.00	79100000.00	14480000.00	.30

WEALTH GROWTH RATE AS INVESTMENT CRITERION
REQUIRED RATE OR COST OF CAPITAL = .10

CAPACITY TONS/DAY	EXPECTED VALUE	PROBABILITY CRITERION EXCEDES 0.00	MINIMUM	MOST LIKELY	MAXIMUM	STANDARD DEVIATION	COEFFICIENT OF VARIATION
40000.	.10	1.00	.10	.11	.11	.00	.02
50000.	.11	1.00	.10	.11	.12	.00	.03
60000.	.11	1.00	.10	.11	.11	.00	.03