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AERIAL MAGNETIC SURVEY OF A PORTION OF THE KLONDYKE MINING DISTRICT GRAHAM COUNTY, ARIZONA

THE RALPH M. PARSONS COMPANY
APRIL 1968

AERIAL MAGNETIC SURVEY OF A PORTION OF THE KLONDYKE MINING DISTRICT

GRAHAM COUNTY, ARIZONA

for

THE RALPH M. PARSONS COMPANY

April 1968

by

HEINRICHS GEOEXPLORATION COMPANY
P. O. Box 5671 Tucson, Arizona

TABLE OF CONTENTS

	Page
Introduction	1
Conclusions & Recommendations	2
Interpretation	3
Reference	6
Results of Susceptibility Measurements	7

In Pocket:

One Composite Magnetic and Interpretation Plan Map

One Topographic Map

INTRODUCTION

During the period February 22, 1968 to March 12, 1968, Heinrichs Geoexploration Company of Tucson, Arizona conducted an aerial magnetic survey over a portion of the Aravaipa District, located in the western portion of Graham County, Arizona. The work was done at the request of The Ralph M. Parsons Company. The area flown consisted of approximately 128 square miles and lies between latitudes 32° 47'N to 33° 02'N and longitudes 110° 15'W to 110° 23'W.

The survey flight lines were run on a bearing of approximately N 15° W and S 15° E. Tie-lines were run at right angles to the main survey lines. A total of 27 lines and two tie-lines were flown for a total of approximately 470 line miles. The survey altitude was 500 ft. above terrain.

A Fairchild-Hiller Heli-porter turbo-prop aircraft with a Varian Model 4937-A Proton Precession, total intensity measuring magnetometer was used for this survey. Sensitivity of this instrument is +/- one gamma when used on the one cycle sample rate. Additional equipment included a ten inch rectilinear chart recorder to record magnetic data, a 35 mm camera, a Bonzer radar altimeter and associated recorder to monitor terrain clearance. Sensitivity of the radar altimeter is within +/- 1.0 percent at 500 ft. Flight line recovery was accomplished by correlating the 35 mm camera strips with high altitude photographs and then plotting the data on U.S.G.S. topographic maps.

The base map used for the contour-plan map was a blow-up of portions of the San Carlos Reservation, Klondyke and Jackson Mountain U.S.G.S. quadrangles which are at a scale of 1:62,500. Geologic correlation with magnetic features was by the geologic map supplied by the client and by the U.S.G.S. by F. S. Simons (1957-59) P.P. #461. The scale of the base map is 1:24,000. The total magnetic contour interval of the plan map is 20 gammas. Reduction and compilation of the magnetic data was done using a Univac 1108 computer. A regional gradient was removed by fitting a third order polynomial to the data. All data from the computer was then fed into a Benson & Lehner X-Y Plotter, which performed the actual contouring of the magnetic information as presented on the magnetic contour plan map.

The determination of anomaly depths was done using the Peter's half slope method with an index of 1.6. These depths are considered only approximate, but of sufficient accuracy for this stage of evaluation. As more information is obtained, these depths undoubtedly will be revised and refined. The precision of depth estimates will usually be better than +/- 50%.

An examination of the altimeter records showed that, generally the prescribed terrain clearance (500 ft.) was maintained within +/- 200 ft. The one exception to this is a portion of the north end of the area in which terrain clearance, because of high topographic relief, was as great as 1,500 ft. Because of the good terrain clearance control, topography did not have a significant effect on the observed magnetics.

CONCLUSIONS AND RECOMMENDATIONS

Broadly speaking, the magnetics and geology conform well with each other. Suspected down dropping of the area along Aravaipa Creek is inferred magnetically by fairly abrupt depth changes up to the order of 1,000 ft. plus. The geology suggests this and the magnetic data helps confirm it plus showing a definite lineation or boundary condition which coincides with the postulated fault line. Possible displacement aspects are not indicated magnetically except that the top of the volcanics are about 1,000 ft. to 1,500 ft. below surface.

Nineteen specific anomalies and/or anomalous zones have been interpreted within the specific Aravaipa Area. Of these, seven of the more interesting are considered worthy of further evaluation and examination. These are identified by alphabetical letters on the plan map.

Anomalous zones M, N and O lie along the contact of the Goodwin Canyon quartz monzonite, and are generally associated with or near exposures of undifferentiated limestones and the Pinkard Formation and possibly schist. The presence of magnetic anomalism in and near to these sediments is definitely interesting, as some have been locally good hosts for economic mineralization produced in the past. Because of the shallow depths to these anomalies they take on even more interest and therefore should certainly be further evaluated by geophysical and other appropriate methods.

Anomaly Q lies over a tongue of the Williamson Canyon volcanics between outcrops of undifferentiated limestones and the Pinkard Formation. The depth to the source of this anomaly is very shallow and may in fact extend down from the surface. This anomaly is likely due to variations within the volcanics. However, because of the close proximity to mineralization the feature could still be related to factors of economic importance. It is recommended that several rock samples be obtained from the volcanics and any other rocks exposed in the vicinity of the anomaly so that their magnetic susceptibilities may be obtained.

An evaluation of these susceptibilities should help determine the cause of the anomaly and advisability of any further work. If the anomaly is due to the Williamson Canyon volcanics, probably the presence of an intrusive at depth would be impossible to confirm by magnetics. Probably the best solution would be one or two induced polarization traverses across the anomaly which might indicate the presence of an intrusive and tell if sulfide mineralization is present.

Anomaly P probably is as much as 2,000 ft. below the surface and could be due to an igneous intrusive at depth. In view of this, the possibility of mineralization in or near the overlying sediments is cnnsidered good. Several lines of induced polarization (I.P.) are recommended to evaluate the potential of this anomaly.

Anomaly J, because of its close proximity to the Grand Reef fault system, is considered a target for further work. The depth to this feature is estimated at 400 ft. One or two I. P. lines are recommended across this feature.

Anomalies G and H are directly attributed to polarization and generally high magnetic susceptibility within the Horse Mountain volcanics. However, there is still definite indirect interest because of the related strong structural intersection nearby of the Grand Reef and Waterfall Canyon faults and the suggestion of continuation of the Grand Reef fault south of the Waterfall Canyon fault. If this fault does continue on to the south, the possibility of associated mineralization is considered good. A careful geologic examination to determine if the fault continues is recommended. Several east-west I. P. lines are also recommended to attempt to determine the existance of a fault and/or mineralization.

INTERPRETATION

The Aravaipa Area is characterized in general by a series of north-south to northwest-southwest to east-west trending magnetic lineations. These lineations seem to map the major fault structures through the area.

The area is divided roughly into two zones by characteristics of magnetic intensity. The greatest portion of the area lies east of Aravaipa Creek and is characterized by relatively near surface magnetic features. The western strip, which lies in the center of the Aravaipa Basin is rather smooth magnetically as would be expected over areas of deeper alluvial cover.

Within the eastern portion of the survey there are four major magnetic zones. The most pronounced of these has a total magnetic relief of 2,500 gammas and lies adjacent to the Grand Reef fault, in the Horse Mountain volcanics. The other three lie respectively; south of the Waterfall Canyon fault, in the Pinal schist; along the Tule Springs fault; and along the Cobre Grande and Landsman Camp fault.

Anomaly A is over an area covered by Quaternary alluvium and Gila fanglomerate. The source depth to this feature is on the order of 1,000 ft. and probably represents the top of volcanics underlying the surface exposed Gila fanglomerate.

Anomaly B lies approximately one-half mile west of the outcropping Buford Canyon volcanics. Assuming that they continue under the Gila fanglomerate, the anomaly, which is about 500 ft. below the surface, could be attributed to them.

Anomaly C. has a magnitude of 250 gammas and a source depth of about 1,000 ft. This is beyond the area covered by the areal geology map, but it may be related to northwest trending faults and contacts.

Anomaly D and E are a complex of several features which lie almost wholly within the Pinal schist. The anomalies, which are caused by at or very near surface effects, are probably explained by the diabase intrusives in the Pinal schist itself. The northern portion of the anomalism is very probably strongly influenced by the fault contact between Pinal schist and Santa Teresa granite.

Anomalies F, G and H all lie along a northerly trend which generally is bordered on the east by the Grand Reef fault, and the projection of it to the south. All of these features are at or very near surface and probably are caused by the locally exposed Horse Mountain volcanics. Several rock samples furnished by the client from the field have been run for magnetic susceptibility and are generally strongly polarized. Differences in susceptibility and degree of polarization within the various elements of the total volcanic sequence comprising one formation probably explains the different magnetic character which is observed over the Horse Mountain volcanic complex. Nothing in this either specifically confirms or refutes this area being substantially down dropped and/or otherwise importantly cross-faulted.

Anomaly I lies about two miles due west of Anomaly H in the Gila fanglomerate and alluvium. This feature is possibly caused by volcanics or other igneous material at a depth of 1,200 - 1,500 ft.

Anomaly J has a depth to source of approximately 400 ft. and is located in the Laural Canyon granodiorite.

Anomaly K consists of two north trending magnetic lows over the diabase intrusives in the Laurel Canyon granodiorite. These lows may be caused, at least in part, by reverse polarization in the diabase, although the anomaly appears to be fairly deep seated. Depth estimate reliability factors are not high and range from 1,500 ft. to 2,000 ft. maximum.

Anomaly L has a magnetic relief of 100 gammas and is situated near the contact between the Santa Teresa granite and the Laurel Canyon granodiorite. The depth to the source is estimated at approximately 250 ft. below surface.

Anomalies M, N and O all lie along the northwest trending contact between Goodwin Canyon quartz monzonite and the various rock types to the southwest. All of these features are near surface and probably related to concentrations of magnetite along the contact.

Anomaly P has an estimated source depth which may be as great as 2,000 ft. This feature is possibily caused by the presence of an intrusive body at depth.

Anomaly Q lies near the contact between the Williamson Canyon volcanics and the Pinkard formation. Depth estimates indicate that the source of anomalism is at the surface, which would limit it to the Williamson Canyon volcanics. Possibly this anomaly is due to polarization effects in the volcanics.

Anomaly R appears to be due to reverse polarization within the Goodwin Canyon quartz monzonite.

Anomaly S lies at the extreme northwest corner of the survey area. The depth to this anomaly is approximately 600 ft. This anomaly is out of the area covered by the areal geology map and no interpretation was made. A geologic check of this area is recommended.

Respectfully submitted,
HEINRICHS GEOEXPLORATION CO.

Donald B Cooley
D. B. Cooley
Geologist

J. P. Matthews
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Geophysicist

C. S. Ludwig
C. S. Ludwig
Senior Geophysicist

Approved: W. E. Heinrichs, Jr.
W. E. Heinrichs, Jr.
President & General Manager

April 23, 1968

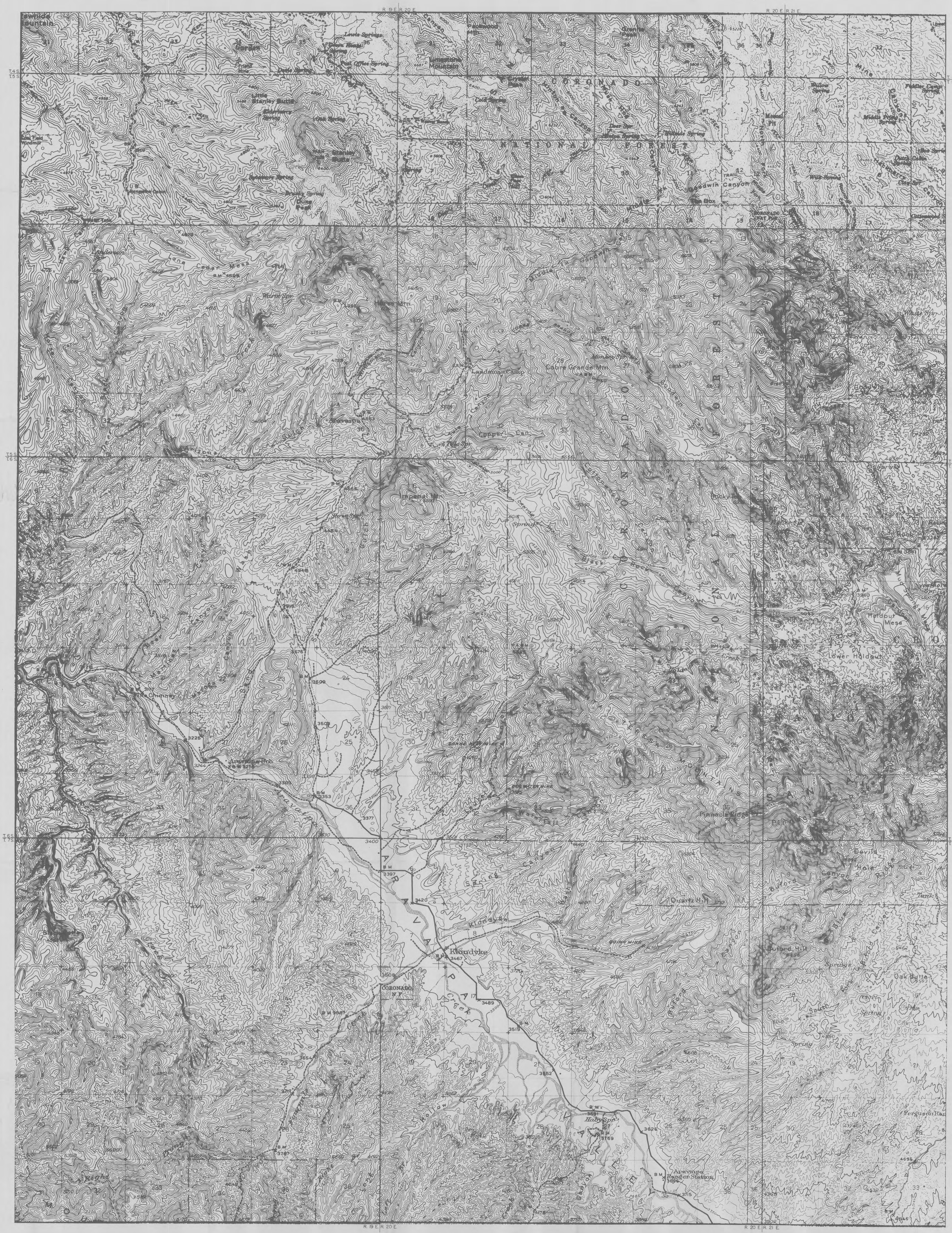
REFERENCE

Simons, S.F., 1964, Geology of the Klondyke Quadrangle Graham and Pinal Counties, Arizona. U.S. Geological Survey Prof. Paper 461, 171 p.

RESULTS OF SUSCEPTIBILITY MEASUREMENTS

The following table gives the measured magnetic susceptibilities of eleven rock samples from the Klondyke Mining District. Their location is shown on the Composite Magnetic and Interpretation Plan Map.

SAMPLE	ROCK TYPE	SUSCEPTIBILITY x 10^6 in c.g.s. units
1	Tkh	very strong & polarized
2	rhyolite	21,000 & polarized
2A	rhyolite	7,100
3	Tkh	41,000 & polarized
4	rhyolite	nil
5	granodiorite	nil
6	andesite	nil
7	altered limestone	nil
8	Tkh	nil
9	altered schist	6,800
10	tactite in limestone	nil
11	Bolsa Quartzite	nil



HEINRICHS
GEOEXPLORATION COMPANY
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vancouver
sydney
geophysical engineers

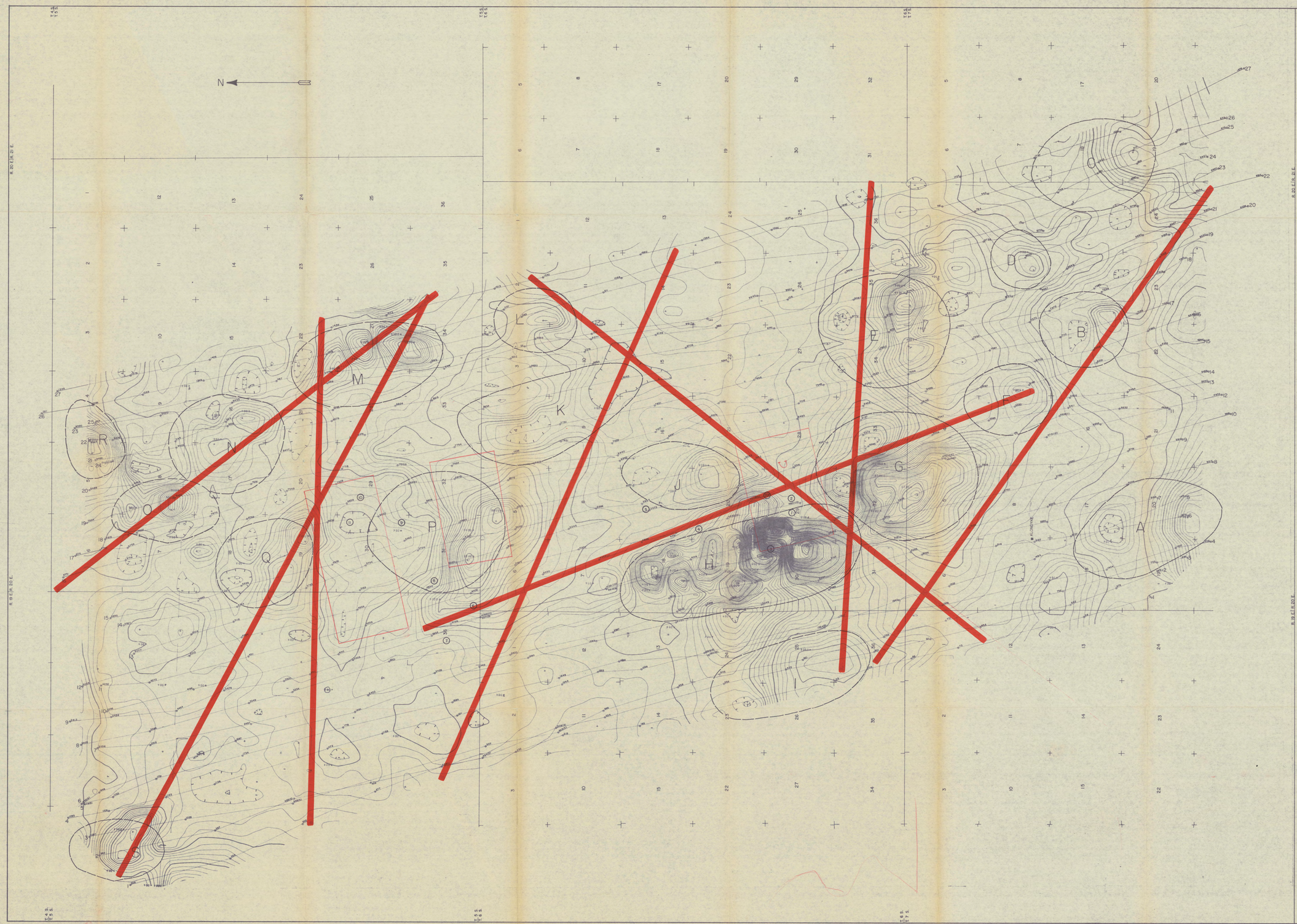
TOPOGRAPHY OF ARAVAIPA CREEK AND SANTA TERESA MTN. AREA

USGS TOPOGRAPHIC QUADRANGLES

SCALE-1:24000

FOR THE RALPH M. PARSONS COMPANY

APRIL 1968



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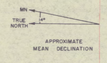
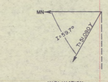
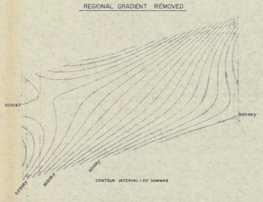


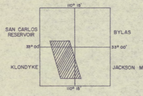


REGIONAL GRADIENT REMOVED



LOCATION OF PROJECT

INDEX TO PROJECT AREA



EXPLANATION

FLIGHT LINE WITH FIDUCIALS
FLIGHT LINE INTERVAL = .025 MI.
TERRAIN CLEARANCE = 500 FEET
CONTOUR INTERVAL = 20 GAMMAS

B

AREA OF INTEREST

APPROXIMATE ROCK SAMPLE LOCATION

LINEATION

CONTOURING BY X-Y PLOTTER

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Geophysical engineers Mineral exploration consultants

AERIAL MAGNETIC SURVEY
OF
ARAVAIPA CREEK AREA
GRAHAM COUNTY, ARIZONA

PROTON PRECESSION TOTAL MAGNETIC INTENSITY SURVEY

FOR

THE RALPH M. PARSONS COMPANY

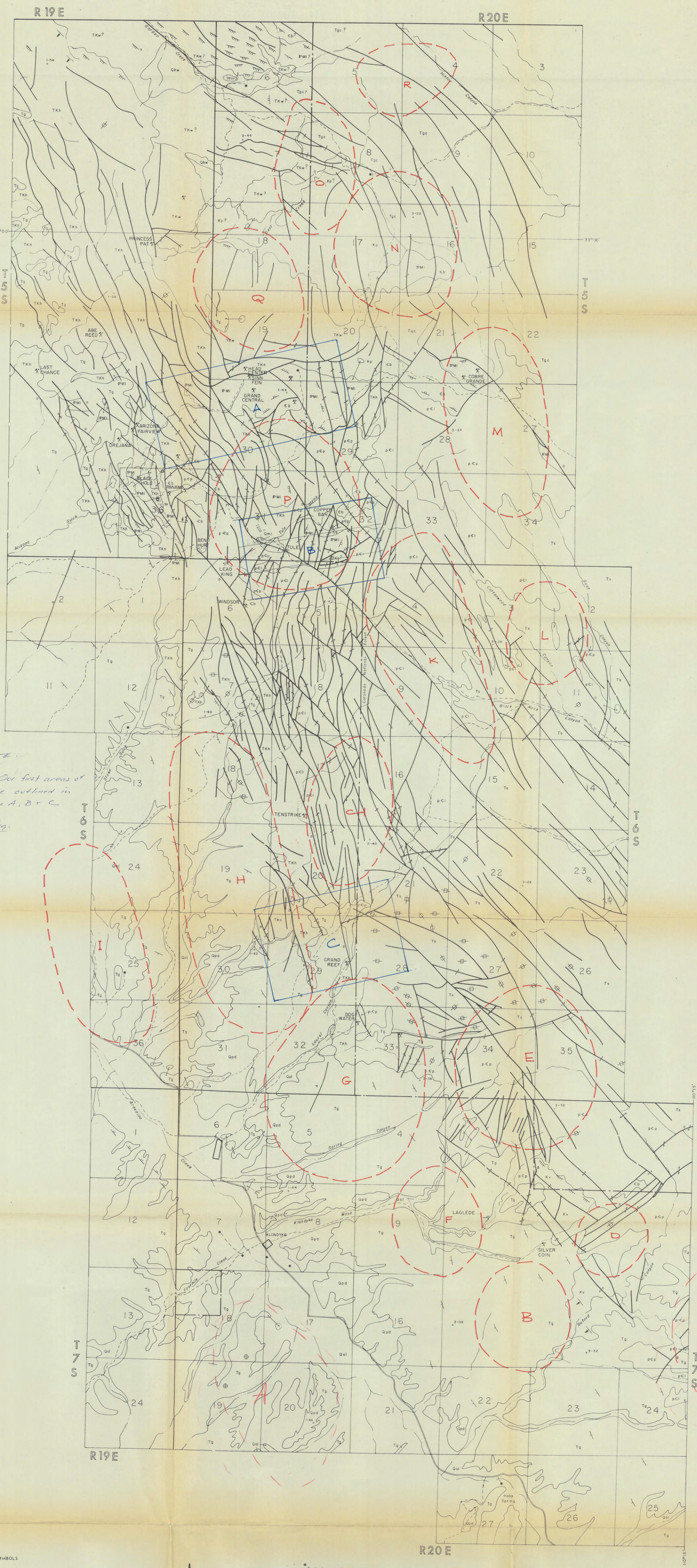
SCALE 1:24000	DRAWN BY MJS	DATE MARCH 1966

SCALE 1:24000

1 .5 0 1 2 3 4 5

STATUTE MILES

BASE MAP FROM USGS QUADRANGLES



NOTE:
Gerard: Our first areas of interest are outlined in blue, area A, B + C.
Reg.

GEOLOGIC SYMBOLS

GROUP 1: 3 OR LESS
GROUP 2: 3 TO 10
GROUP 3: 10 TO 25
GROUP 4: 25 TO 45
GROUP 5: 45 TO VERTICAL
BEDDING APPEARS VERTICAL
OVERTURNED BEDDING
BEDDING APPEARS HORIZONTAL
LINEAR OUT CROP APPEARS HORIZONTAL
FIELD OBSERVED
AMOUNT OF DIP CANNOT BE ESTIMATED
QUESTIONABLE
JOINTS
FAULT (DASHED WHERE APPROXIMATE D INDICATES DOWNTHROWN SIDE
FAULT AND/OR DIKE
THRUST FAULT (INDICATES UPPER PLATE
FAULT WITH DOMINANTLY HORIZONTAL DISPLACEMENT
ALIGNMENT TOPOGRAPHIC OR VEGETATIONAL
GEOLOGIC CONTACT (DASHED WHERE APPROXIMATELY LOCATED
KEY BED
INTERTONGUING CONTACT
NOMENCLATURE OF FACIES CHANGE
ANTICLINE (DASHED WHERE APPROXIMATELY LOCATED
ANTICLINE PROBABLE
ANTICLINE OVERTURNED
SYNCLINE (DASHED WHERE APPROXIMATELY LOCATED
SYNCLINE PROBABLE
SYNCLINE OVERTURNED
MONOCLINE
STRUCTURAL TERRACE

N

SCALE
1/24,000
1 0 1/2 1 2
MILES

* Evaluation conducted without benefit of field check.

CULTURAL AND GEOGRAPHIC SYMBOLS

INTERSTATE HIGHWAY DESIGNATION
FEDERAL HIGHWAY DESIGNATION
STATE AND COUNTY ROAD DESIGNATION
PAVED ROAD
MAINTAINED ROAD
MINOR ROAD OR TRAIL
RAILROAD
ABANDONED RAILROAD
DAM
STREAM
LAKE OR RESERVOIR
TOWN
PIPELINE
PLAYA
PICTURE CENTER
GROUP AND PICTURE NUMBER

LEGEND

QUATERNARY	Qal	Alluvium	
	Qpd	Pediment gravels	Qmc Mantle cover
	Qhw	Hillwash	
	Tg	Gila-type fanglomerates	
TERTIARY	Ts	Santa Teresa granite	Tgc Goodwin Canyon quartz monzonite
	Tkh	Horse Mountain volcanics	
	Tkw	Williamson Canyon volcanics	
CRETACEOUS	Kv	Undifferentiated volcanics	
	Kp	Pinkard fm.	
PENNSYLVANIAN	IPh	Horquilla ls.	PMI undifferentiated
MISSISSIPPIAN	Me	Escabrosa ls.	
DEVONIAN	Dm	Martin fm. (not identified)	
CAMBRIAN	Ꞓs	Bolsa qtzite	
PRECAMBRIAN	pCl	Laurel Canyon granodiorite	
	pCp	Pinal schist	

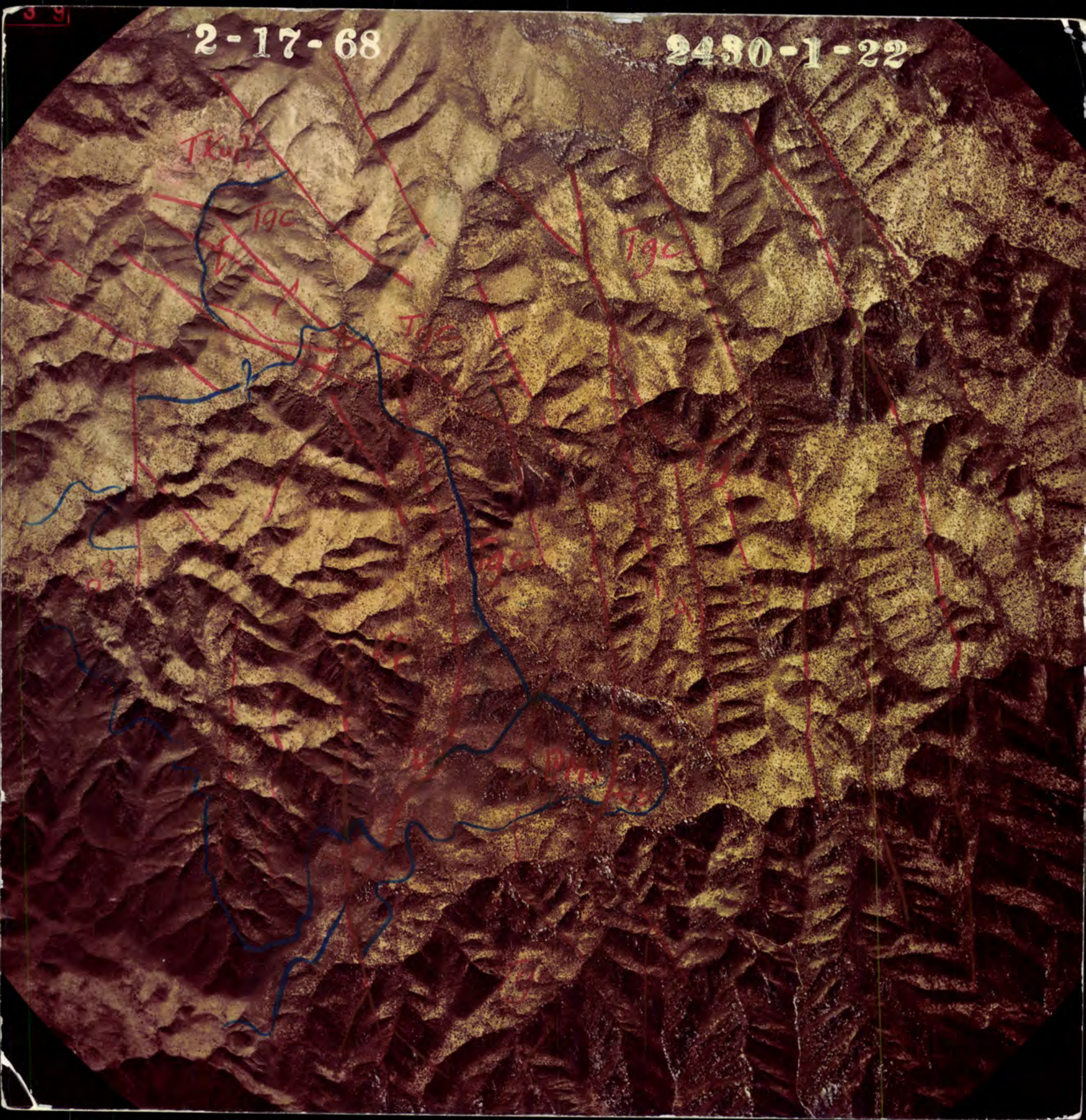
MULLEN (AHAVAIPA) PROJECT

AREAL GEOLOGY AND STRUCTURAL INTERPRETATION MAP*

THE RALPH M. PARSONS COMPANY
LOS ANGELES

PREPARED BY
SPACE SENSOR SYSTEMS INC.
TUCSON

4268 AX 100-1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Tgc
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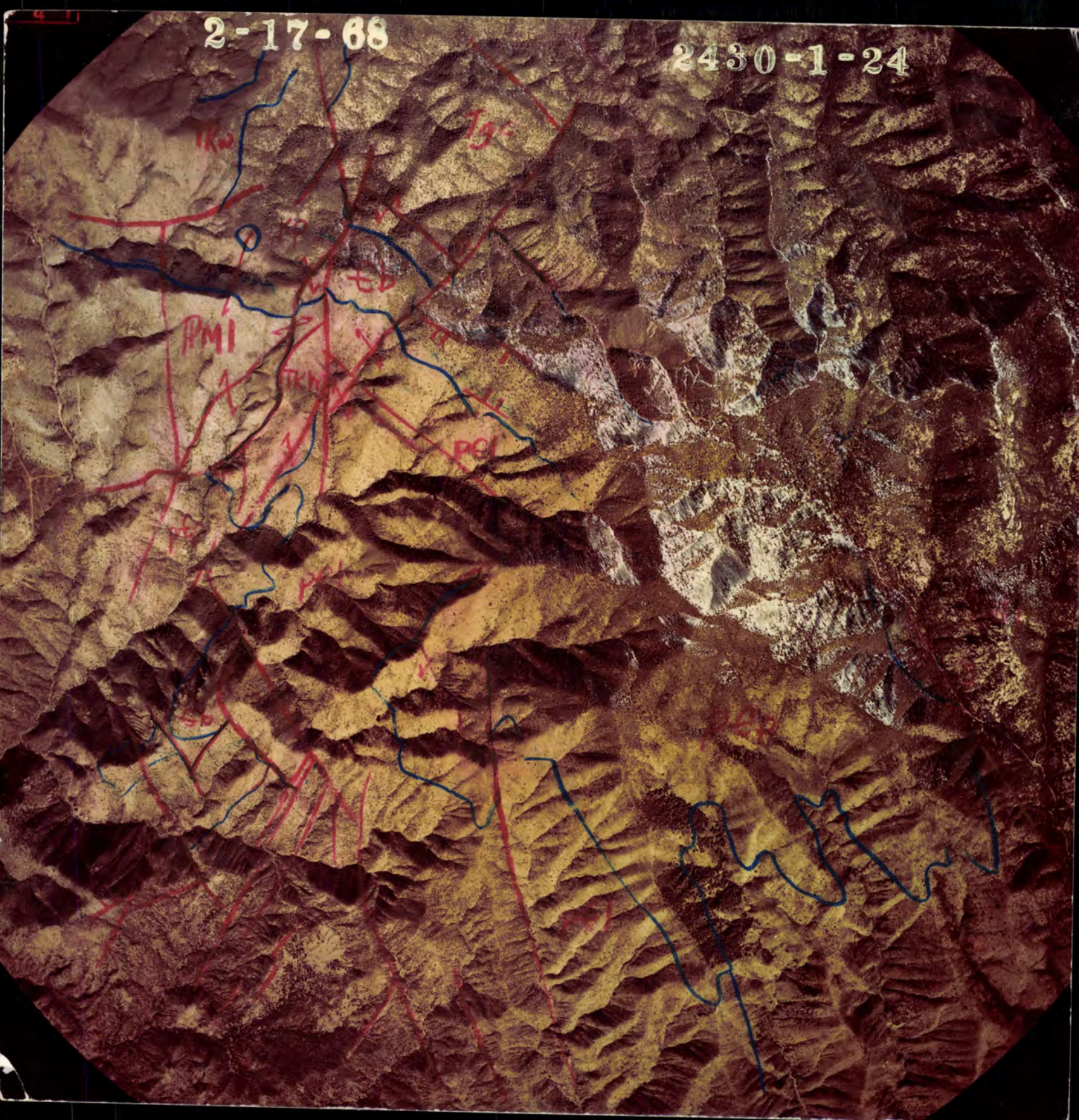
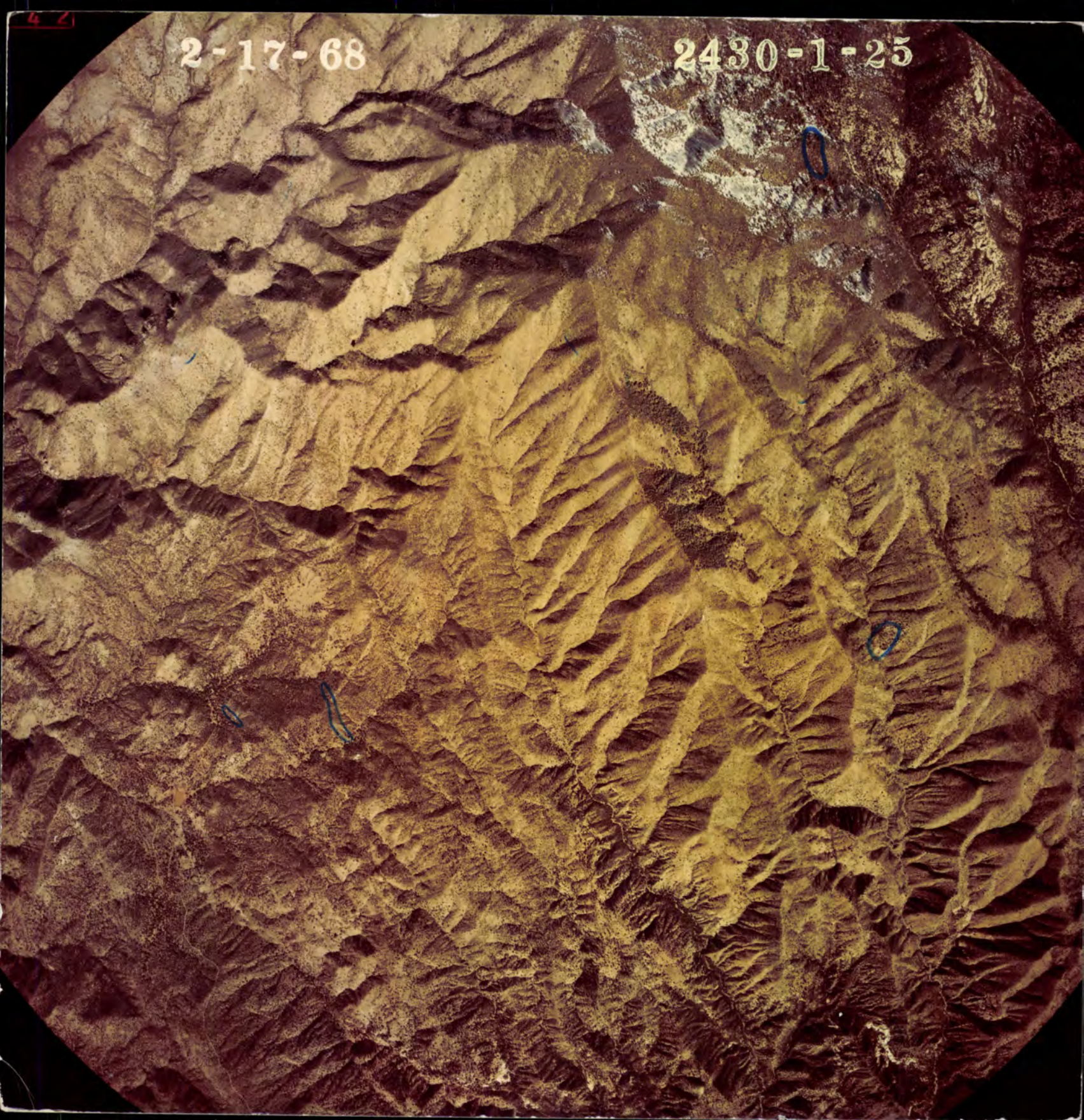
2-17-68

2430-1-24

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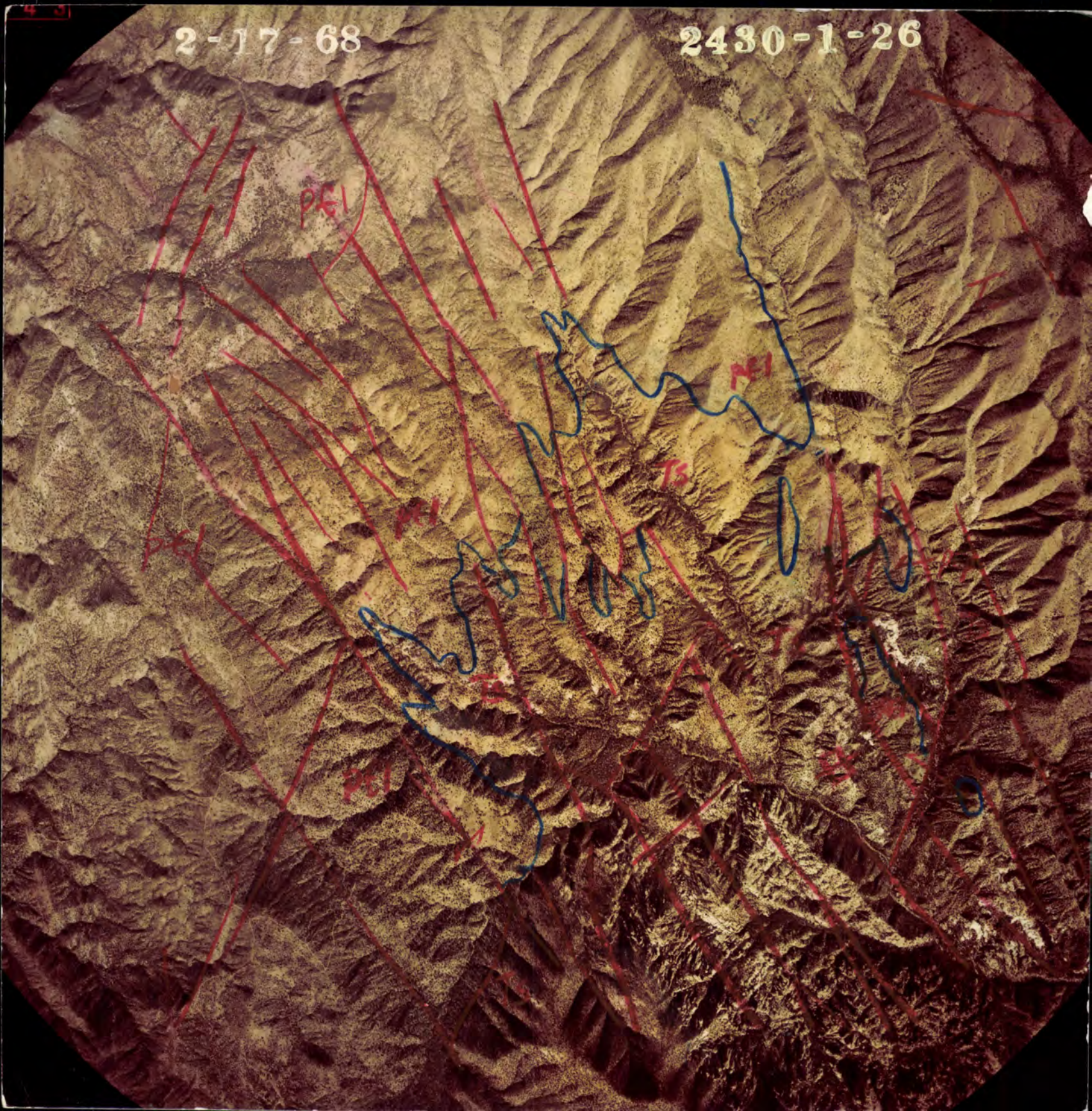
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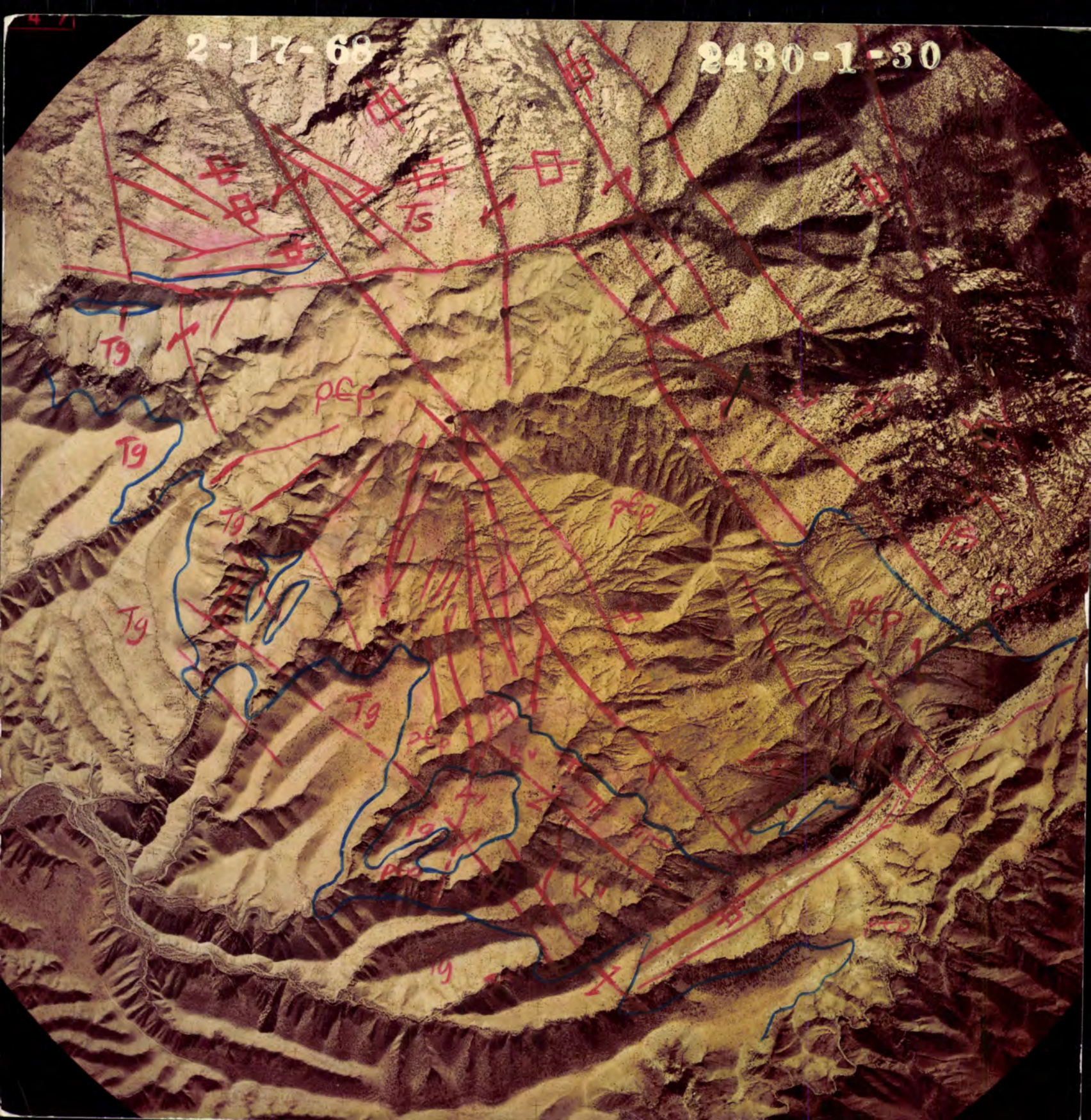
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Ts
Tg
pЄp
Kv

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Tg
Kv
Tg
Tg
Tg
Tg
Tg
Tg
Tg
Tg
Qal

2-17-68
2430-1-33

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Qpd
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Tg
Tg

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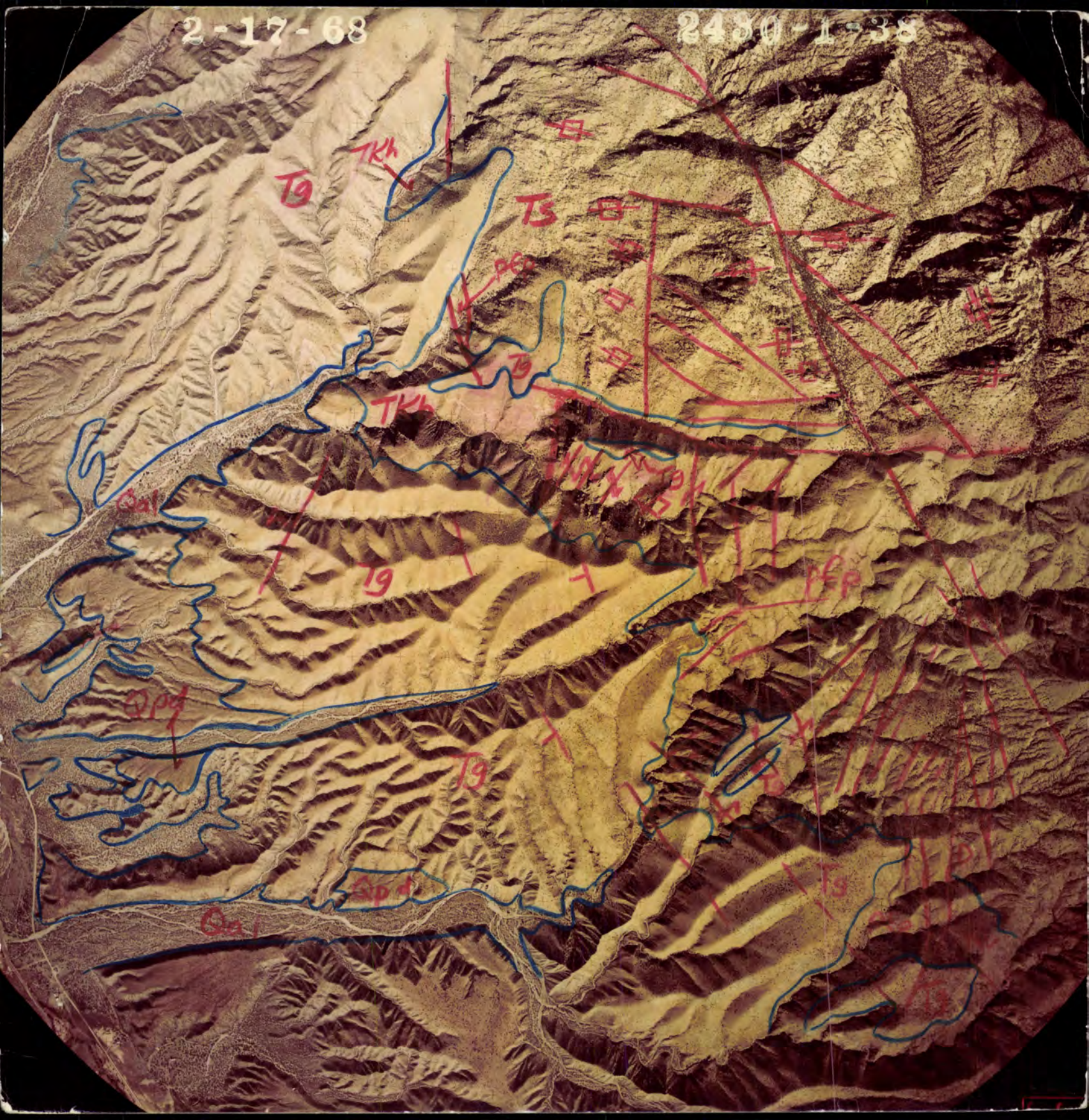
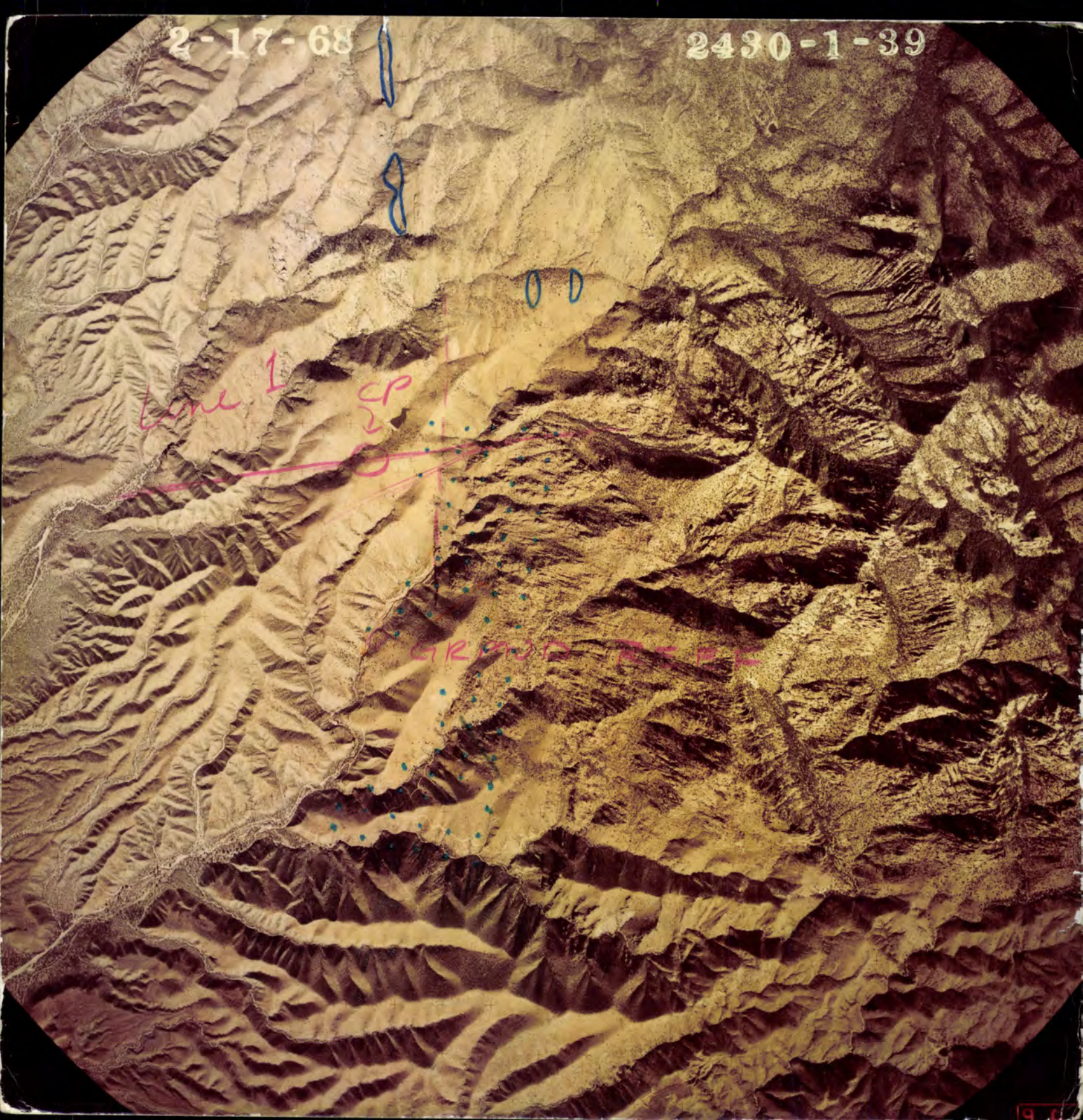
2430-1-37

2-17-68 2430-1-38

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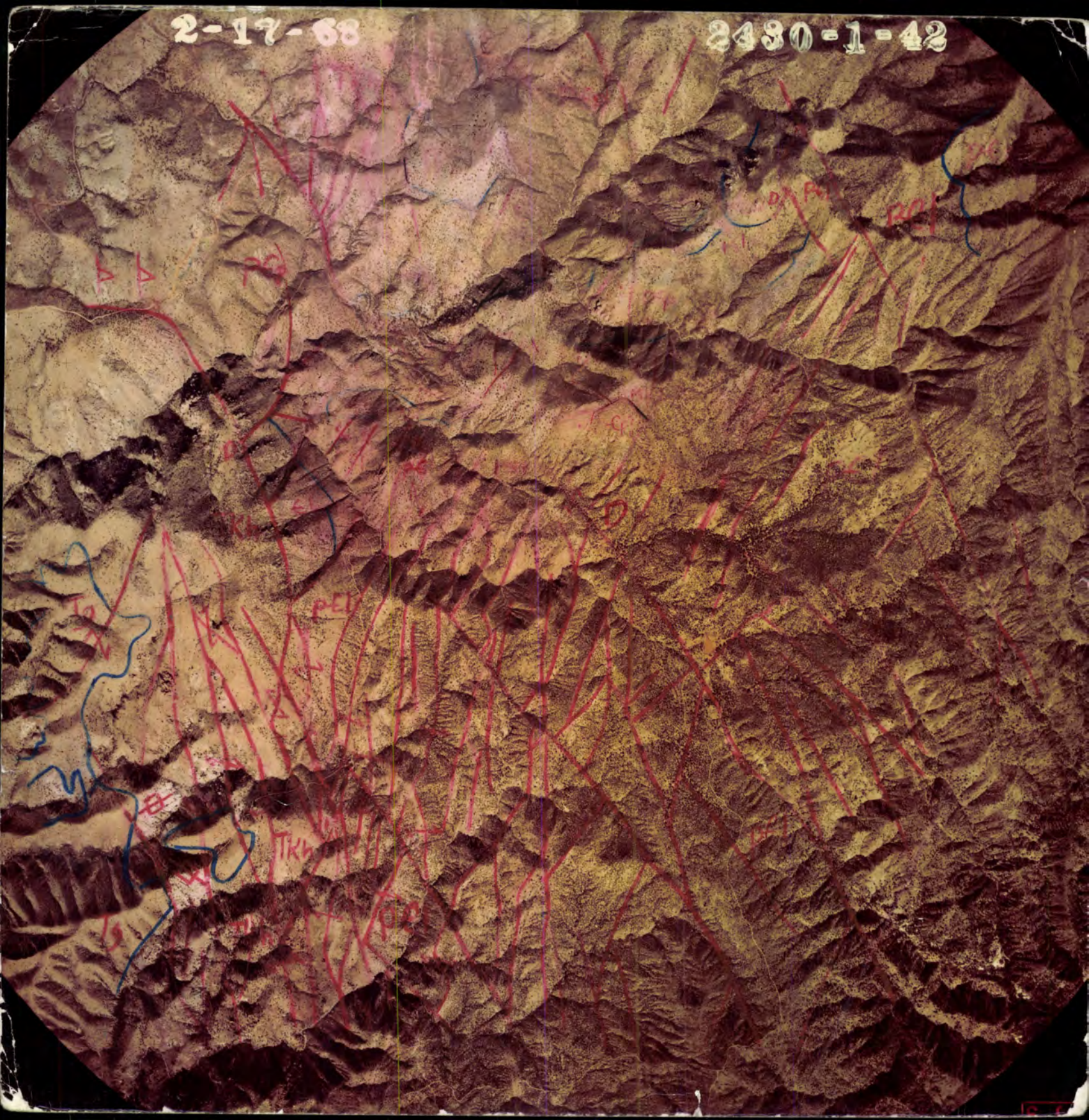

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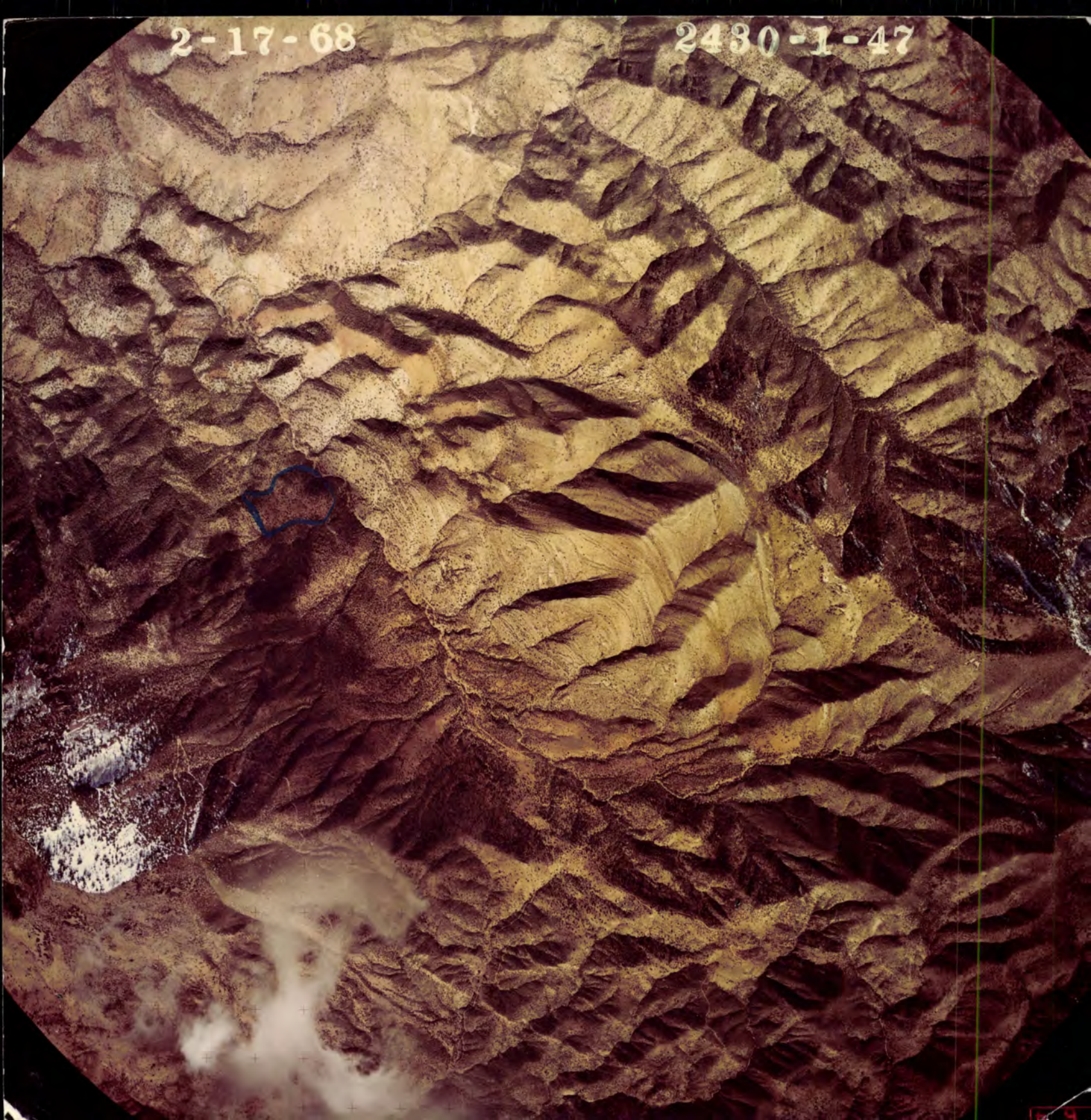
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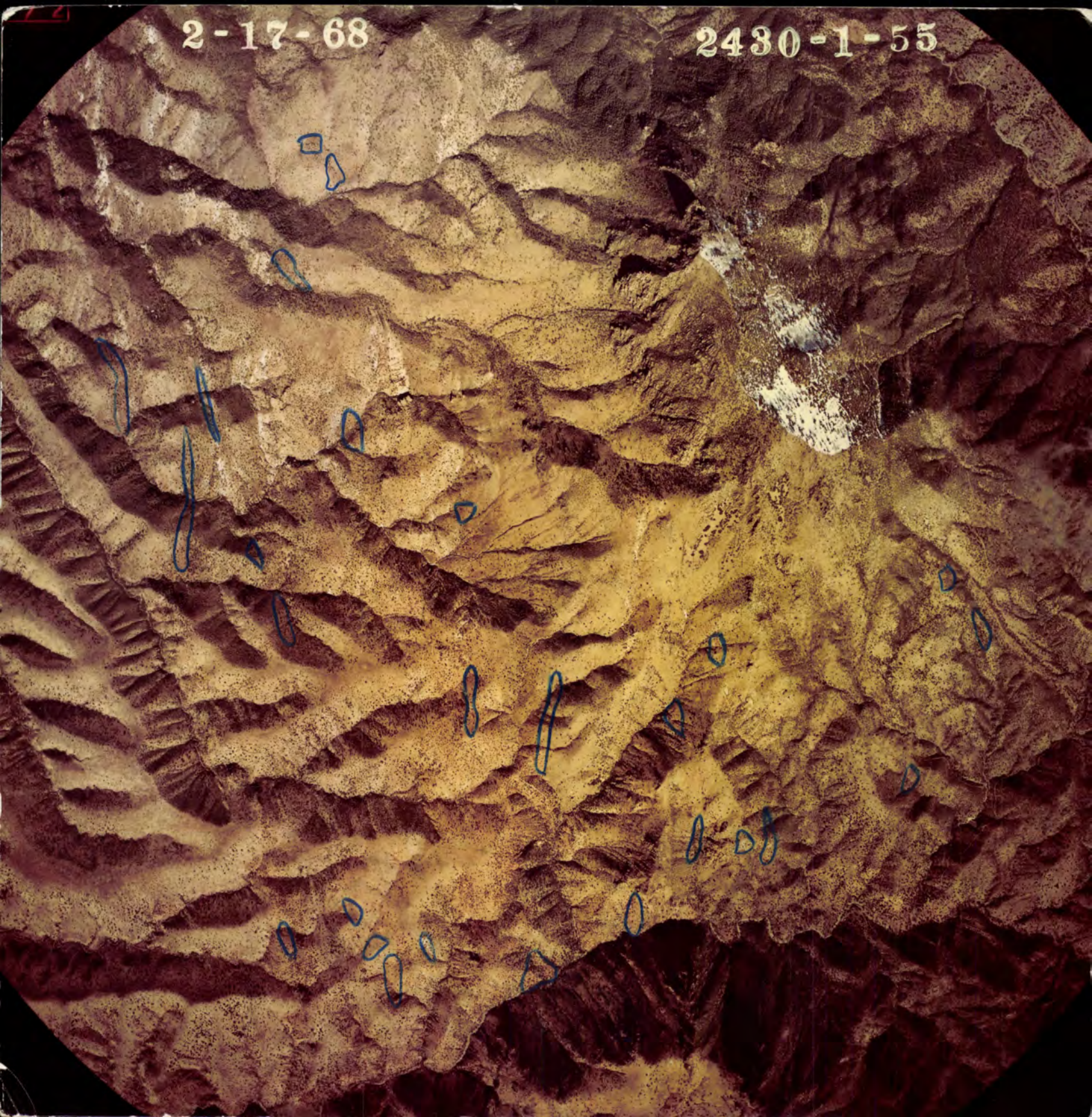
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2-17-68

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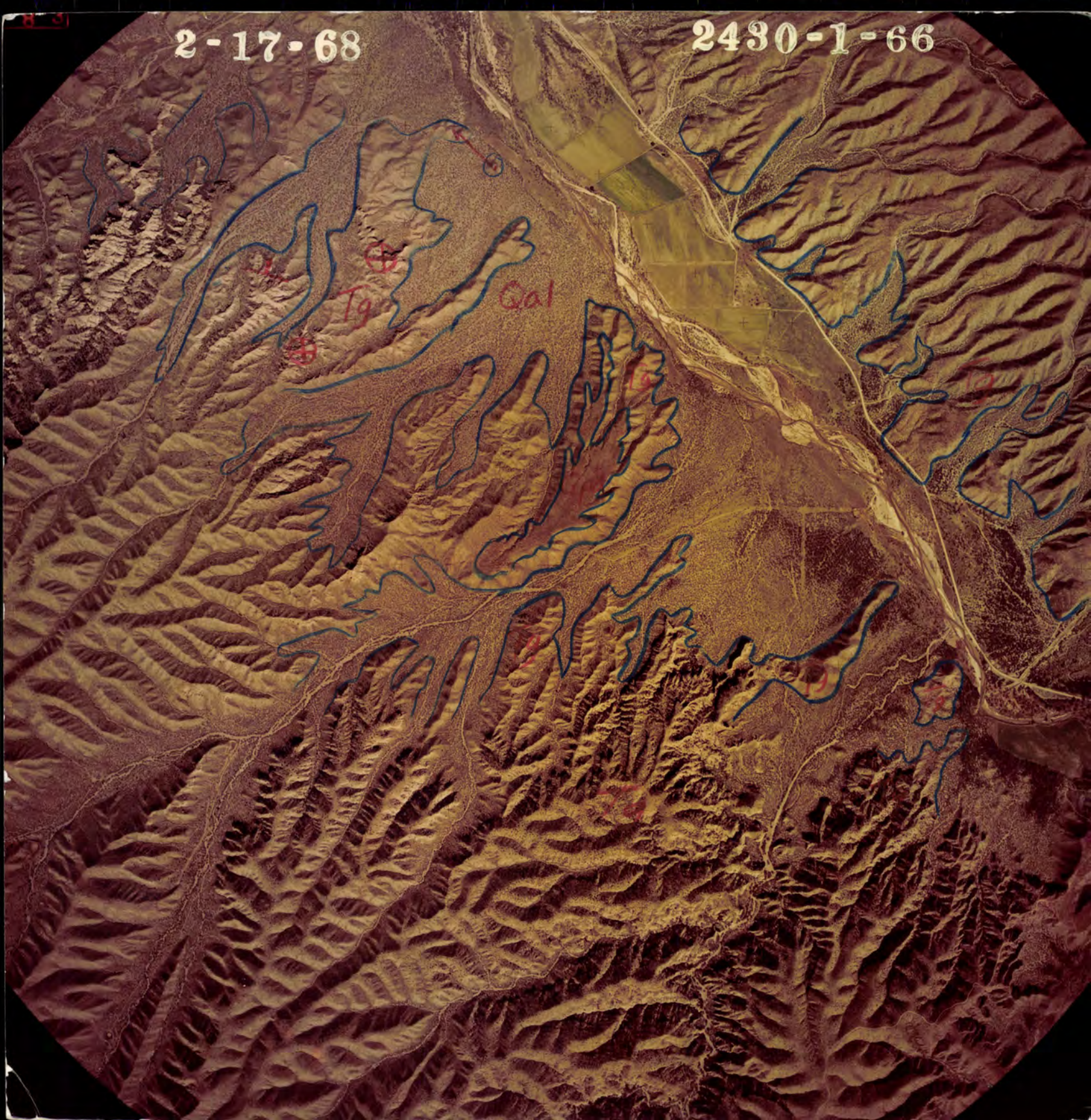
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Tg
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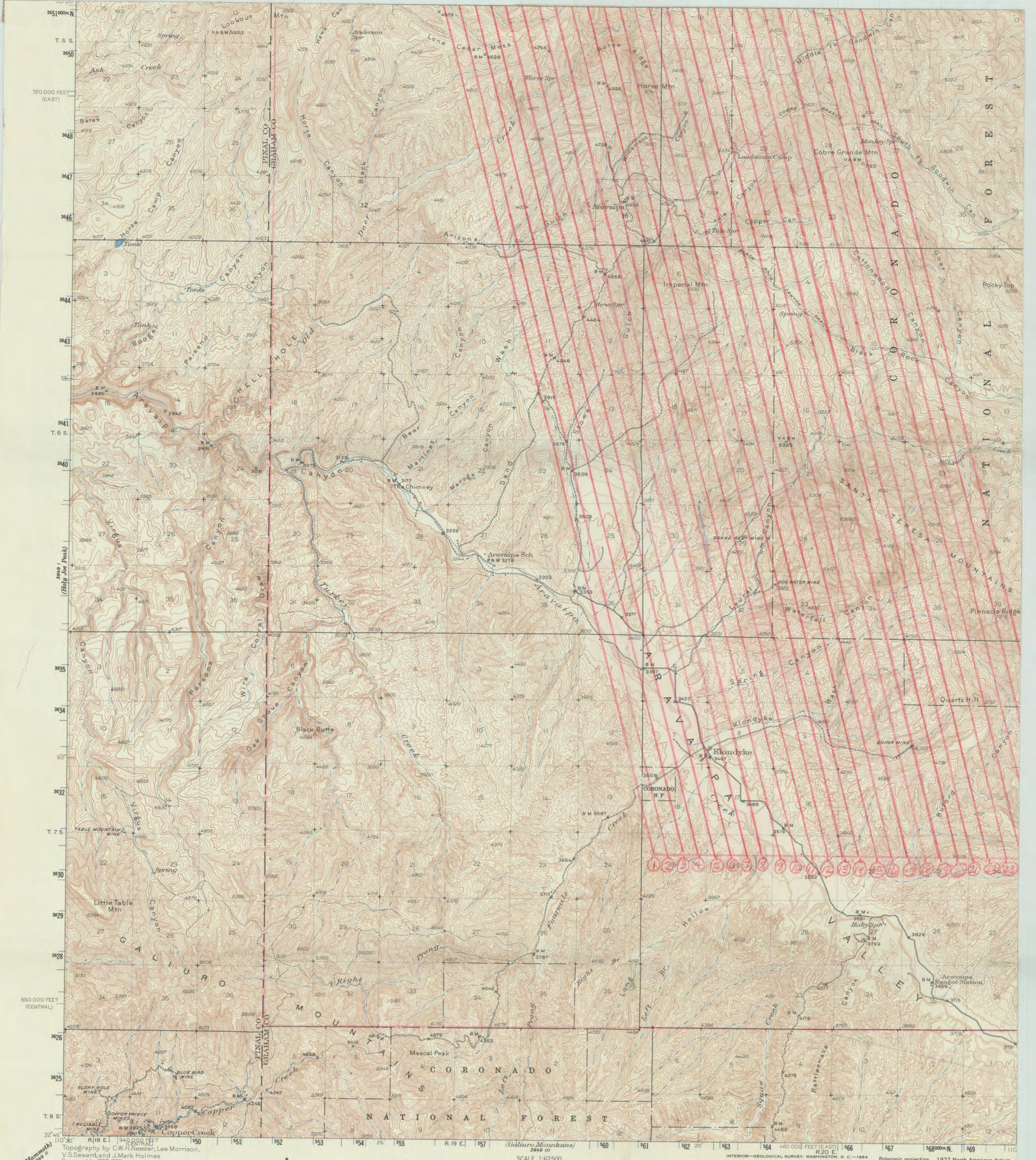


FOR SALE BY U. S. GEOLOGICAL SURVEY, DENVER 25, COLORADO OR WASHINGTON 25, D. C.
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

July 24, 1968

Mr. Reginald Skiles
The Ralph M. Parsons Company
617 West Seventh Street
Los Angeles, California 90017

Re: Revised Proposal for I.P. Work
on Aravaipa Property,
Graham County, Arizona
Your Job No. 42-68-1

Dear Mr. Skiles:

As you requested in your letter of June 14, 1968, we herewith submit a revised proposal for our mutual understanding and agreement for doing induced polarization (I. P.) over the three areas (A, B and C) you outlined on the areal geology maps of the Aravaipa Property, Graham County, Arizona. Also, estimates are given on doing I. P. over the additional areas, if desired, as outlined in our aeromagnetic report.

We recommend using a 600 foot dipole spacing on the initial reconnaissance coverage of Areas A, B and C. This gives a good compromise between resolution, depth of penetration and efficiency of lineal coverage per spread. A 600 foot dipole spacing typically gives resolvable penetration within the zone from about 150 feet or 200 feet to about 750 or 1,000 feet below surface. Each five electrode, 13 station standard spread increment of coverage will give 4,200 feet of "subsurface" lineal data.

Outlined below are the total number of spreads required to process in a reconnaisance fashion each area:

AREA	A	3 lines and 6 spreads @ 600 foot dipole
	B	3 lines and 3 spreads @ 600 foot dipole
	C	3 lines and 3 spreads @ 600 foot dipole.

If anomalous indications are encountered, lines halfway between these initial lines can be run and will give almost complete coverage of the area with reasonable target resolution. The program should be left flexible in case additional detailed coverage or increased penetration is needed in some areas. Line orientation should be chosen to cross the main

geologic grain more or less normal to strike. Therefore, the lines should be oriented along the long axis of the areas of interest, namely WNW.

The charges for this work, as outlined, will be at the rate of $350.00 per day for a five man combined geophysical crew: induced polarization, resistivity, self potential, wire layout. In addition, vehicle charges will be $12.00 per day per vehicle, plus 12¢ per mile and two vehicles are recommended. Living expenses, directly related supplies and communications and other directly related incidentals charged at our cost. Final compilation, interpretation and report is $125.00 per Tucson staff day.

Mobilization and demobilization, travel, excessive weather delay and standby charges are one-half the daily rate. Breakdown of our equipment in excess of one hour per day will be made up or not charged.

Our technical staff will be involved as needed and/or are supplied as requested and mutually agreed upon.

All property permits, brushing and trespassing-liability and related costs incurred on behalf of client assumed by client. Charges for extra equipment and personnel employed if mutually desired, are extra.

Geoex will save client harmless from all Workmen's Compensation, public liability, and property damage liability incurred by Geoex employees.

Preliminary reports or copies of rough field plotting sheets will be available as work progresses.

It is estimated that this project including report as outlined on Areas A, B and C, not including any follow up or detailed and/or deeper electrical coverage, will cost approximately $10,000.00.

The additional areas recommended in our aeromagnetic report for I. P. coverage, exclusive of most of Area P which is covered by your Areas A and B, should perhaps be approached on a broad reconnaissance basis. Two or three well chosen spreads of I. P. in each area would likely suffice in determining the need for more detailed coverage. This would amount to about 16 spreads of I. P. The per day charges for this phase would be the same as in your Areas A, B and C and would total about $13,000.00. Of course, if interesting anomalism is encountered on this broad reconnaissance work, considerable follow-up coverage may be necessary before detailed targets can be selected.

Payments are due on presentation of billings, and an immediate advance on account in the amount of $2,500.00 is requested. Billings may be submitted periodically with final statement after completion of final report. Crew availability would be within two weeks upon notification and receipt of advance.

Indication of your understanding and approval of the above by executing as provided below on the attached copy of this letter and returning it to us, will be most appreciated.

Very truly yours,

HEINRICHS GEOEXPLORATION COMPANY

Walter E. Heinrichs
President and General Manager

Chris S. Ludwig
Senior Geophysicist

DATE: _____

ACCEPTED BY: _____

TITLE: _____

cs

June 25, 1968

Mr. Reginald Skiles
The Ralph M. Parsons Company
617 West Seventh Street
Los Angeles, California 90017

Re: Proposal for I.P. work on Aravaipa Property, Graham County, Arizona
Your job no. 42-68-1

Dear Mr. Skiles:

As you requested in your letter of June 14, 1968, we herewith submit a proposal for our mutual understanding and agreement for doing induced polarization (I.P.) over the three areas (A, B, and C) you outlined on the areal geology maps of the Aravaipa Property, Graham County, Arizona. Also, estimates are given on doing I.P. over the additional areas we recommended in our aeromagnetic report.

We recommend using a 600 foot dipole spacing on the initial reconnaissance coverage of Areas A, B, and C. This gives a good compromise between resolution, depth of penetration and efficiency of lineal coverage per spread. A 600 foot dipole spacing typically gives resolvable penetration within the zone from about 150 feet or 200 feet to about 750 or 1,000 feet below surface. Each five electrode, 13 station standard spread increment of coverage will give 4,200 feet of "subsurface" lineal data and two or three spreads will be needed per line to cover the length of the area.

A line separation of about 1,800 feet to 2,000 feet is recommended on the initial work and will give roughly a 75%

areal coverage considering the lateral penetration. If anomalous indications are encountered, lines halfway between these initial lines can be run and will give almost complete coverage of the area with reasonable target resolution. The program should be left flexible in case additional detailed coverage or increased penetration is needed in some areas. Line orientation should be chosen to cross the main geologic grain more or less normal to strike. Therefore, the lines should be oriented along the long axis of the areas of interest, namely WNW.

The recommended coverage in your areas of interest is as follows:

Area A: Three lines separated about 2,000 feet of three spreads each giving nine spreads total.

Area B: Three lines separated about 1,800 feet of two spreads each giving six spreads total.

Area C: Four lines separated about 1,800 feet of two spreads each giving eight spreads total.

Also, it is suggested that hand magnetometer readings be taken along the I.P. lines on 100 foot stations. Additionally, geochemical soil and/or rock chip samples may prove advantageous.

The charges for this work as outlined will be at the rate of $350.00 per day for a five man combined geophysical crew: induced polarization, resistivity, self potential, wire layout, magnetometer and geochemical sampling. In addition, vehicle charges will be $12.00 per day per vehicle, plus 12¢ per mile and two vehicles are recommended. Living expenses, directly related supplies and communications and other directly related incidentals charged at our cost. Final compilation, interpretation and report is $125.00 per Tucson staff day.

Mobilization and demobilization, travel, excessive weather delay and standby charges are one-half the daily rate. Breakdown of our equipment in excess of one hour per day will be made up or not charged.

Our technical staff will be involved as needed and/or are supplied as requested and mutually agreed upon.

All property permits, brushing and trespassing-liability and related costs incurred on behalf of client assumed by client. Charges for extra equipment and personnel employed if mutually desired, are extra.

Geoex will save client harmless from all Workmen's Compensation, public liability, and property damage liability incurred by Geoex employees.

Preliminary reports or copies of rough field plotting sheets will be available as work progresses.

It is estimated that this project including report as outlined on Areas A, B, and C plus allowance for some follow-up detailed and/or deeper electrical coverage and with magnetometer coverage down the lines will be in the neighborhood of $20,000.00 to $25,000.00.

If geochemical sampling is done, charges are typically $3.00 per soil sample for three elements and $3.75 per rock sample for three elements. The particular elements chosen affect the price somewhat. On this basis, geochemical samples every 200 feet down the I.P. traverses, testing for three elements will add about $2,500.00 to the project cost.

The additional areas recommended in our aeromagnetic report for I.P. coverage, exclusive of most of Area P which

is covered by your Areas A and B, should perhaps be approached on a broad reconnaissance basis. Two or three well chosen spreads of I.P. (with geochemistry and magnetics as above) in each area would likely suffice in determining the need for more detailed coverage. This would amount to about 16 spreads of I.P. The per day charges for this phase would be the same as in your Areas A, B, and C and would total about $15,000.00. Of course, if interesting anomalism is encountered on this broad reconnaissance work, considerable follow-up coverage may be necessary before detailed targets can be selected.

Payments are due on presentation of billings, and an immediate advance on account in the amount of $7,500.00 (approximately one month's estimated charge) is requested. Billings may be submitted periodically with final statement after completion of final report. Crew availability would be within two weeks upon notification and receipt of advance.

Indication of your understanding and approval of the above by executing as provided below on the attached copy of this letter and returning it to us, will be most appreciated.

Very truly yours,

HEINRICHS GEOEXPLORATION COMPANY

E. Grover Heinrichs
Vice President

Chris S. Ludwig

Chris S. Ludwig
Senior Geophysicist

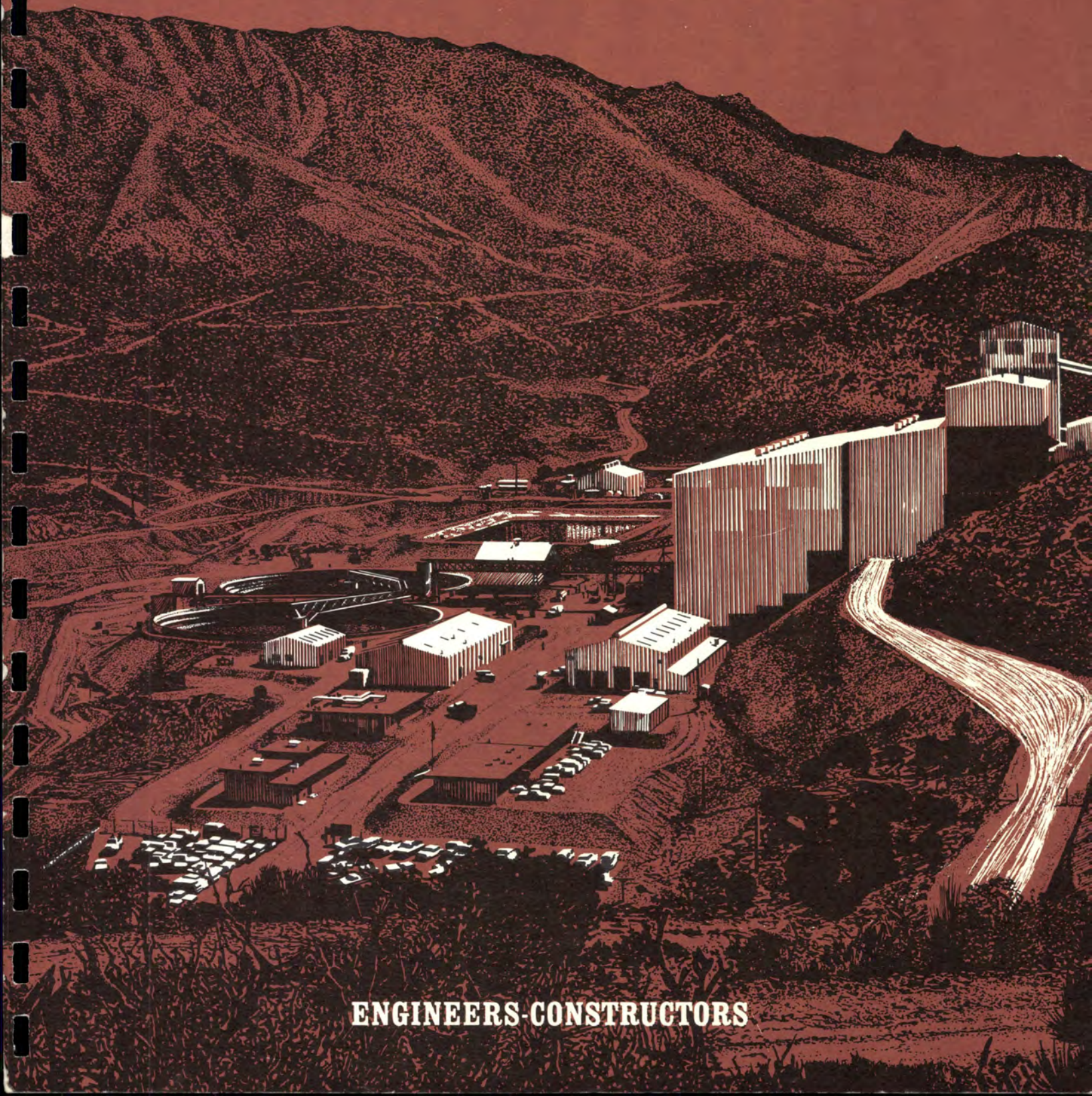
DATE:_____

ACCEPTED BY:_____

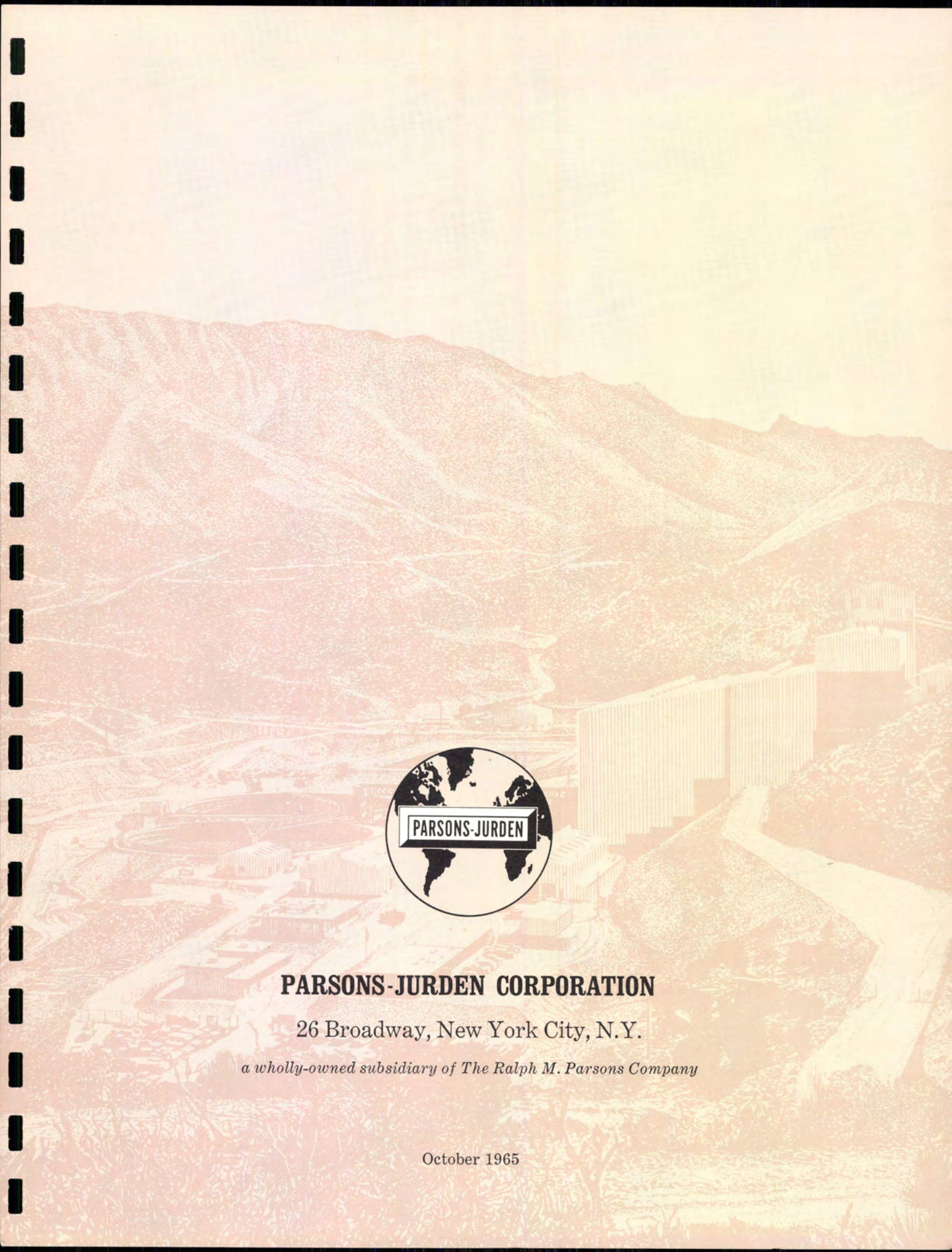
TITLE:_____

jc
Enclosure: 1

PARSONS-JURDEN CORPORATION



ENGINEERS-CONSTRUCTORS



PARSONS-JURDEN

PARSONS-JURDEN CORPORATION

26 Broadway, New York City, N.Y.

a wholly-owned subsidiary of The Ralph M. Parsons Company

October 1965

PARSONS-JURDEN CORPORATION

PARSONS-JURDEN, a pioneer engineering and construction organization, has won a distinguished reputation by imaginative and highly professional skill in its work for leading firms in the field of mining and chemical processing.

PARSONS-JURDEN and its parent company, THE RALPH M. PARSONS COMPANY, offer their combined skills to provide facilities for the petroleum processing, nuclear, and aerospace industries, and for the world wide development of natural resources, including minerals, natural gas, water and electric power.

PARSONS-JURDEN, with comprehensive services, versatility, objectivity, attention to detail, and overall teamwork PRODUCES FOR YOU!!

TOTAL
Engineering-Construction
CAPABILITY

SEASONED MANAGEMENT

COMPETENT PERSONNEL

MODERN FACILITIES

AMPLE RESOURCES

PROVEN PROJECT
ORGANIZATIONAL METHODS

The Management of Parsons-Jurden . . . from chief executive officers to project managers . . . has earned a notable record for consistent success. No Parsons Company has ever failed to complete a project in full conformity with the terms of the contract.

Parsons-Jurden's current workforce numbers many hundreds of professional personnel. . . exclusive of construction forces. All engineering disciplines, as well as architectural, procurement, construction and specialized technical personnel are represented in this remarkably experienced organization.

Comfortable air-conditioned offices and drafting rooms, modern business machines, and efficient supporting services are provided for all personnel to encourage economy of effort in a productive environment.

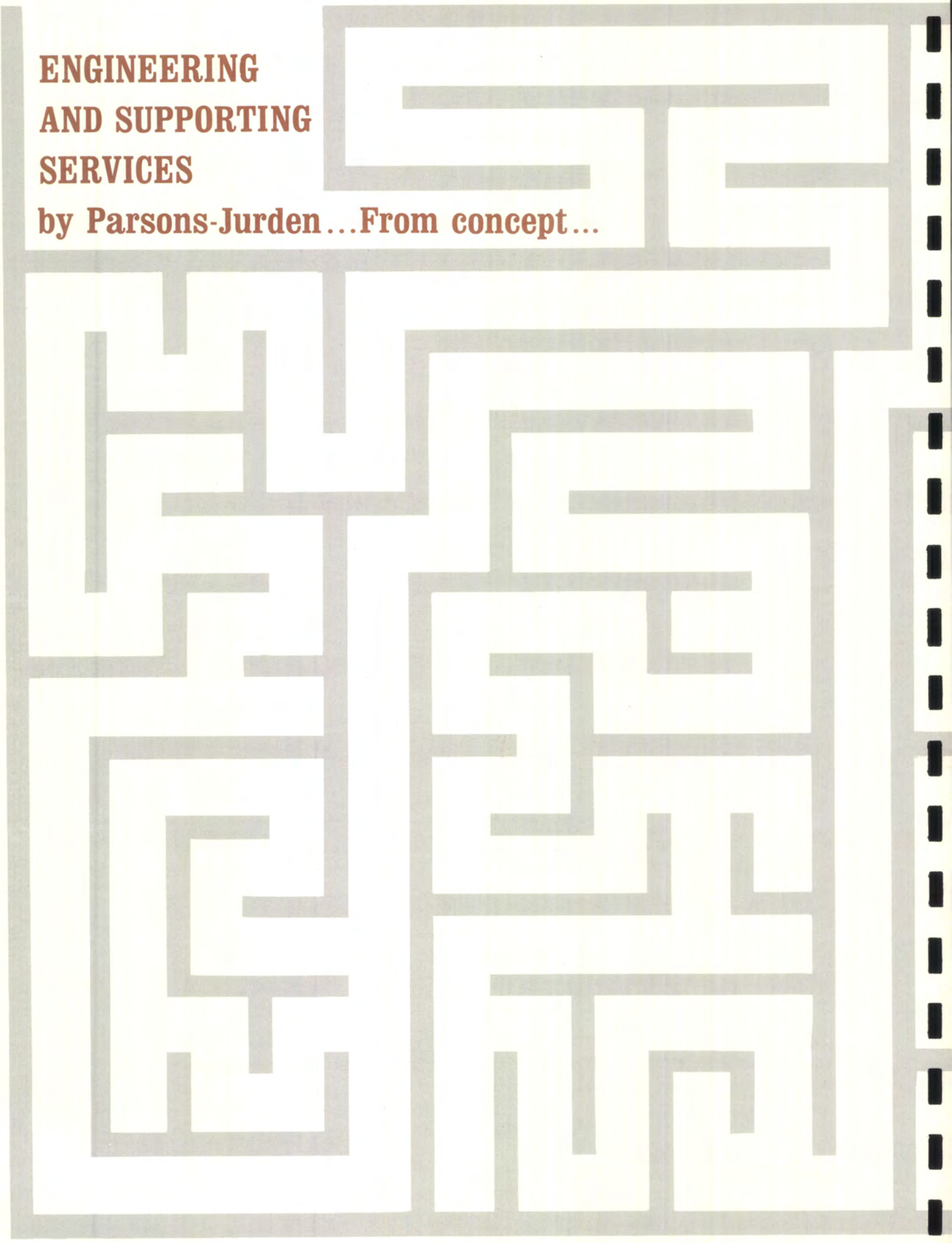
Financially, Parsons-Jurden is prepared to undertake projects of any size . . . in any part of the world. The Company has executed individual projects in excess of $50,000,000 simultaneously with its normal workload.

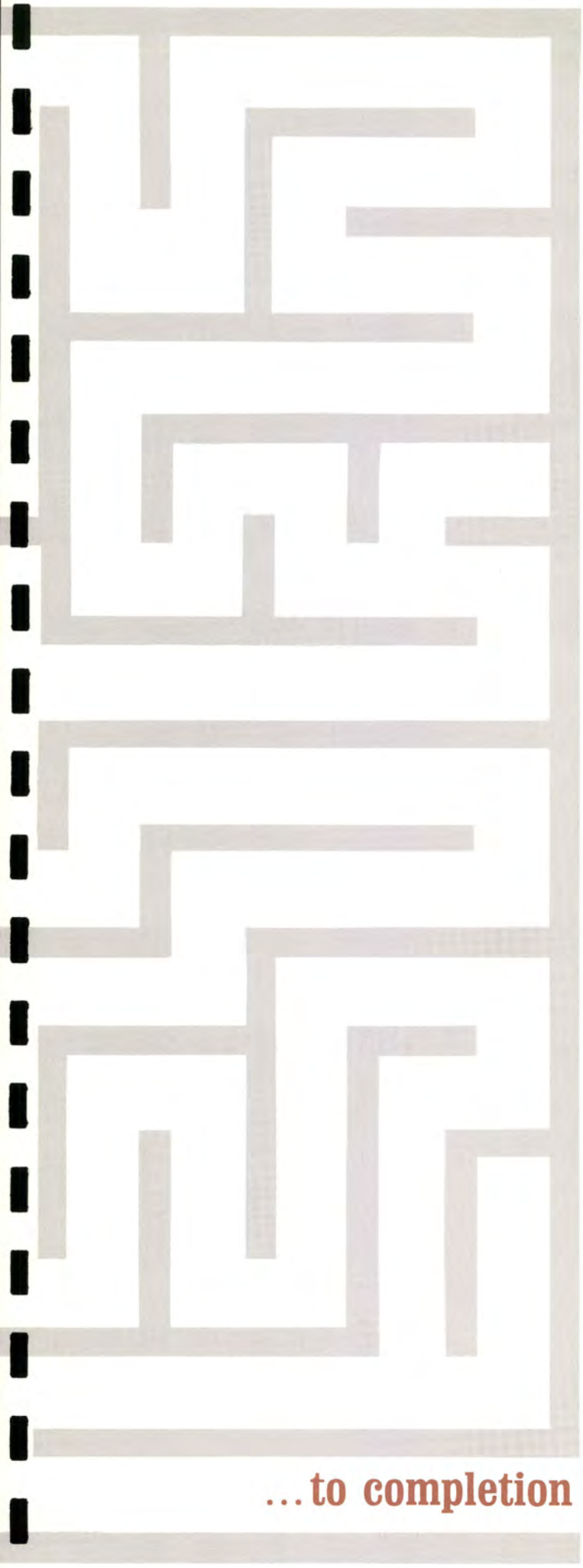
A Project-Type organization is employed by Parsons-Jurden as the most efficient method of project execution. Each project organization functions as a team for the duration of the project, with specialized talent assigned to the group solely on an as-needed basis. This task-force concept. . . with clearly defined responsibilities and authority. . . assures the most effective and most economical use of manpower.

A Single Source for COMPLETE PROJECT RESPONSIBILITY

ENGINEERING AND SUPPORTING SERVICES

by Parsons-Jurden...From concept...





...to completion

Market studies

Site evaluation

Project feasibility

Process evaluation

Criteria development

Master planning

Conceptual design

Site preparation

Process design

Engineering

Design-drafting

Materials handling

Instrumentation

Power & utilities

Rail, roads & wharfage

Offsites

Product storage & transfer

Construction

Construction supervision

Purchasing

Expediting

Inspection

Field campsites

Permanent housing

Start-up

Initial operation

Personnel training

Repeatedly Successful Performance

. . . . has earned for the Parsons organization the continued confidence of its customers.

Among major firms in the metallurgical, petroleum, chemical and aerospace industries, 77 COMPANIES HAVE AWARDED 3 OR MORE CONTRACTS TO PARSONS. Many hundreds of repeat contracts have been completed for agencies of the United States Government.

Together, Parsons-Jurden and its parent company have completed projects in 62 foreign countries and their possessions.

Current Activities

In addition to projects described on pages to follow, current Parsons-Jurden activities include:

9000 TPD Metals Concentrator

COMPANY CONFIDENTIAL

Ontario, Canada

Designed by Parsons-Jurden and being built by The Ralph M. Parsons Construction Company of Canada, Ltd. under a "turnkey" contract, this mining complex will produce copper, zinc, lead and silver concentrates by selective flotation from finely disseminated ore.

The source of the ore is one of the most valuable recent mineral discoveries in the world and, when the plant goes on-stream in the Fall of 1966, it will employ the most advanced technology and state-of-the-art.

The plant site, some 15 miles east of the mine, is in an expanse of marshy muskeg, making it necessary to build a new road and railroad spur to provide access between the mine and the plant. Completely winterized for sustained sub-zero operations, the completed facilities will include offices, warehouses and a locomotive and car repair shop.

The Concentrator, capable of meeting three mining programs – lead-silver ore, copper-zinc ore, and either lead-silver or copper-zinc ore – will have a roofed area covering approximately seven acres.

Molybdic Oxide Plant

KENNECOTT COPPER CORPORATION

Salt Lake City, Utah

Awarded to Parsons-Jurden in March, 1965, this contract calls for design, purchasing and construction services for a plant to produce molybdic oxide from concentrates of molybdenum sulfide. Annual output of molybdic oxide will roughly approximate 10 million pounds of basic molybdenum.

Phthalic Anhydride Plant

W. R. GRACE & CO.

Cornwall, Ontario, Canada

This plant, to be operated by newly-formed subsidiary of W. R. Grace & Co., will produce 25 million pounds of phthalic anhydride annually, using orthoxylene as feedstock. All elements are designed for easy future expansion to a doubled capacity of 50 million pounds. The Ralph M. Parsons Construction Company of Canada, Ltd. is responsible for purchasing activities and construction of the facility.

Copper Recovery Facilities

UNION CARBIDE CORPORATION

Bishop, California

This facility, an addition to an existing tungsten flotation concentrator, utilizes a new process developed by Union Carbide to process bulk copper and moly sulfide concentrates by stages to cathode copper and pelletized molybdenum. Parsons-Jurden was selected to engineer and design the new facilities for sulfate roasting of the concentrates in a fluid bed reactor, leaching, solvent extraction and subsequent reduction of a complex moly sulfate, and electrowinning of cathode copper from the residual liquor.

Philadelphia Plant

U.S. GENERAL SERVICES ADMINISTRATION

Parsons-Jurden is responsible for the design of the new building for the United States Mint in Philadelphia that will cost an estimated $14.4 million. The structure will occupy approximately 365,000 gross square feet and will contain the most modern production line in the world.

In addition to this work, and following a state-of-the-art study for coin production processes, Parsons-Jurden negotiated a follow-on contract with the U. S. Bureau of the Mint for all engineering related to process equipment, its procurement and installation.

Copper-Molybdenum Project

Under plans now being finalized, a leading producer of non-ferrous metals proposes to exploit a major orebody in the Southwestern United States from which copper and molybdenum will be obtained by the use of flotation circuits.

Parsons-Jurden is designing the facility, which will include primary, secondary and tertiary crushing plants, rod and pebble mill grinding circuits, together with an extensive belt haulage system from the pit to the plant.

PARSONS-JURDEN CORPORATION
NEW YORK

H O R I Z O N T A L V E S S E L

EMC - 714-1 2D-810 RUN 1 09-10-65

	DIMENSIONS I.D. INCHES	HEIGHT FT. IN.	THK INCHES	CORR ALLW IN	MAWP CORR PSIG	MAWP NEW PSIG	EFF	XRAY 100 PC	PWHT	MATL SA-	STRESS PSI	DESG TEMP F
HEAD L	SE 2.1		.5625	.1250	124	160	1.00	NO	NO	285-C	13750	170
SHELL	96.0000	20- .000	.5625	.1250	105	136	.85	NO	NO	285-C	13750	170
HEAD R	SE 2.1		.5625	.1250	124	160	1.00	NO	NO	285-C	13750	170
BOOT S	17.0000	24- .000	.5000	.1250	540	724	.85	NO	NO	106-C	15000	170
BOOT H	FLGDSH		.5000	.1250	649	877	1.00	NO	NO	106-C	15000	170

		SADDLE ANGLE	WEARPLATE THK LEFT	WEARPLATE THK RIGHT	RING GIRD LEFT THK/A	RING GIRD LEFT DEPTH/S	RING GIRD RIGHT THK/A	RING GIRD RIGHT DEPTH/S
AL	3- 6.625	150.0	.0000	.0000	1.0000	5.0000	1.0000	5.0000
AR	3- 6.625				7.3516	6.6108	7.3516	6.6108

WEIGHTS	LBS	AREA	SQ.FT.	PRESSURE		FLANGES-RATING	150
FAB	21000	SHELL	508	OPER PRES	20	DESIGN	120
EMPTY W/PK	36600	HEAD	149	DESG PRES	50	NEW+COLD PRES	160
OPER	104600	BOOT	11	HORIZ TEST	204	TEST PRESSURE	250
TEST	93600	VOL	1142				
PACK	-0						
LINING	14299						
LADDER	1300						
PLAT	-0						

STRESS CHECK

	CIRCUM BENDING	LONG BEND-C	LONG BEND-C	TANG SHR-SH	TANG SHR-HD	ADDED HD-ST	RING COMP
OPER-LEFT	13775-OK	2[illegible]3-OK	223-OK	43[illegible]-OK	0-OK	0-OK	0-OK
OPER-RIGHT	13775-OK	2[illegible]-OK	223-OK	4[illegible]3-OK	0-OK	0-OK	0-OK
OPER-MIDPT		2871-OK	121-OK				
TEST-LEFT	18327-OK	8853-OK	149-OK	305-OK	0-OK	0-OK	0-OK
TEST-RIGHT	18327-OK	8853-OK	149-OK	305-OK	0-OK	0-OK	0-OK
TEST-MIDPT		8798-OK	94-OK				

	THICN IN	CORR IN	PRES [illegible]	PRES CORP	INSUL IN	WEIGHT SHELL	WEIGHT INSUL	WEIGHT LINING
HEAD L	.5625	.1250	160.94	124.89	-.000	1914.	0.	159[illegible].
HEAD R	.5625	.1250	160.94	124.89	-.000	1914.	0.	159[illegible].
SHELL	.5625	.1250	136.01	105.67	-.000	12362.	0.	109[illegible].
BOOT S	.5000	.1250	724.43	540.25	-.000	199.	0.	[illegible]3.
BOOT H	.5000	.1250	877.19	649.35	-.000	48.	0.	34.

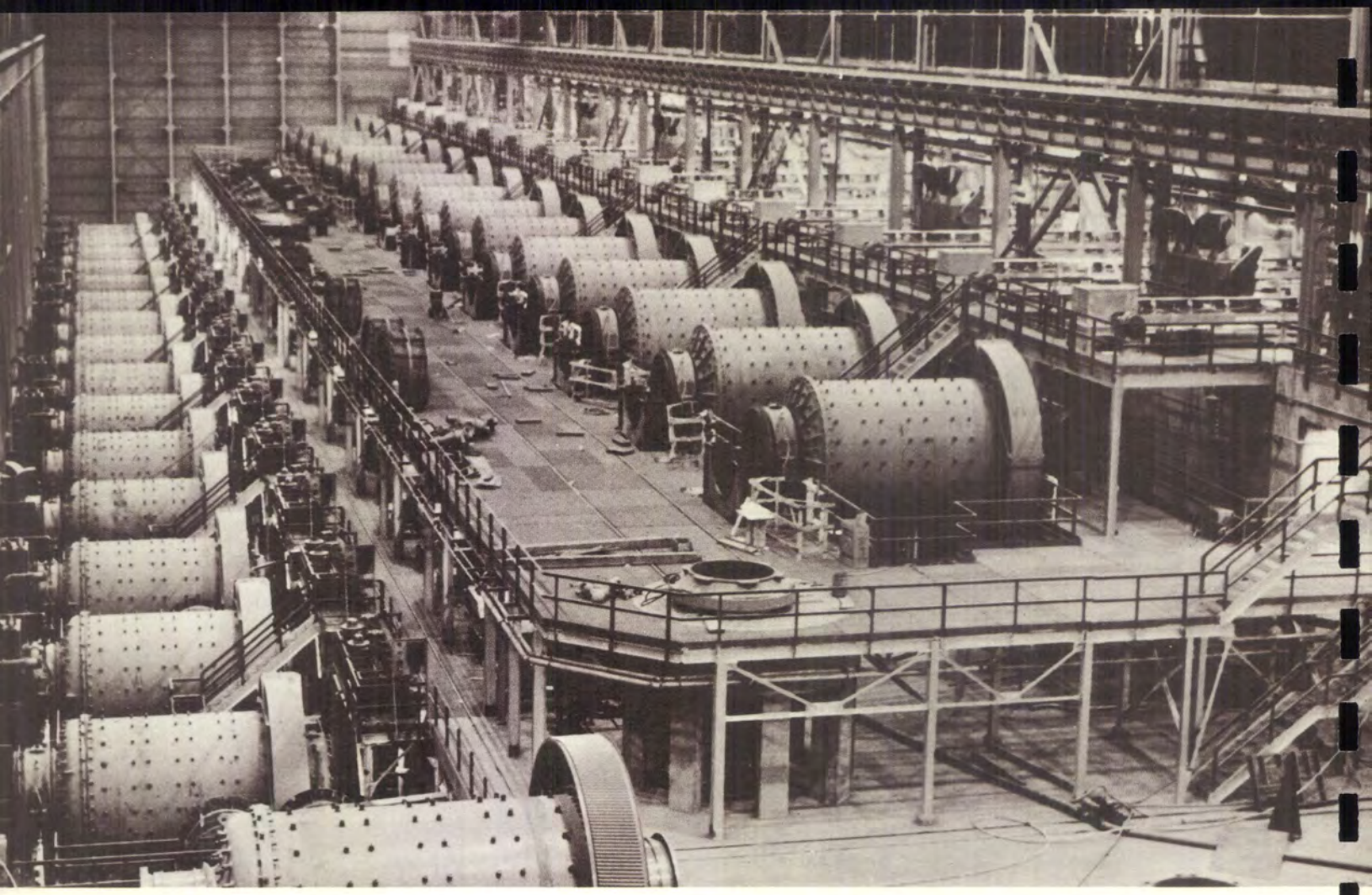
ALLOW 10[illegible]

EMC	- 714-1	D-810	20.	170.	[illegible]	SA-285-C	2 1 1 1 1
13750.0	13750.0	30000.0	30000.0	.4375	[illegible]	1.5000	1.5000
96.0000	97.1250	20 -.00	120.00	-.0000	[illegible].0000	3 6.600	3 6.600
1.000	1.000	-.0000	1.0000	13[illegible]	1.0000	130.000	
2370.	1240.	1300.	-0.	[illegible]	-0.	.0625	

150	120	1[illegible]0	250			
09-10-65	17.[illegible]	[illegible].0000	15000.	15000.	24.0000	SA-106-C

	EMPTY LEFT	EMPTY RIGHT	OPER LEFT	OPER RIGHT	TEST LEFT	TEST RIGHT	EMPTY MID	OPER MID	TEST MID
REACTION	.1828+05	.1828+05	.5228+05	.5228+05	.4679+05	.4679+05			
SHEAR	.8755+04	.8755+04	.2336+05	.2336+05	.2054+05	.2054+05			
MOMENTS	.2444+05	.2444+05	.6032+05	.6032+05	.5192+05	.5192+05	.6271+04	.3295+05	.3272+05
K2,K3,K5,K6,K6R		.3183-00	.4394-01	.0000	.5386-01	.1982-01			

Recent Project Experience by Parsons-Jurden



Hoyt Lakes

Taconite Processing and Pelletizing Plant

ERIE MINING COMPANY

In 1957 when this great metallurgical complex began production, it was the largest ore processing plant in the world ever designed and built as a unit. Over 12 years was spent in process development work by Erie and Pickands Mather & Co., Managing Agent, to assure feasibility of process design. The Masabi taconite crude ores average 55,000 psi in compressive strength, and recovery requires very fine milling.

As designed, the Hoyt Lakes plant produces 7.5 million tons of high grade pellets annually from about 22.5 million tons of ore.

In addition to the milling and beneficiation facilities, a complete pelletizing plant, a 150,000 kw winterized power plant, a 74-mile railroad, a harbor and dock on Lake Superior, a permanent townsite of about 800 houses, and various maintenance and service facilities were provided by Erie.

April 1965:
A contract was awarded to Parsons-Jurden for design and construction to enlarge the processing capacity of this plant by over 35%. When completed, the facility will handle 85,000 tons of raw ore daily, and produce 10.3 million tons of high grade iron ore pellets annually.

Of the engineering-design workforce for the original plant, over 60 men are now valued members of Parsons-Jurden's technical staff.

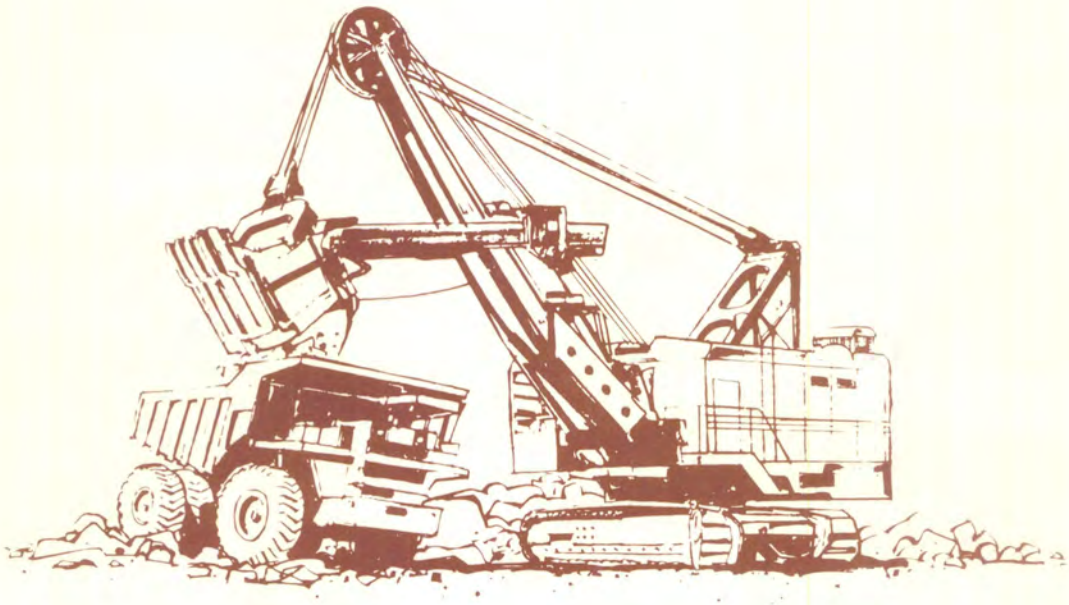
Clyde E. Weed

Copper Concentrator

THE ANACONDA COMPANY

Unquestionably one of the world's most advanced metallurgical process plants, the Clyde E. Weed Concentrator beneficiates 42,000 tons of lower grade copper ores daily. It is one of the first and the largest plants to feature autogenous pebble grinding. In addition, a high degree of automation was provided, with a Central Control Room where all operations are monitored by both recorder and closed-circuit television; and controlled by remotely activated instrumentation and controls.

Parsons-Jurden engineered and designed this $50 million facility, including a 25 mile, 34 inch fresh-water pipeline and other supporting elements. The Ralph M. Parsons Company constructed the plant, which was completed and initially operated in the Fall of 1963.



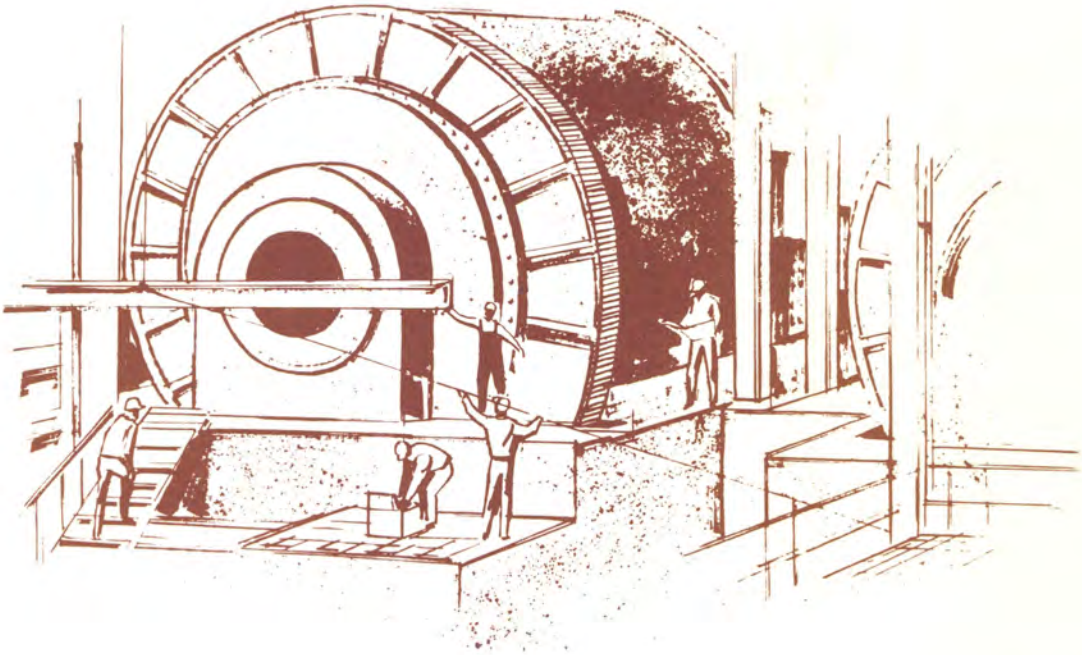
Mineral Park

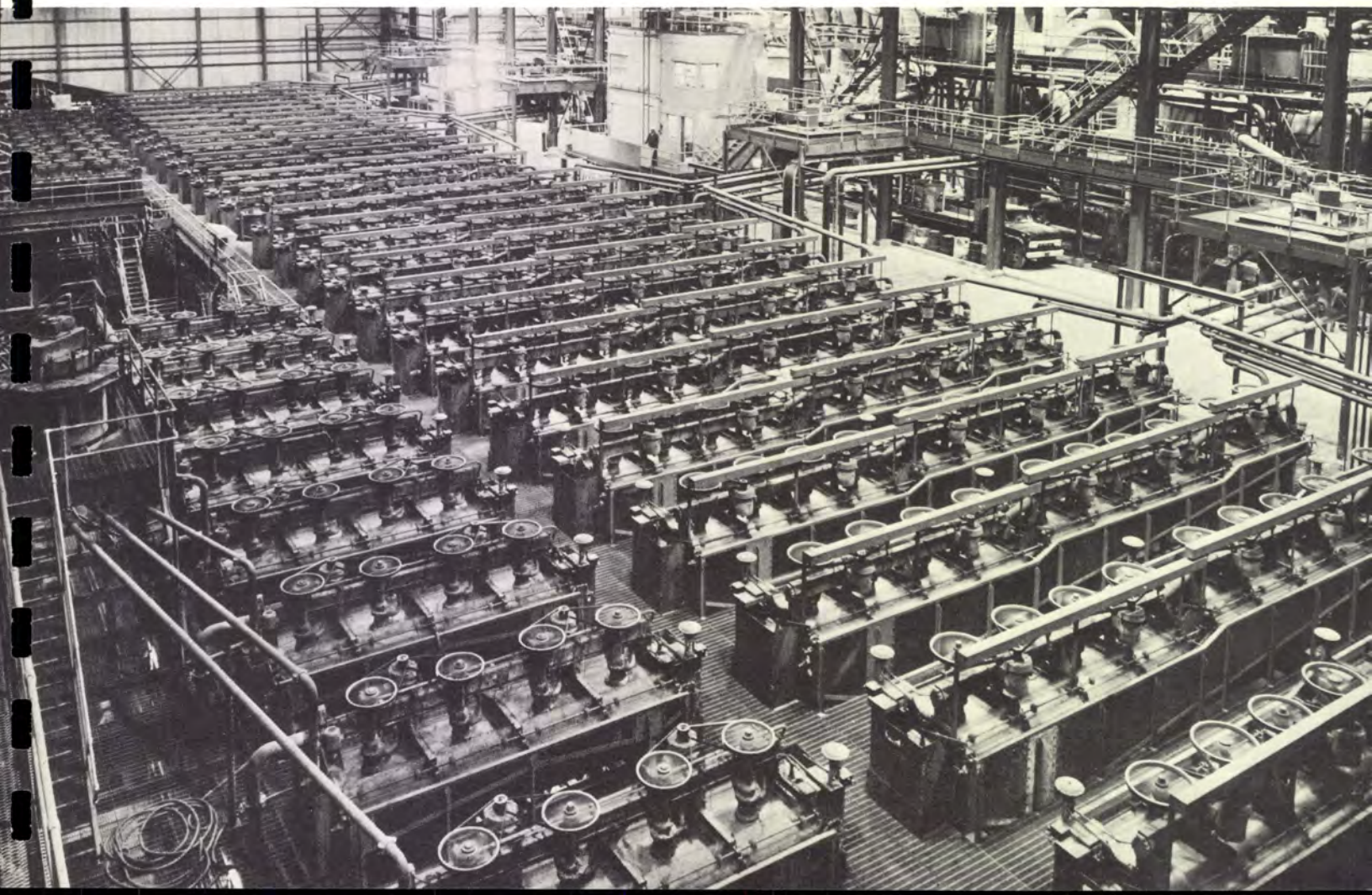
Copper Concentrator

DUVAL CORPORATION

In November 1964, the first concentrates were shipped from this Parsons-Jurden-designed, and Parsons-built concentrator near Kingman, Arizona. This grass-roots plant with a design capacity of 12,000 tons of ore per day produces 50 million pounds of copper and 3.5 million pounds of molybdenum trioxide annually.

This plant features unique crushing and grinding sections which permit conventional ball milling or autogenous grinding in the wet circuit. Currently all mills are operating with ball charges. In addition to the preparation and processing facilities, a 14,000 kw diesel power plant was designed and built on adjacent property for the local utility company. To satisfy process water needs, 5 wells; 17 miles of 16 inch pipeline with booster stations; and a unique, automated control system employing microwave activation was provided.





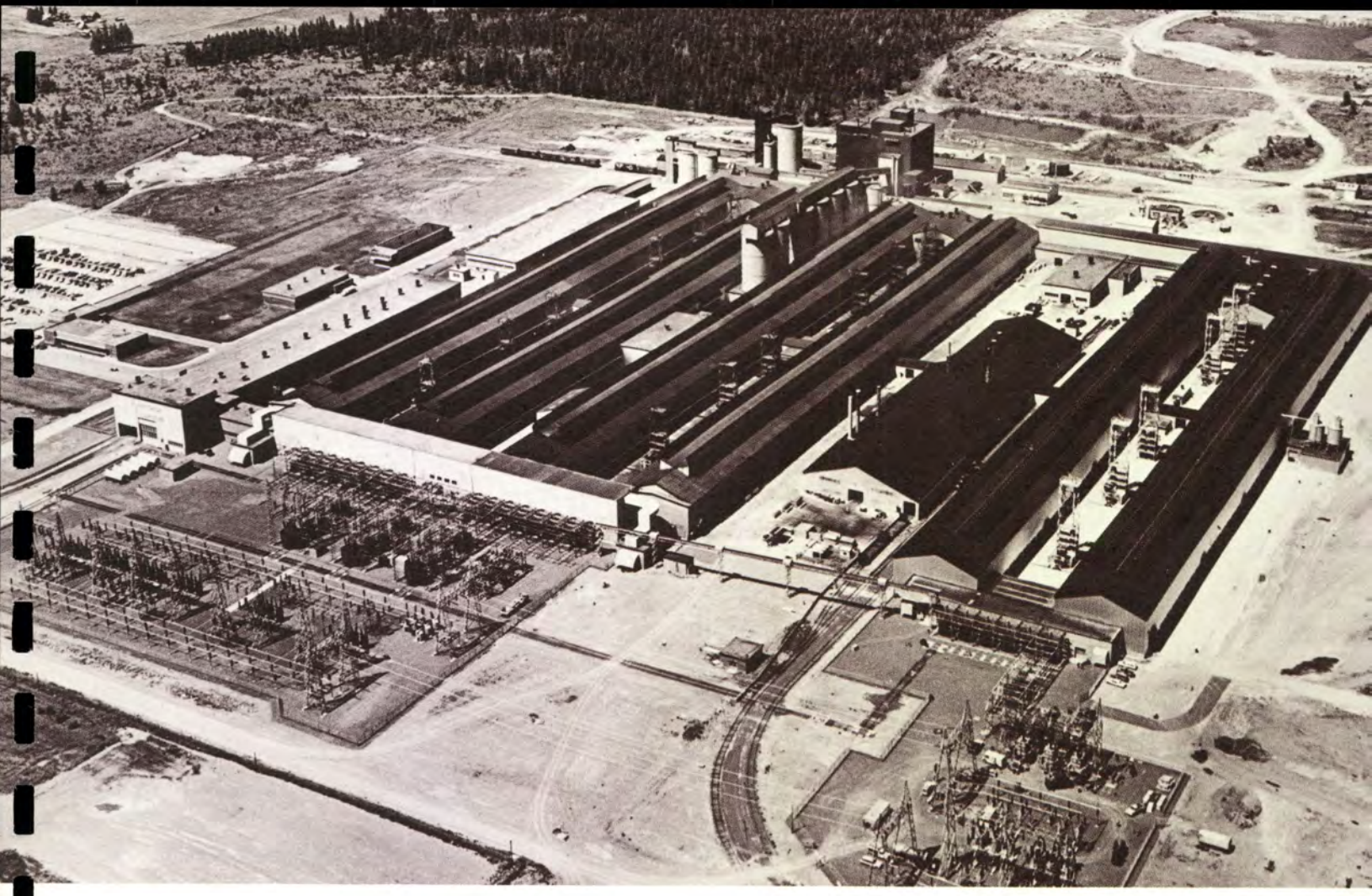
Columbia Falls

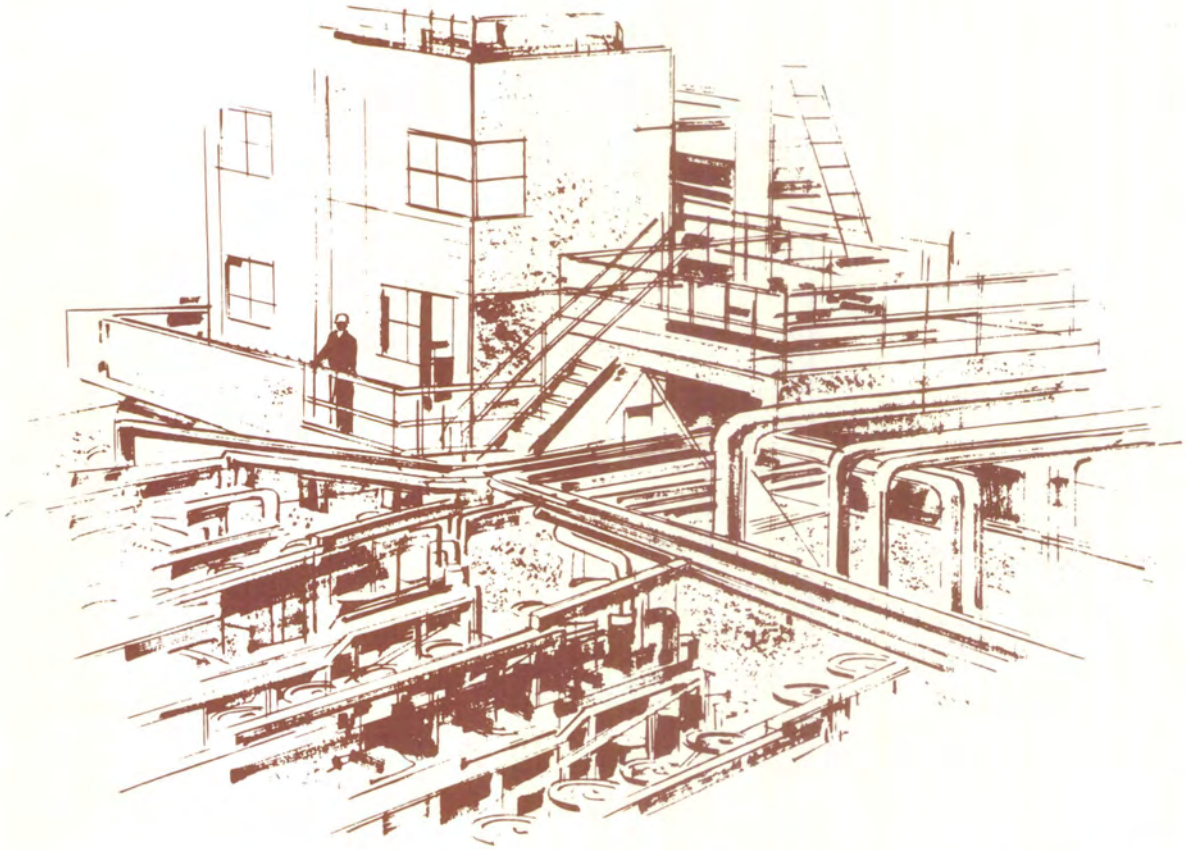
Aluminum Reduction Plant

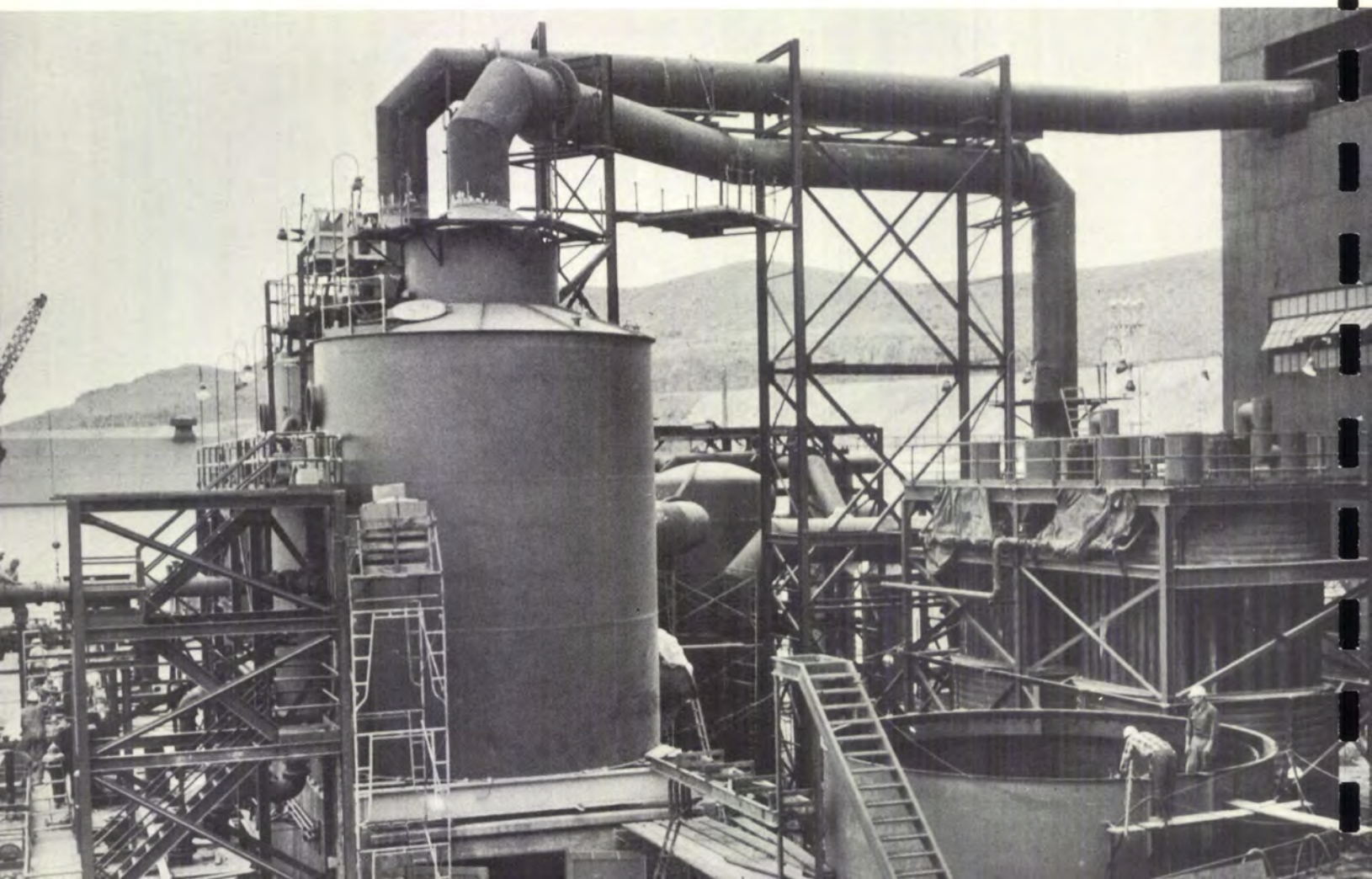
THE ANACONDA ALUMINUM COMPANY

The Columbia Falls Plant was completed late in 1955 and, until its major expansion 10 years later, produced 60,000 tons of aluminum annually. Utilizing vertical pin Soderberg anode pots, the original facilities comprised 4 potrooms, each 1140 feet long, a paste plant for the manufacture of pot anodes and cathode paste, a casting plant for semi-continuous casting of ingots, and all auxiliary structures. Power, supplied from Hungry Horse Dam at 230,000 volts, is converted by 16 ignition type rectifiers rated 6250 amps at 700 volts dc to provide 90 to 100 thousand ampere input to the potline circuit.

In 1964, the decision was made to expand the Columbia Falls Plant by the addition of a third potline. The Parsons-Jurden organization was again selected for engineering and design of the new facilities. In addition to the new 30,000 tons per year potline, a new pot rebuilding shed, expanded alumina storage, a new rectifier room utilizing modern silicon rectifiers, a substation, and other modifications were provided. The Ralph M. Parsons Company was the construction contractor.







Morenci

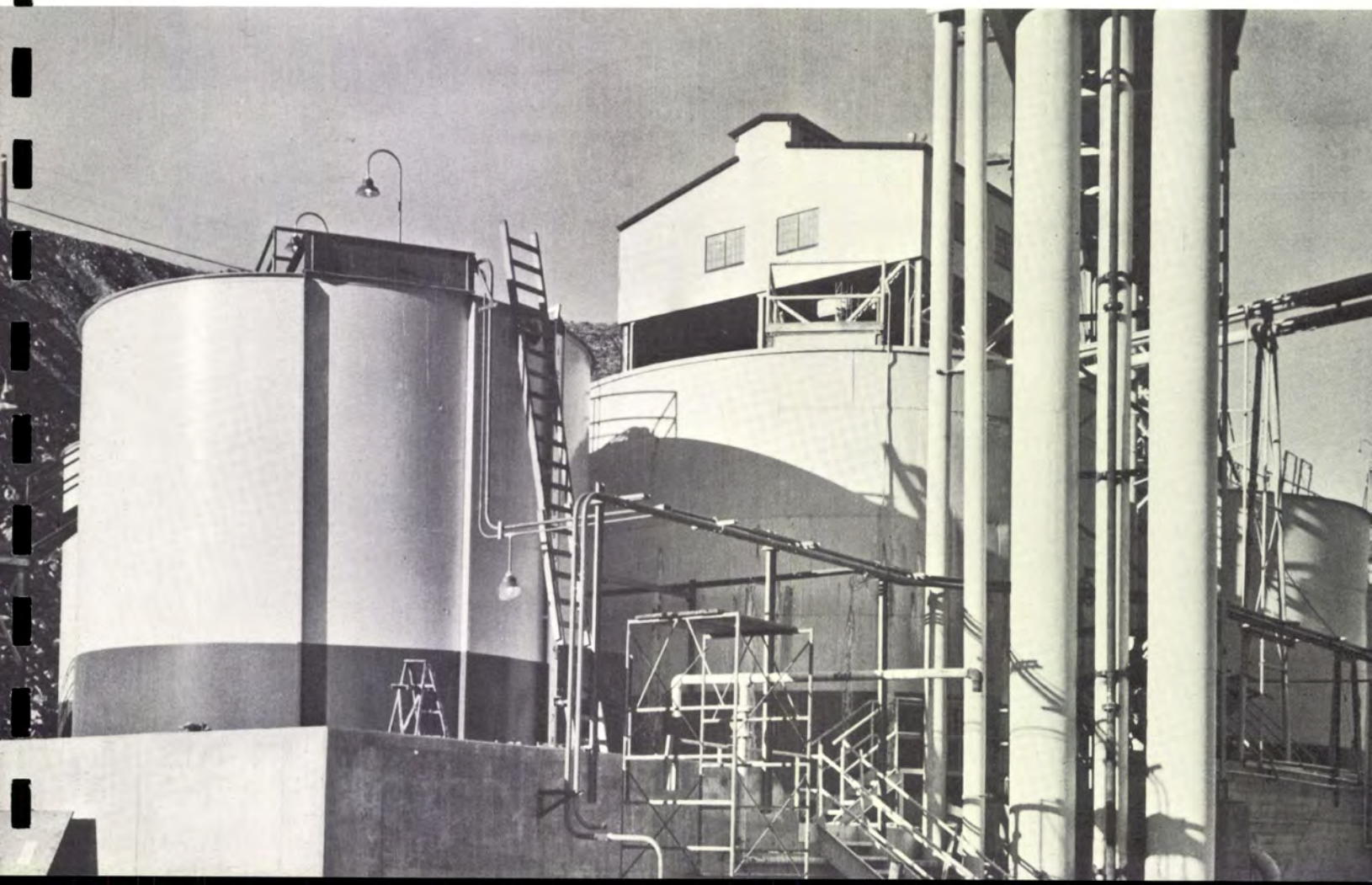
Leach-Precipitation-Flotation Facilities

PHELPS DODGE CORPORATION

From process design developed by the Customer, Parsons-Jurden engineered and designed these multimillion dollar facilities for the conversion of non-sulfide minerals into forms permitting conventional sulfide flotation recovery.

New facilities included a plant to manufacture a pelletized precipitant employed in the process, a 600 tons per day sulfuric acid plant, an enlarged lime plant, additions and alterations to smelter facilities, and expansion of the existing Morenci Power Station.

Construction was performed by The Ralph M. Parsons Company.



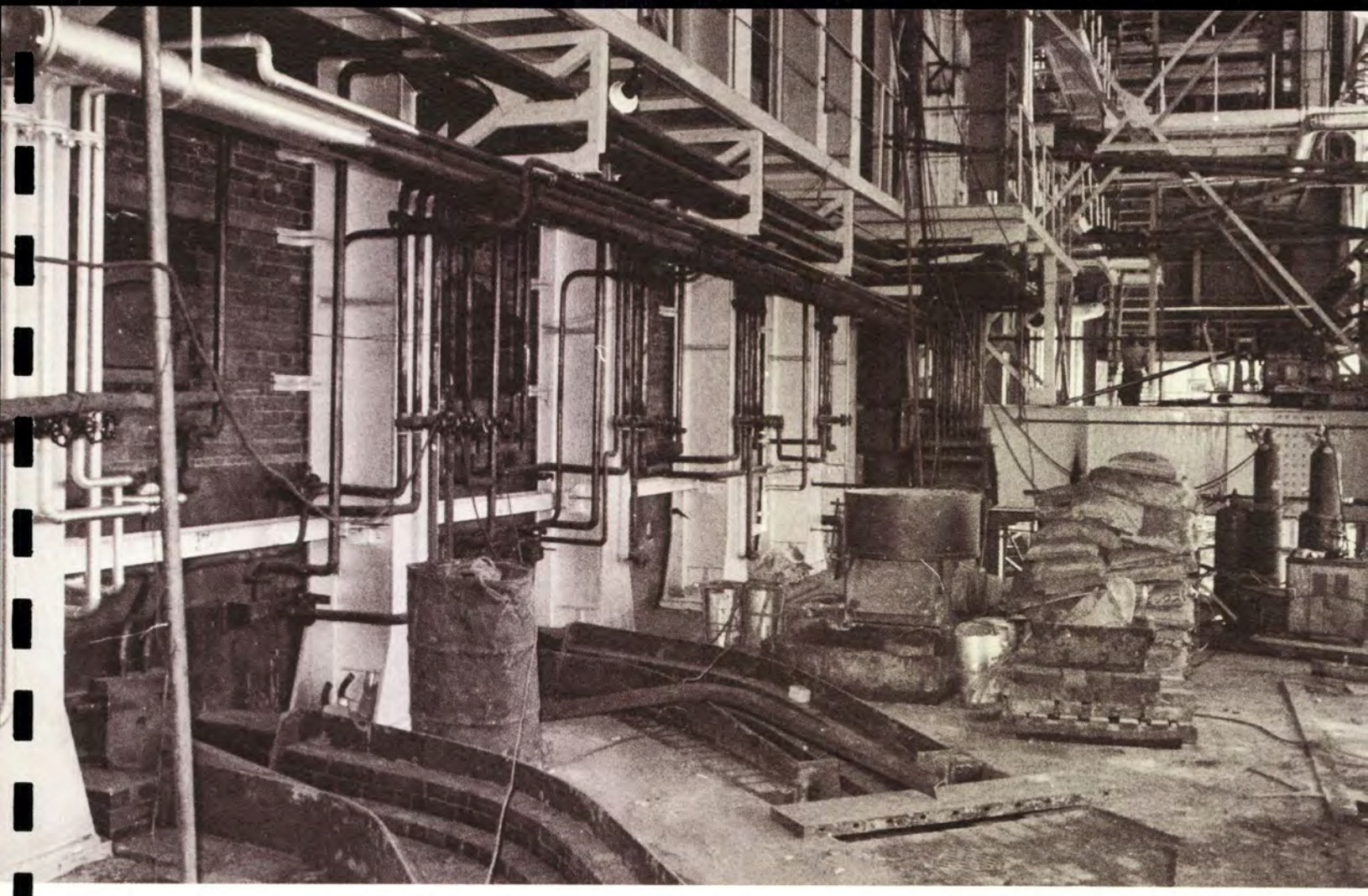
Onahama

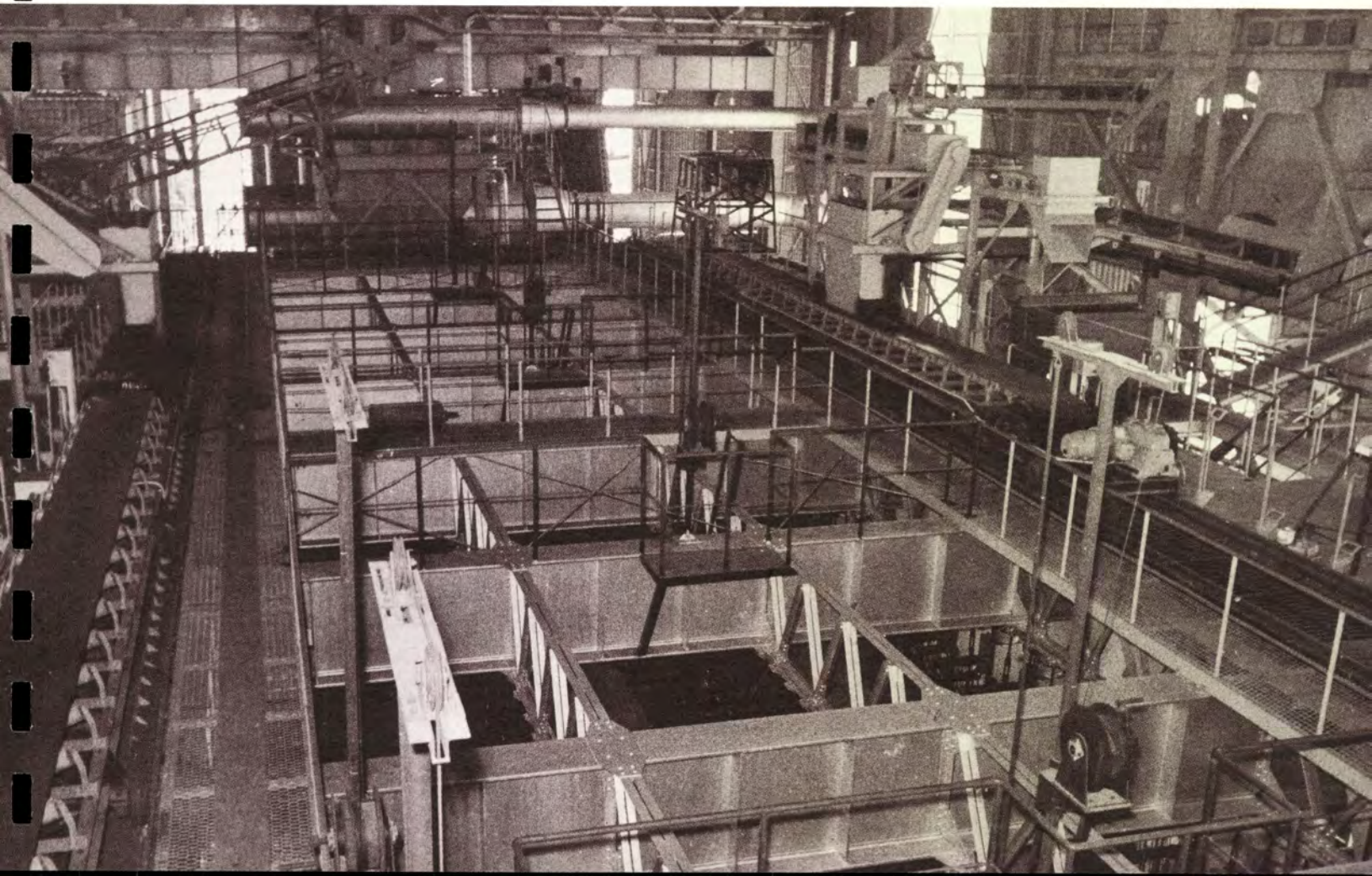
Copper Smelting Facilities

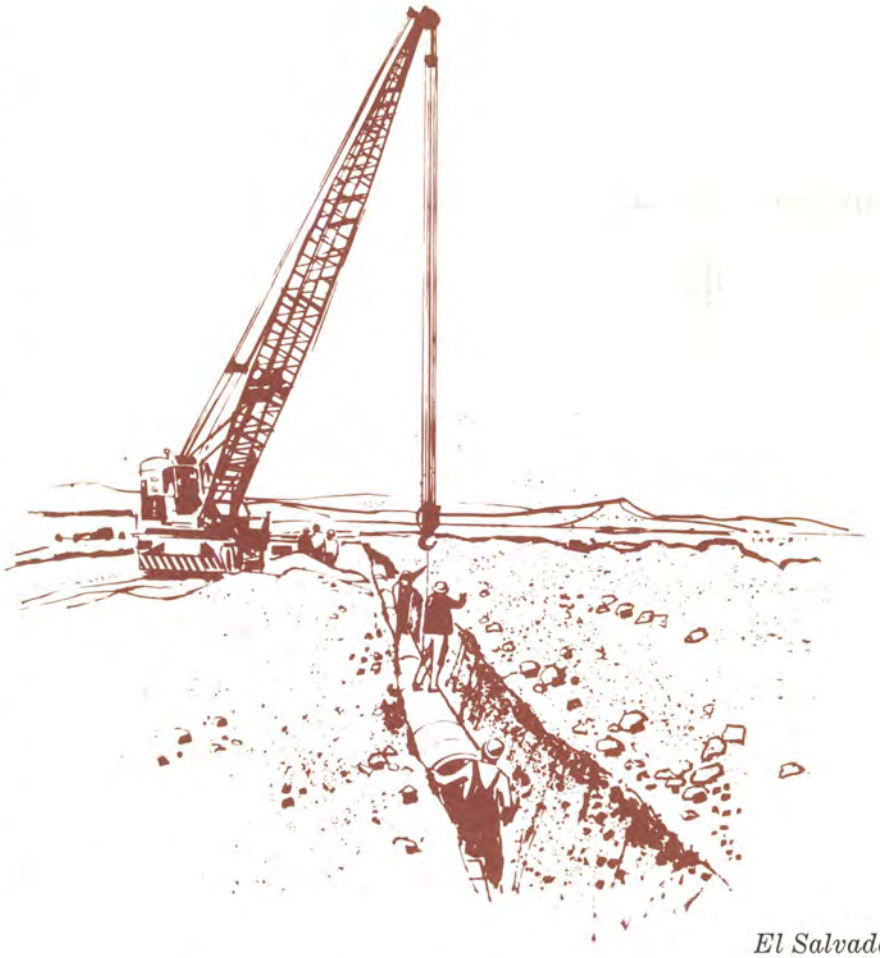
MITSUBISHI METAL MINING COMPANY

As consultants to Mitsubishi Metal Mining Company, Parsons-Jurden conducted both process and systems studies for a proposed copper smelting facility. Subsequently, a new firm was organized to own and operate the new facilities, and Parsons-Jurden was engaged to provide basic design for the reverberatory furnace, waste heat boilers, concentrate charging and fuel systems, and launders for slag and matte. In addition, supervision of equipment detailing, construction and start-up of the furnace were provided.

The reverberatory furnace, 32 by 100 feet in size, is the largest of its type in the world and required usually extensive foundations. Piles 164 feet deep support a 6½ foot thick concrete pad, on which rests 7½ feet of crushed quartzite, and 7½ feet of cast slag containing air cooling pipes.







El Salvador

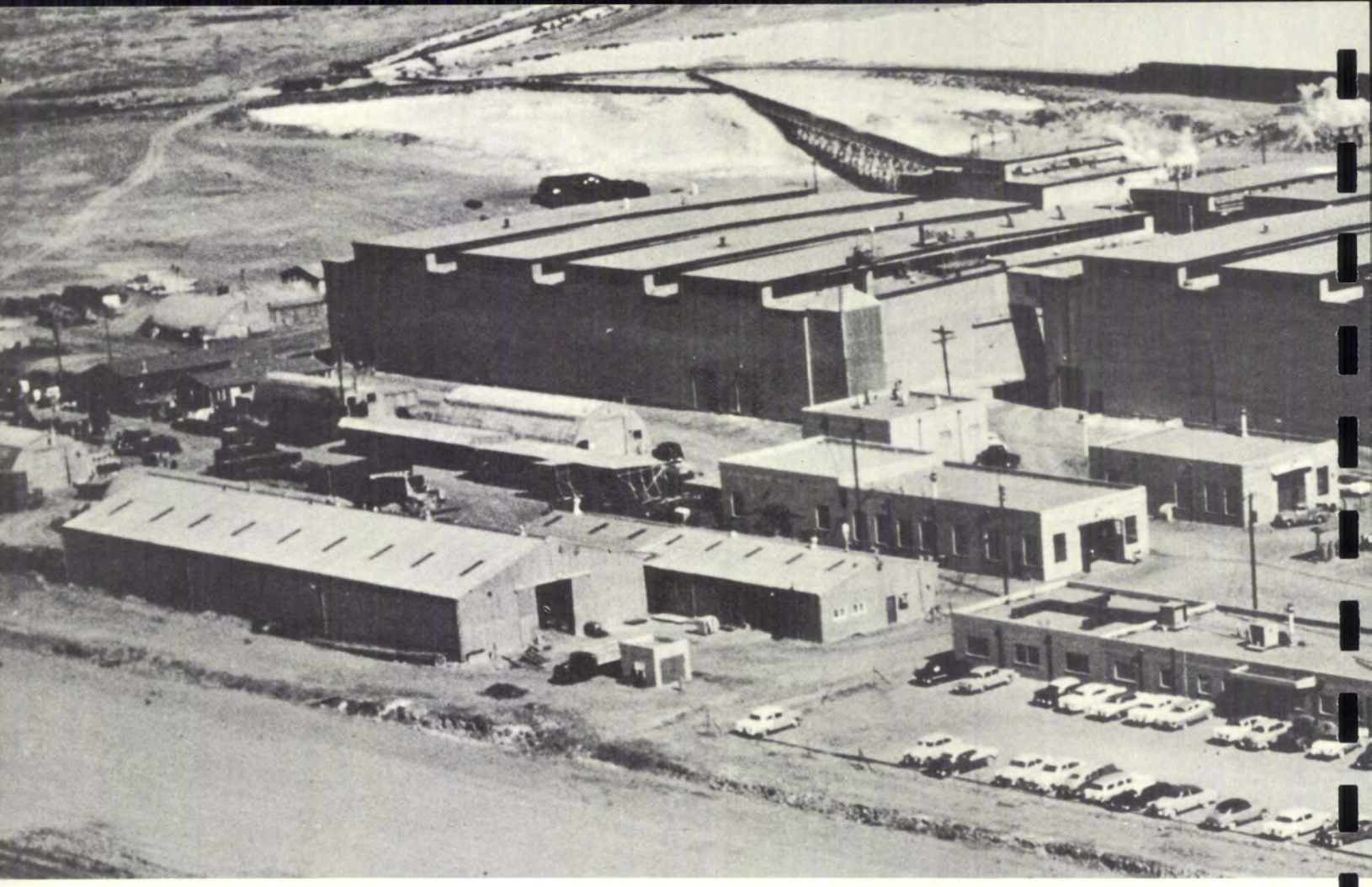
Sulfide Copper Plant

ANDES COPPER MINING COMPANY

Designed to process 24,000 tons of sulfide ores per day, El Salvador was completed in 1959 – ahead of schedule. The project included a 17-mile pipeline for slurried concentrates, and a complete townsite to accommodate 7500 people.

Four mill sections, each comprising one rod mill, and two ball mills in closed circuit with a cyclone classifier, provide feed for the flotation circuit. A closed regrind circuit also serves each of the four sections that produce a 90% – 325 mesh product for cleaner-recleaner-scavenger flotation. Molybdenum concentrate is removed by a cleaner-recleaner operation, and the copper concentrate is sent via a 14 mile pipeline to the railhead, Llanta.

Concentrates move 40 miles by rail, after dewatering, to Potrerillos for smelting and refining.



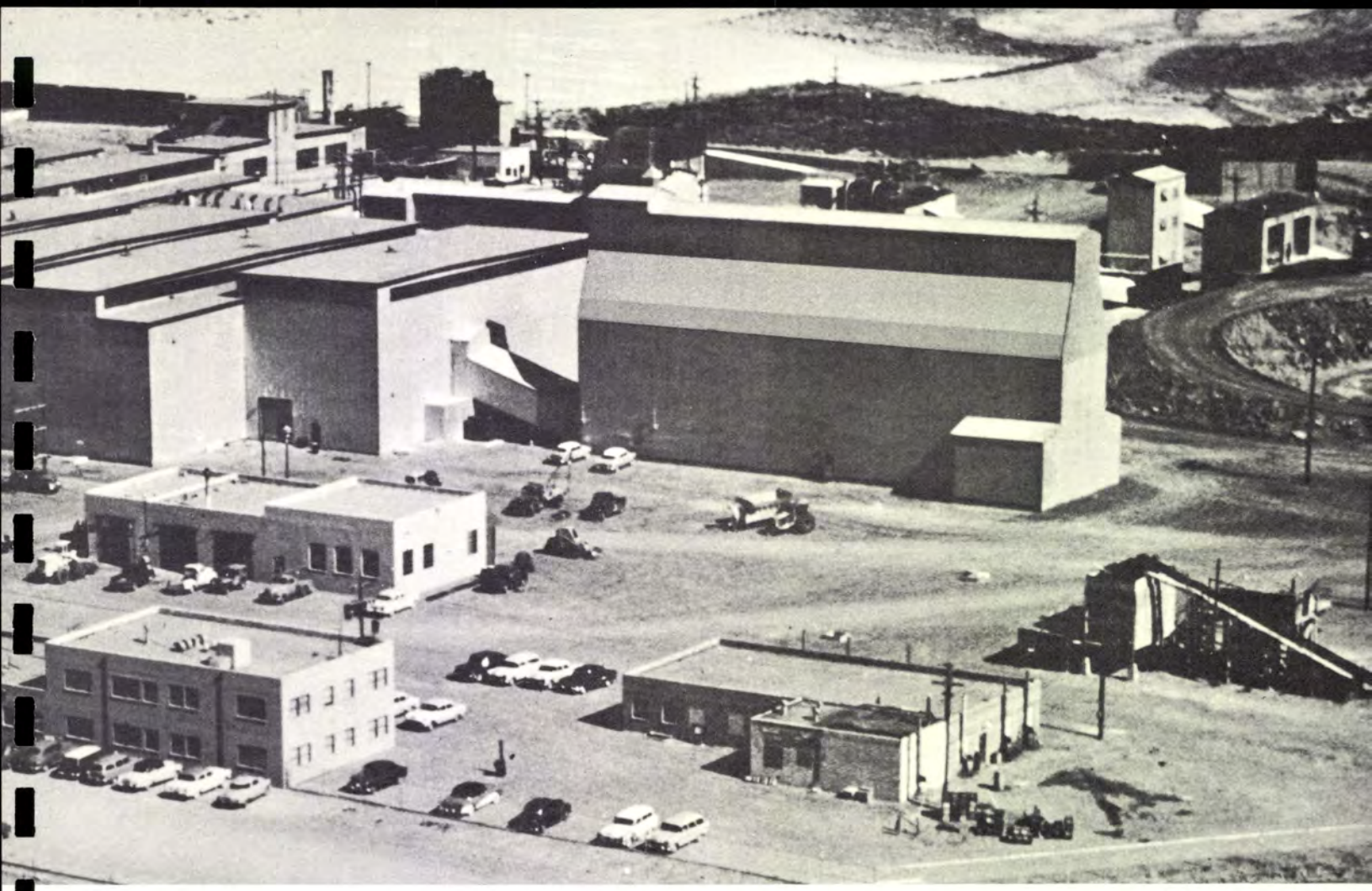
Bluewater

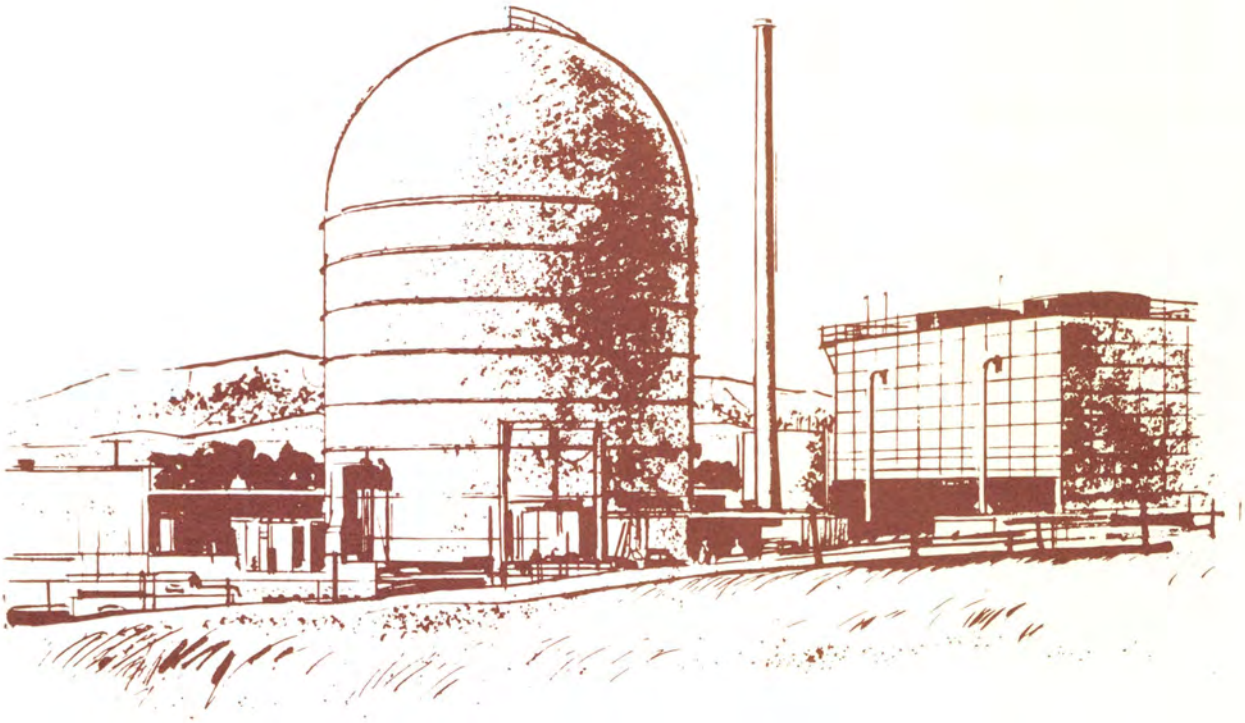
Uranium Processing Plant

THE ANACONDA COMPANY

Originally designed and built to process 200 tons of uranium ores per day, this plant was enlarged in 1955 to process 3500 tons per day. The expansion made this plant the largest producer of uranium oxide concentrate for the U.S. Atomic Energy Commission.

In addition to the processing facilities, a 1400 kw, coal-fired power plant; shops and laboratories; and housing for operating personnel were provided.





Project Feasibility and Planning Studies

Recognition by industry of Parsons-Jurden's Total Capability in all phases of metallurgical engineering-construction is evidenced by the frequent selection of Parsons-Jurden for planning services. Technical feasibility studies, economic evaluation, and facility master planning are major activities of our staff.

The following study projects are current or have been recently completed. To avoid disclosures, the Clients' identities and/or other confidential details are omitted.

Power and Steam Study for Oil Refinery Expansion

In conjunction with a projected five-year refinery expansion program, new power and steam requirements were developed and various methods of supplying these new loads were investigated. Considerable economies were projected since the recommendations made optimum use of waste heat and waste combustible gases available within the refinery. The study also suggested ways to reduce operating costs in the existing power plant, as well as plant modifications that the study indicated would not be advantageous.

Tailings Disposal Study

An investigation and studies were made of the adequacy and security from failure, due to earthquake action and flooding, of tailings dams in copper mines located in Chile and Peru.

Railroad Versus Pipeline Transportation

A study, comparing the relative economic feasibilities of railroad versus pipeline transportation of ore from mine to mill, and of fill tailings from mill to mine, were evaluated for a lead-zinc mining organization in a Far-Eastern country.

Feasibility Study of Conventional Versus Computer-Instrumented Power Plant

This study encompassed a comparison of conventional power plant instrumentation with computer instrumentation of varying degrees of sophistication, ranging from data logging through fully automated computer control. This study included surveys of manpower requirements, computer capabilities, computer accuracies and potential benefits.

Engineering Study of Overland Conveyors and Materials Handling

An engineering study was made of the design engineering and detailed construction requirements for a fully automated bauxite handling system. This study included the consideration of various methods of handling and storage, the writing of equipment lists, and the preparation of bid documents.

Engineering Study of Proposed Smelter and Sulphuric Acid Plant

An engineering study and development of a capital cost estimate for the overseas construction of a smelter, sulphuric acid plant and auxiliary facilities to produce copper anodes.

Power Station Site Selection and Sub-Surface Soils Investigation

This power plant site selection was based on a study of three major factors:

a) Historical background of high and low levels of nearby river.

b) Circulation of water pumping power economy by utilizing syphon action in the circulating water system.

c) Selection of proper bearing soil level for support of the power plant structure. This factor was of critical importance due to the discovery of a Fort Union Shale formation at the elevation selected to meet other conditions.

Facility Instrumentation and Controls

To an ever increasing degree, high quality production and the economic operation of industrial process plants and power facilities depend on controls and instruments that are sensitive, flexible and reliable.

Parsons-Jurden meets the individual needs of many different industries by the application of highly sensitive measuring devices for special processes, data processing, and electronic control instrumentation.

A Parsons-Jurden design of control systems for a Client begins with a detailed systems study, and an analysis of the process characteristics of the plant. An evaluation of the data thus obtained is made by experienced, cost-conscious engineers who are familiar with modern applicable technology, to develop a system which permits the degree of automation required. Some systems, such as Anaconda's new copper concentrator at Butte, and the Three-Line Concentrator Complex for Texas Gulf Sulphur, required extensive automation.

At Parsons-Jurden, the design and application of instrumentation has reached its most advanced form in computer controlled systems that are among the most sophisticated in the world. Several major installations designed by Parsons-Jurden provide a sound basis for the conversion of other industrial facilities from manually-controlled to automatically-controlled processing.

Control systems developed by Parsons-Jurden offer optimum control without incurring the economic and physical disadvantages of over-sophisticated systems.

PROJECTS BY PARSONS...THROUGHOUT THE FREE WORLD

Petroleum Refining • Chemical Processing • Power Generation • Gas Processing and Sulfur Recovery • Mining and Mining Geology • Water Development, Distribution and Waste Treatment • Civil Works • Nuclear Research and Development • Missile and Space Exploration • Aircraft and Missile Propulsion • Biological and Bacteriological Research.

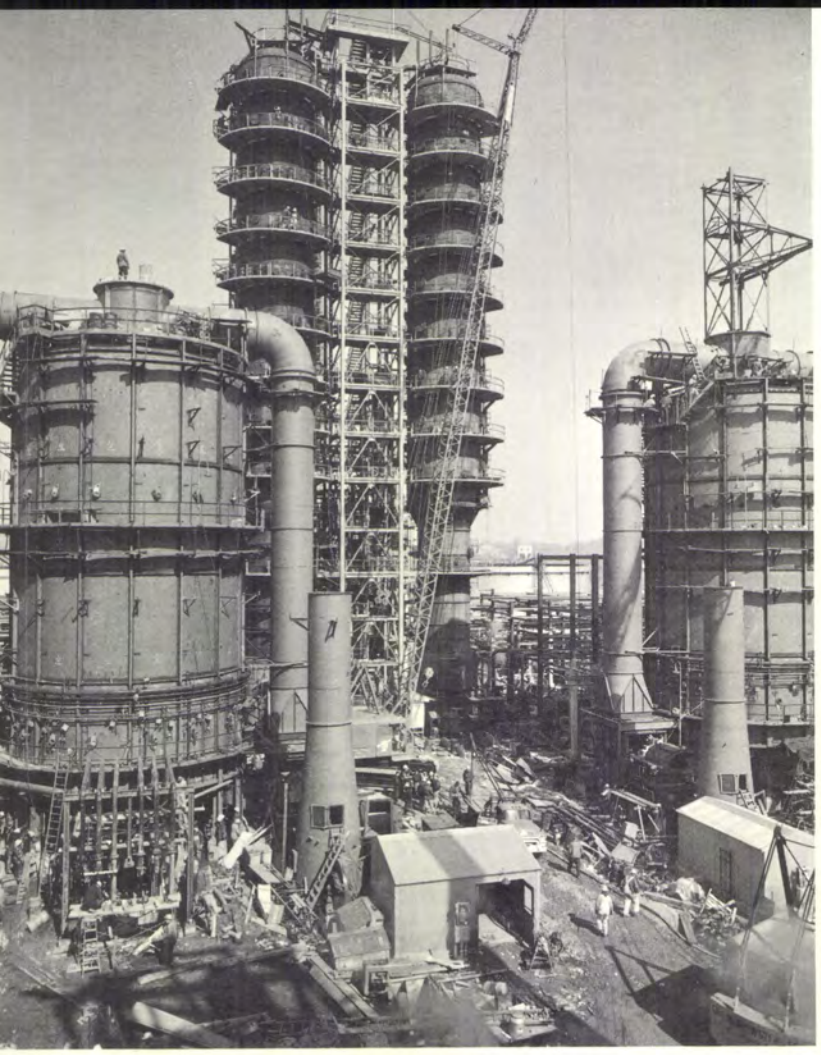
Since its acquisition by The Ralph M. Parsons Company in 1961, the rapid growth of Parsons-Jurden has been paralleled by broad diversification into fields where the parent company is well established.

Petroleum and chemical engineering and construction, systems engineering, water development, and power engineering contracts have occupied an increasing share of the Company's workload. The capabilities of Parsons-Jurden in these activities have been steadily expanded by attracting highly competent engineering personnel, whose experience, knowledge, and talent constitute our main asset.

In the section to follow, representative projects by Parsons-Jurden, by the parent company – or by Parsons in Canada, Germany, London, France, or Japan – illustrate the diversity of services we offer to industry and government.

Complete Petroleum Refineries

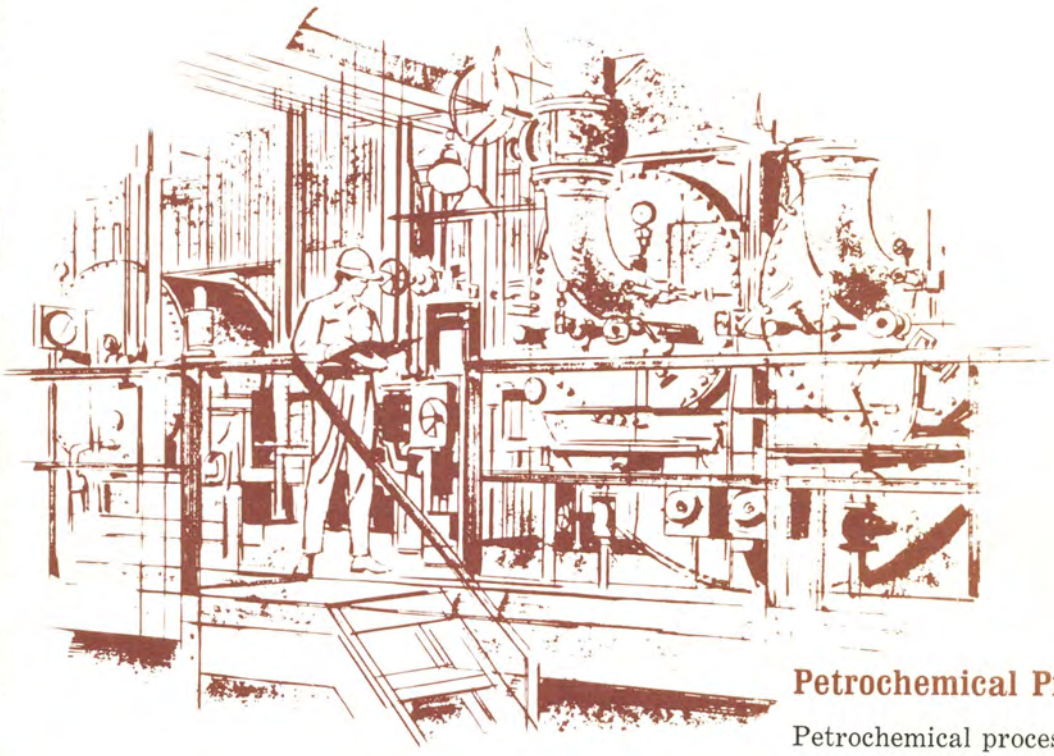
27,500 BPD petroleum refinery, one of 16 grass-roots refineries or complete revamp projects by Parsons to date.



Petroleum Processing Units

Crude and vacuum distillation units constructed by Parsons serve 22 major petroleum processors.

Parsons has designed and constructed many hundreds of major petroleum processing units, utilizing proven process and construction technologies.

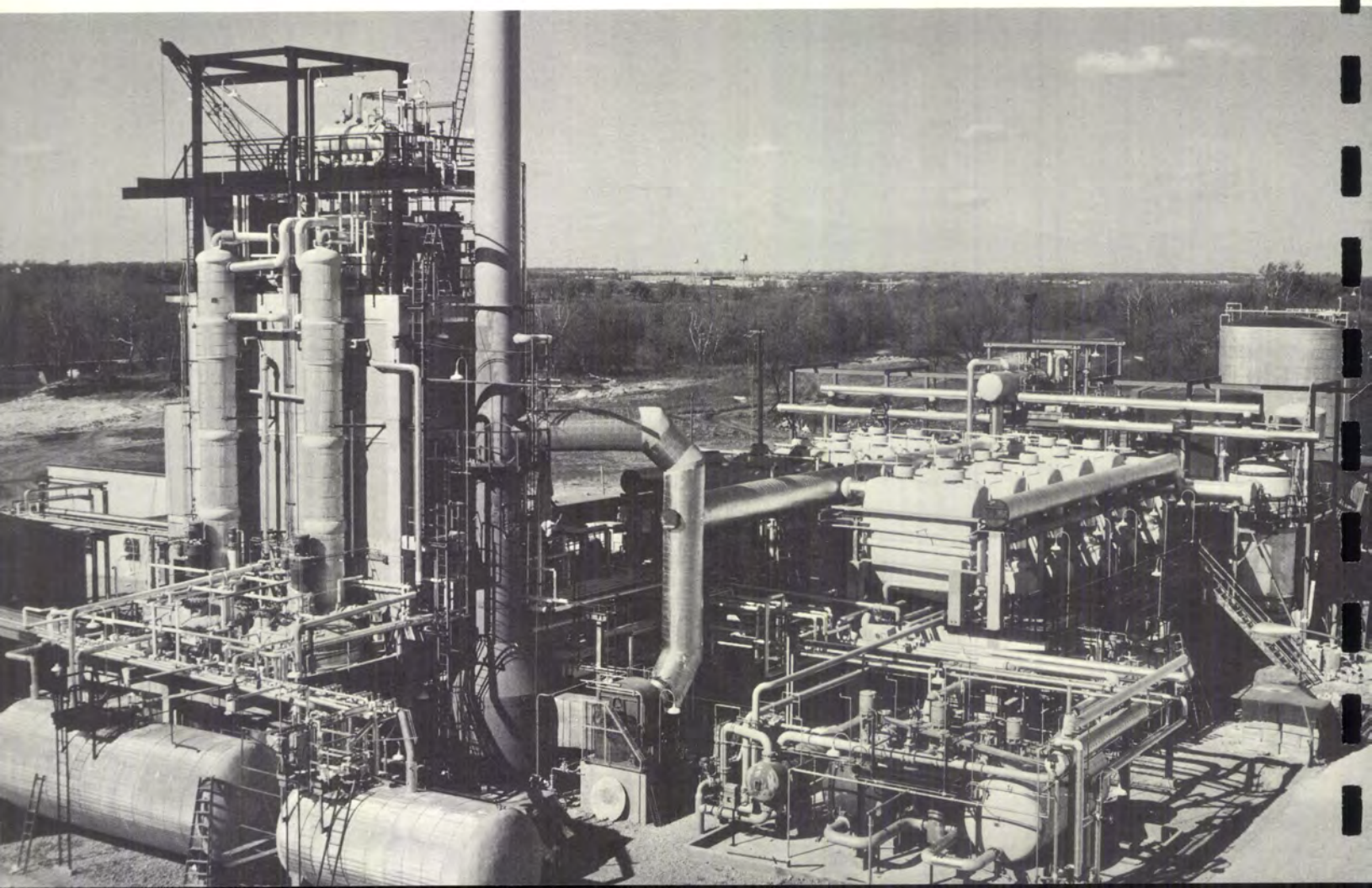


Petrochemical Process Plants

Petrochemical processing plants, typical of which is this 60 million pounds/year styrene plant in Texas, are designed and built for major industrial producers.

Chemical Process Plants

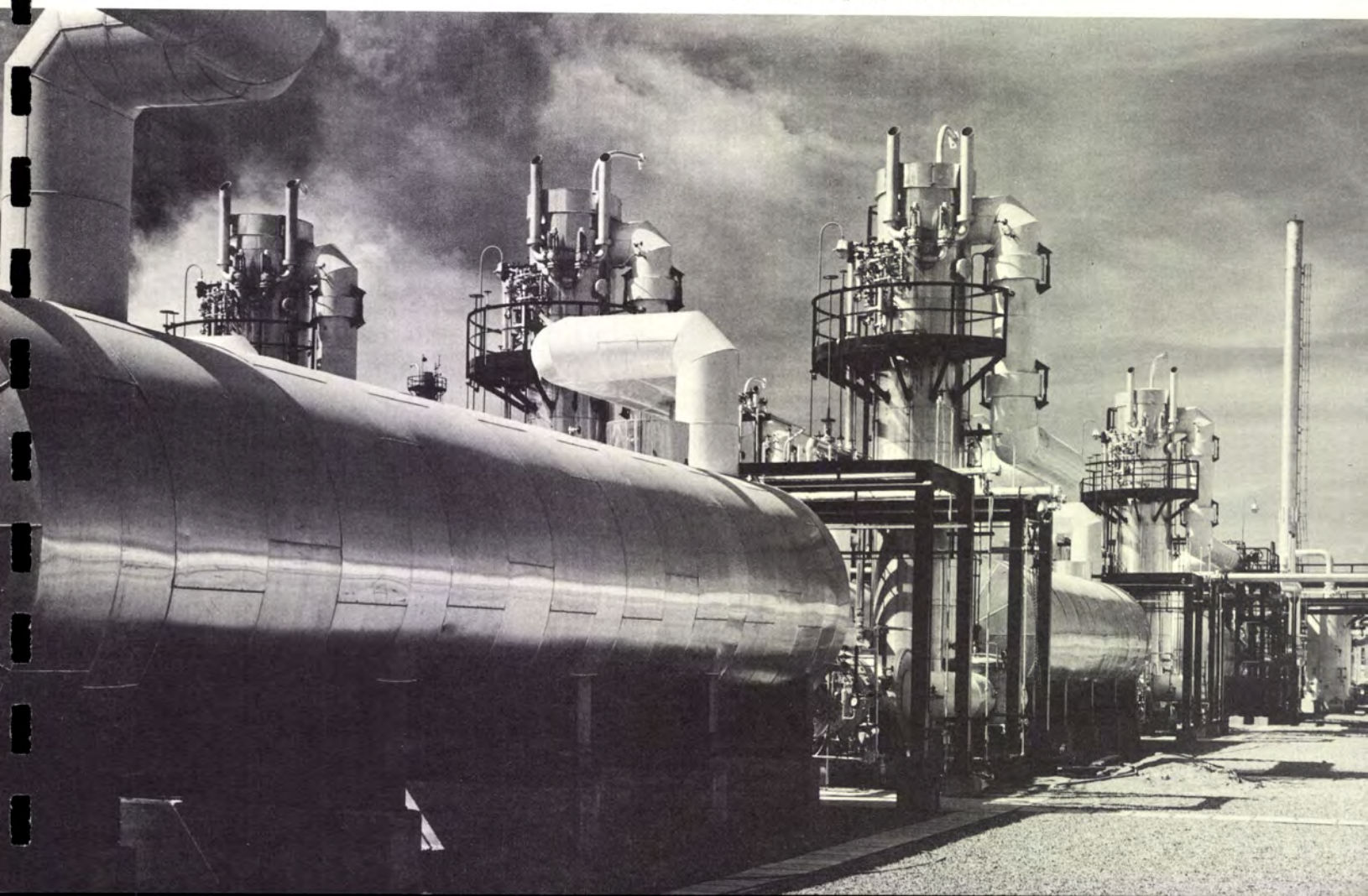
For the chemical and petroleum industries, Parsons has engineered and constructed diverse production facilities. The plant illustrated produces phthalic anhydride.



Gas Processing and Sulfur Recovery Plants

Many of the world's largest natural gas processing plants are Parsons-designed and Parsons-built. This facility in Canada processes 150 million cubic feet per day, and recovers 875 tons of sulfur daily as a by-product.

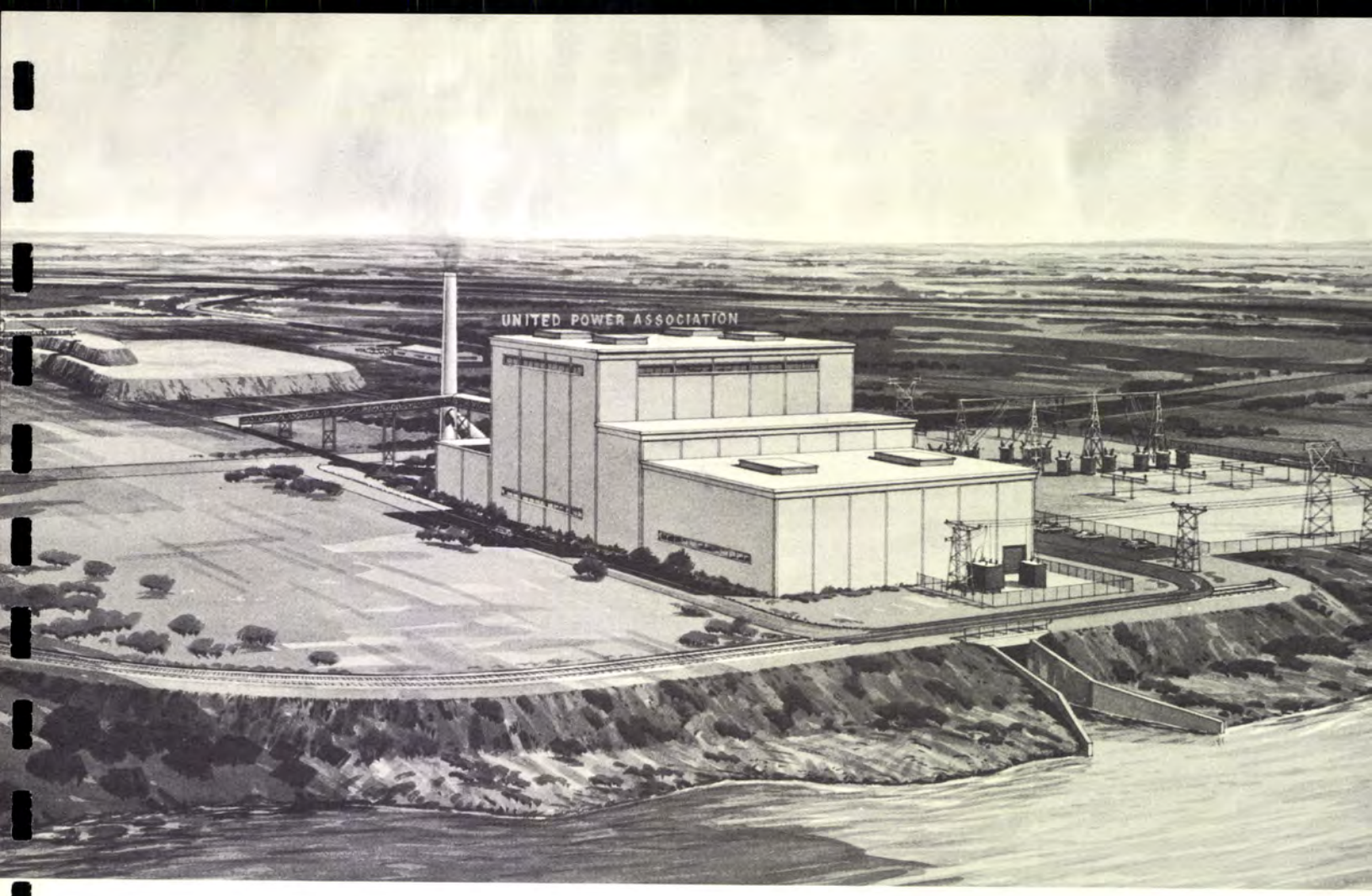
Over 4000 LT/D are recovered from sour gas by this Parsons plant in France.



Civil Works

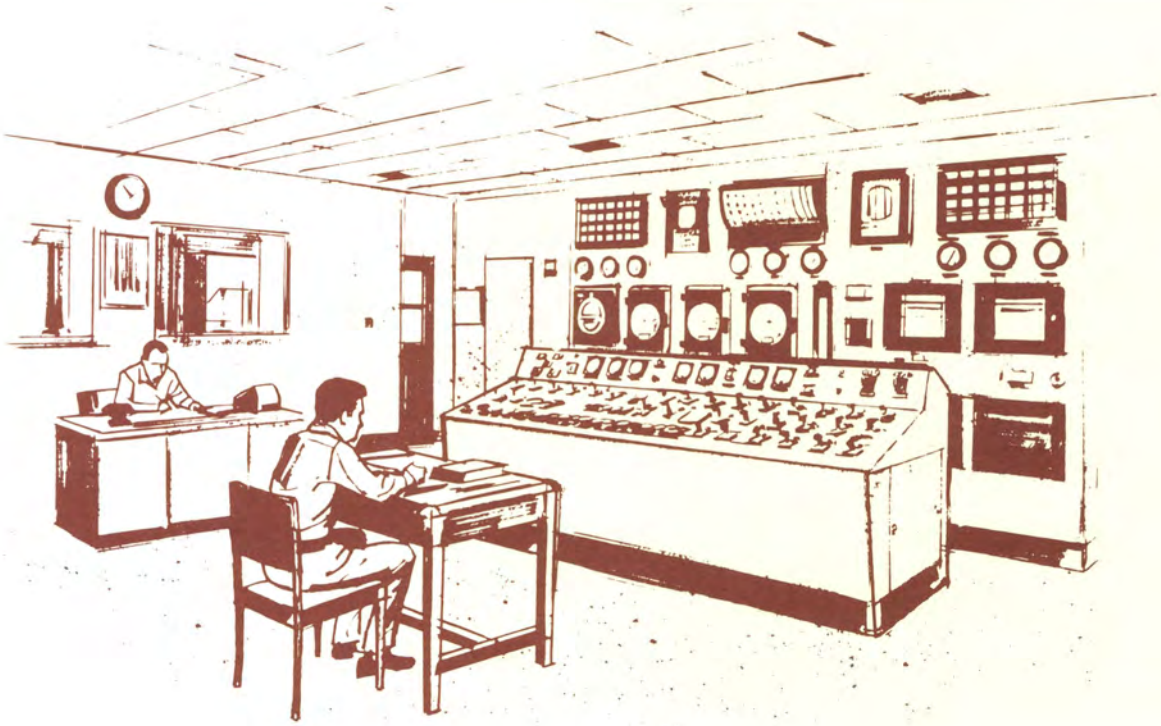
Aqueduct in Pakistan is typical of diverse civil works by Parsons for governments throughout the free world.

First Honor Award for architectural excellence was presented to Parsons in 1963 for the design of the Dhahran Civil Air Terminal in Saudi Arabia.



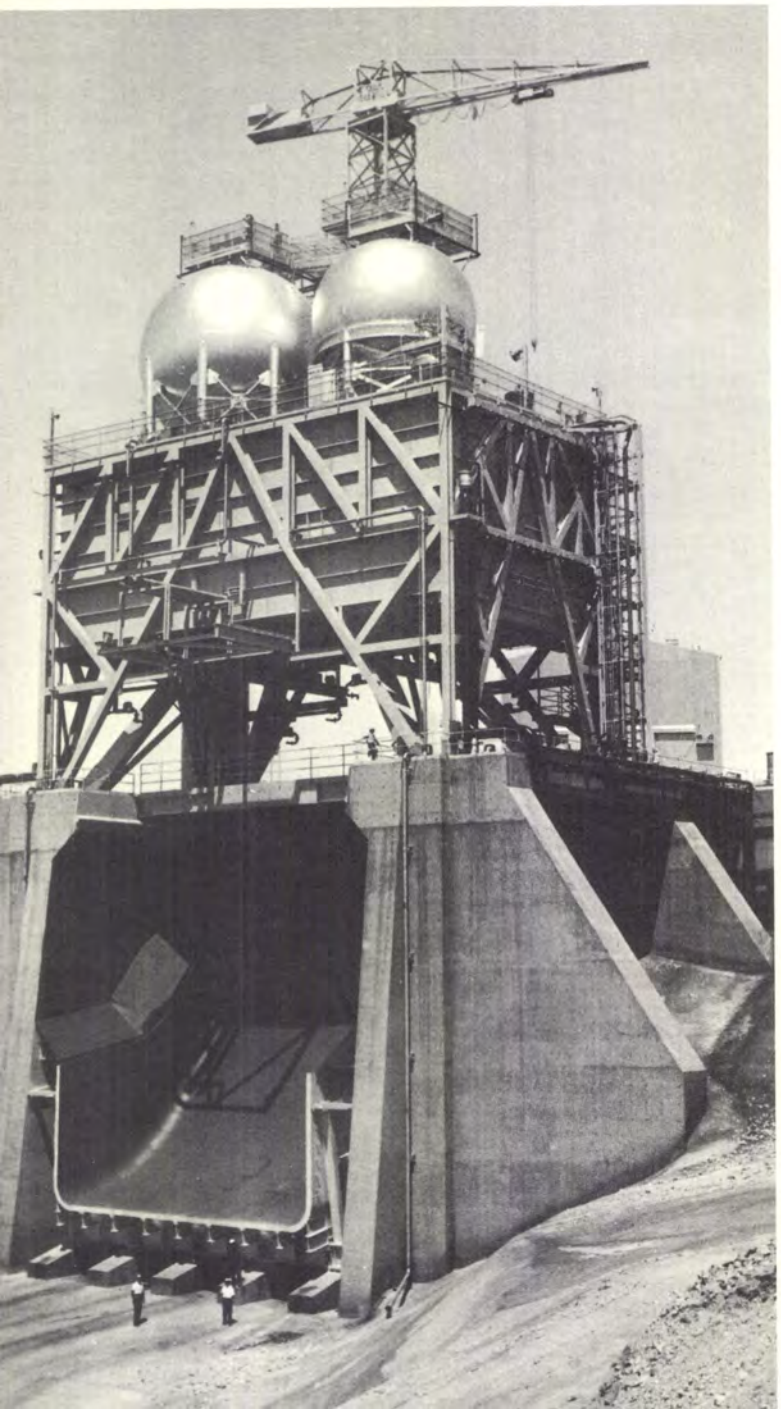
Power Generation Plants

Now under construction at Stanton, North Dakota, this 172,000 kw lignite-fueled power plant was designed by Parsons-Jurden.



Aircraft and Missile Propulsion

World's largest rocket motor plant, designed by Parsons for the production of solid-fuel motors for the Minuteman Missile.

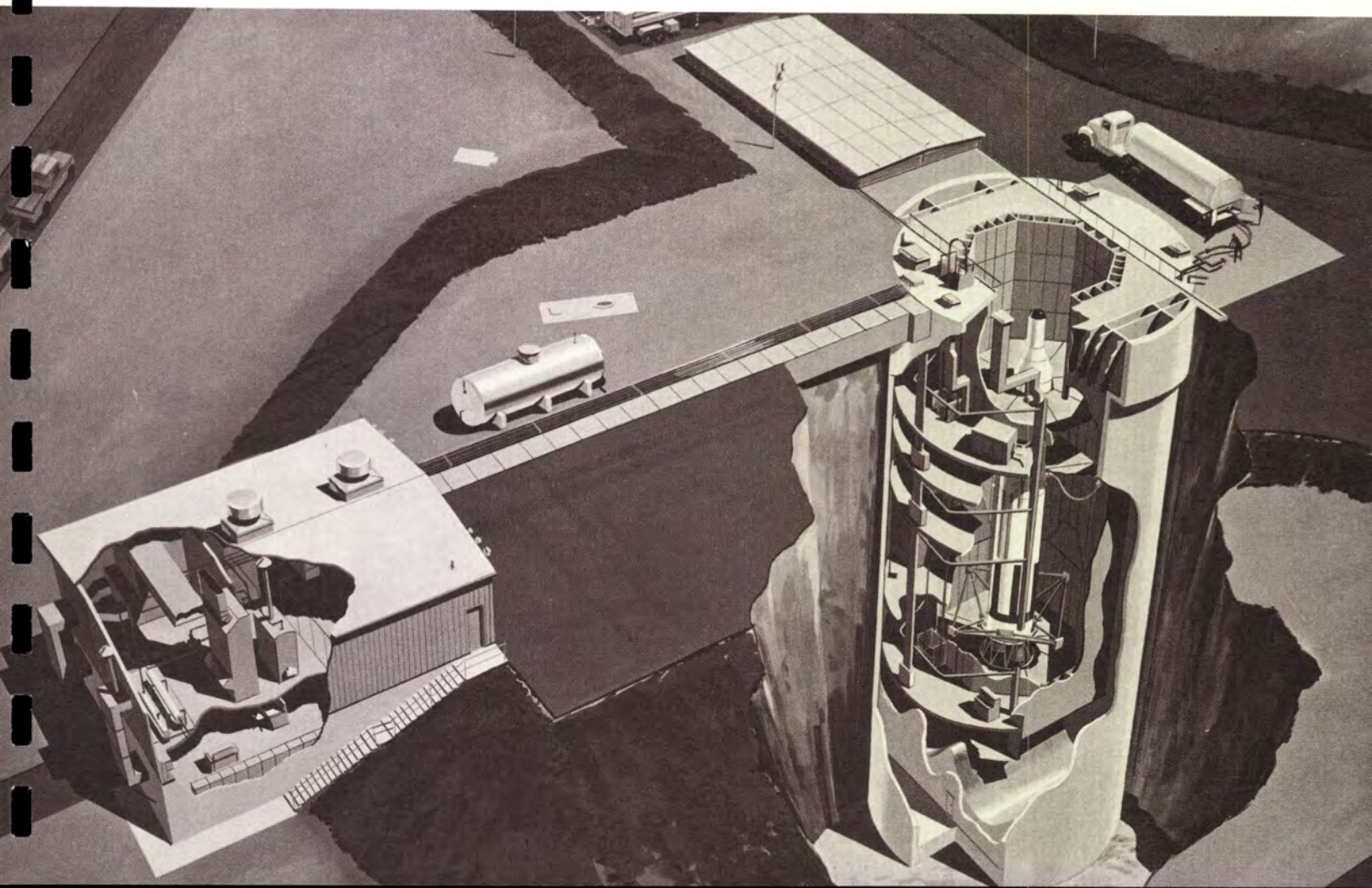


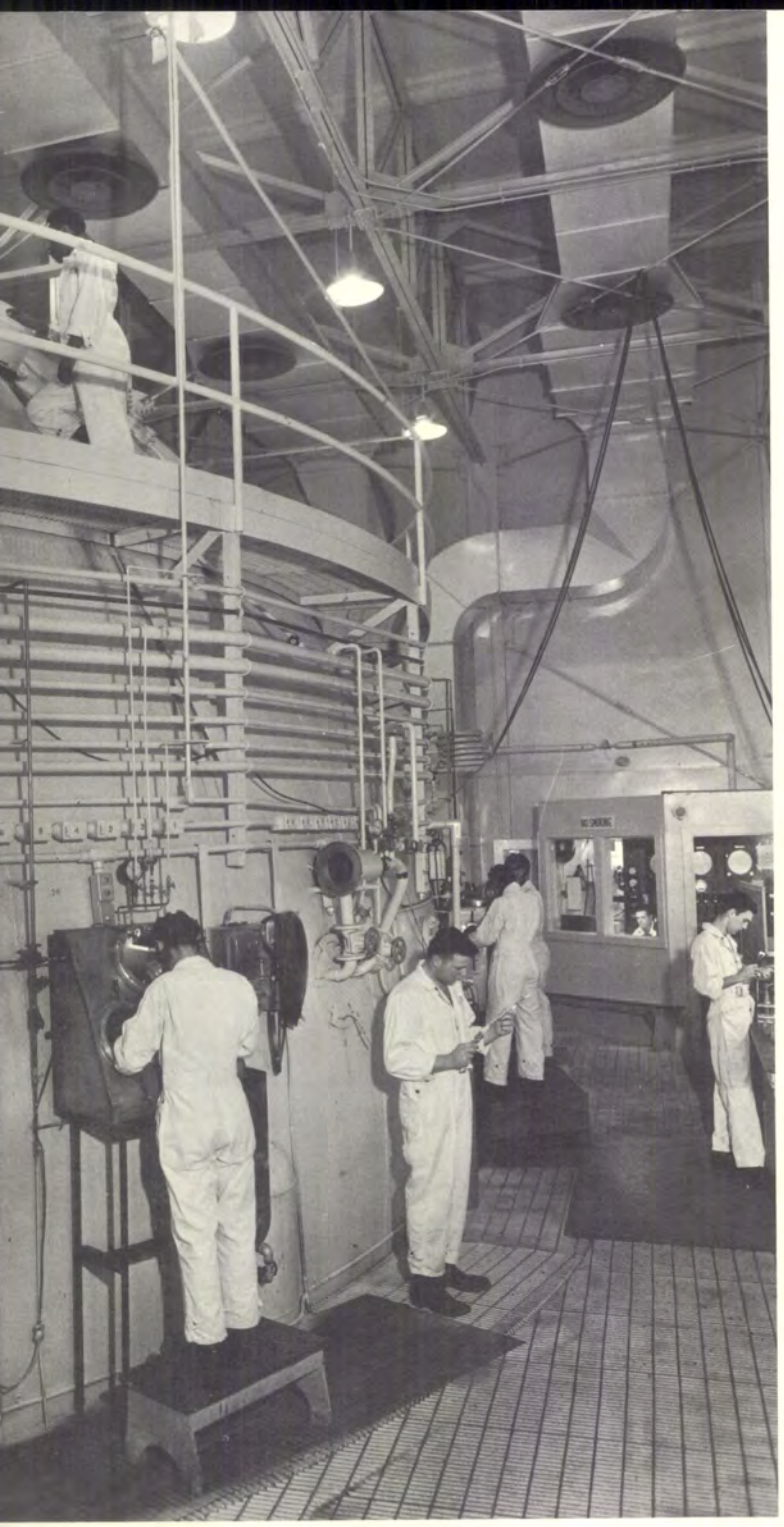
Missile and Space Program Facilities

As associate contractor, Parsons was responsible for architect-engineering of the complete complex for assembly, checkout and launch of the Air Force Titan III space vehicle.

First successful in-silo launch of a missile was from the Parsons-designed-and-built Silo Launch Test Facility (SLTF) at Vandenburg Air Force Base, California.

Over a score of static test stands for rocket engine testing have been engineered by Parsons. This facility accommodates the F-1 engine for NASA's Saturn family of boosters.





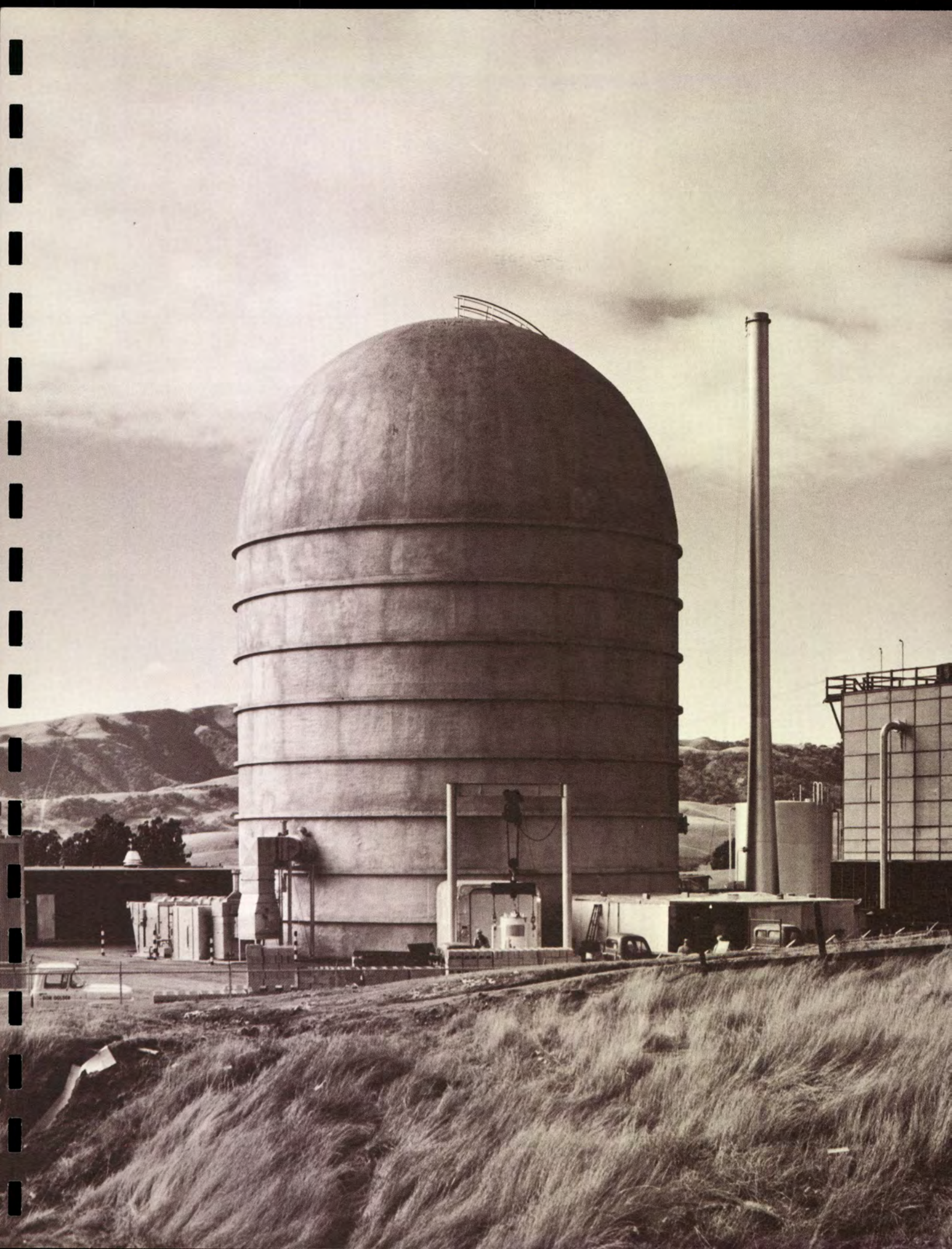
Nuclear Research & Development

This test reactor facility in California is typical of nuclear engineering and design projects completed for both government agencies and private industry.

Biological and Bacteriological Facilities

Unusually sophisticated ventilation, climate control, waste disposal and personnel protective systems are basic criteria for Life Science Laboratories.

For the U. S. Department of Agriculture Parsons designed The National Animal Disease Laboratory at Ames, Iowa.



Experts on the earth sciences comprise this team of Parsons engineers exploring remote areas of Ethiopia.

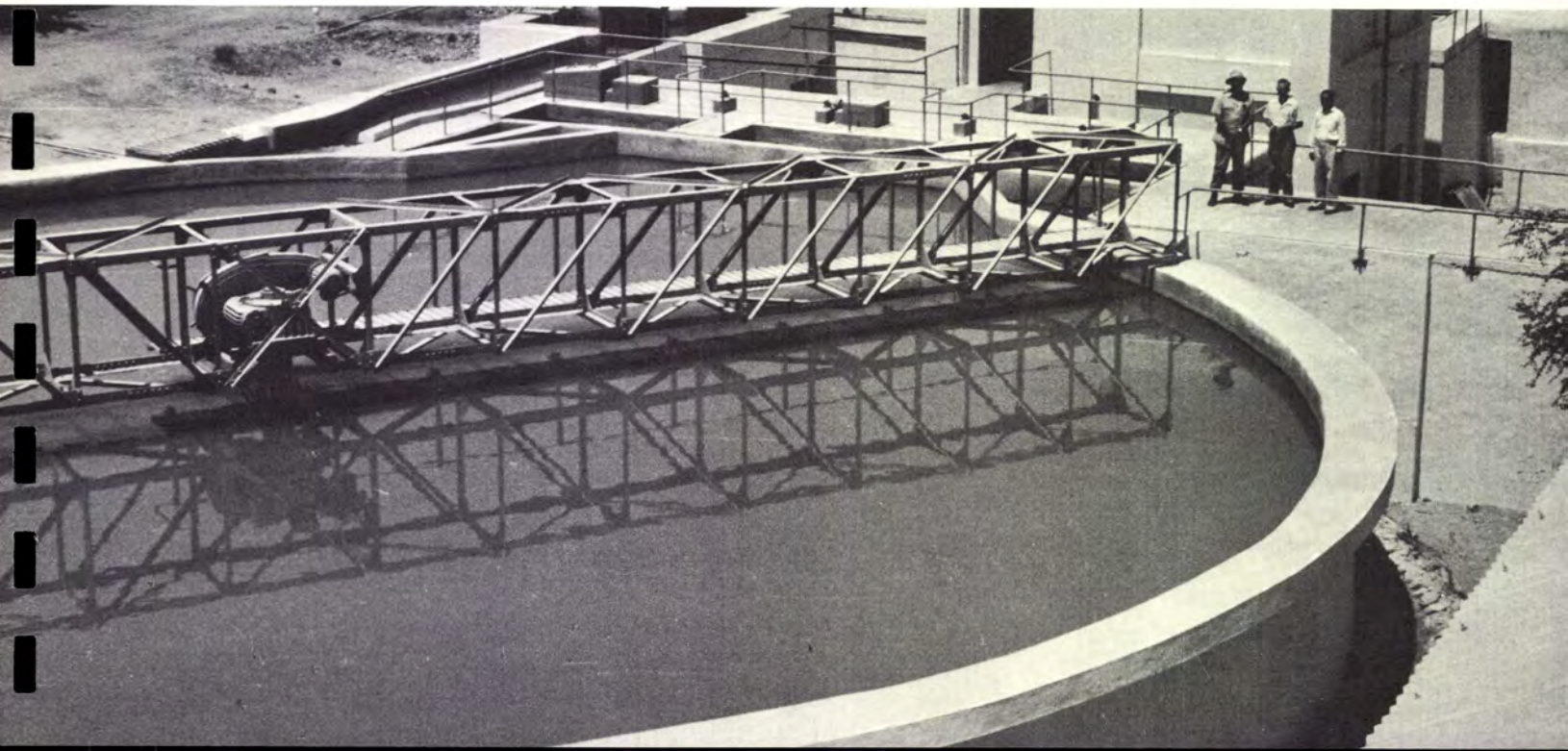
Mineral and Agricultural Resources Development

For the government of Iran, Parsons developed a complete agro-industrial complex of irrigated sugar cane plantations and processing facilities.

Water Development, Distribution, and Waste Treatment

A major Parsons activity is the development of water resources. Programs of exploration, drilling, equipment installation and the laying of distribution pipelines have been completed in vast areas of the Middle East and Asia.

Water and sewerage treatment plants are frequently provided as elements of larger projects.



We Invite Your Inquiry

Additional information on the qualifications of Parsons-Jurden and its staff, or more detailed description of the projects illustrated, will be gladly provided for you.

We would welcome the opportunity to serve you.

PARSONS-JURDEN CORPORATION
26 Broadway, New York, N.Y.

PARSONS-JURDEN

Engineers-Constructors

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EXPLORATION PROGRAM

JOSEPH MULLER CORPORATION ZURICH

ARAVAIPA PROJECT
PHASE II

PARSONS-JURDEN CORPORATION

A WHOLLY OWNED SUBSIDIARY OF THE RALPH M. PARSONS COMPANY
ENGINEERS-CONSTRUCTORS

PARSONS-JURDEN

NEW YORK

Copy No. 10

EXPLORATION PROGRAM

JOSEPH MULLER CORPORATION ZURICH

ARAVAIPA PROJECT
PHASE II

Job No. 4268-01

November 29, 1968

PARSONS-JURDEN CORPORATION

A WHOLLY OWNED SUBSIDIARY OF THE RALPH M. PARSONS COMPANY

ENGINEERS-CONSTRUCTORS

NEW YORK

AERIAL PHOTO OF NORTH AREA

AERIAL PHOTO OF SOUTH AREA

CONTENTS

SECTION		PAGE
1	INTRODUCTION	1-1
2	OBJECTIVE	2-1
	North Zone	2-2
	Recommendations North Zone	2-3
	South Zone	2-4
	Recommendations South Zone	2-5
3	PLAN OF APPROACH	3-1
4	DETAIL OF WORK	4-1
	North Zone Induced Polarization	4-1
	North Zone Geochemical Survey	4-1
	South Zone Induced Polarization	4-2
	South Zone Geochemical Survey	4-2
	South Zone Gravity Survey	4-3
5	RESULTS OF WORK	5-1
	North Zone Induced Polarization	5-1
	North Zone Geochemical Survey	5-1
	South Zone Induced Polarization	5-2
	South Zone Geochemical Survey	5-3
	South Zone Gravity Profile	5-3
6	CONCLUSIONS	6-1
	North Zone	6-1
	Figure 1 - North Zone	6-1a
	South Zone	6-2
	Figure 2 - South Zone	6-2a
7	RECOMMENDATIONS	7-1
	Target Area 1	7-1
	Target Area 2	7-2
	Target Area 3	7-3

SECTION		PAGE
8	ADDITIONAL LAND ACQUISITIONS	8-1
	Figure 3 - Revision of U.S.M.P. Corp. Property (OMITTED)	8-1a
APPENDIX	A - McPhar Geophysics Incorporated Reports	
	Induced Polarization and Resistivity Survey on the Grand Central, Tule and Grand Reef Grids	
	Additional Geophysical Investigations on the Grand Reef Grid	
	B - Geochemical Detail	

Parsons-Jurden Corporation

A SUBSIDIARY OF THE RALPH M. PARSONS COMPANY

26 BROADWAY, NEW YORK, N. Y. 10004

December 3, 1968

Mr. Joseph Muller
Joseph Muller Corporation Zurich
Scheuchzerstrasse 7
CH-0886
Zurich, SWITZERLAND

SUBJECT Joseph Muller - Aravaipa Project
Phase II Report
P-J Job Number 4268-1

Dear Mr. Muller:

We are pleased to submit our Phase II Report on the Aravaipa Project.

The Phase II exploration work was carried out in accordance with our Letter of Approval dated July 12, 1968, as a recommended followup of our original Reconnaissance Report.

In summary, results from work performed during Phase II have been sufficiently encouraging to enable us to recommend that three target areas be tested by drilling. The targets are as follows:

Target 1 is the broad Induced Polarization [I.P.] Anomaly, the edge of which is about one mile west of the Grand Reef mine. This I.P. Anomaly overlaps Magnetic Anomaly "H" and a common source is implied. The top of the source is interpreted as being in bedrock, and less than 1000 feet beneath the surface. We have recommended a minimum program of two 1000-foot holes to determine if the source is disseminated sulfide mineralization.

Target 2 is an I.P. Anomaly just west of the Grand Reef mine. The source is interpreted as being narrow and deep. We have recommended a 2000-foot hole to test this target. In the report we point out that the merits of this target should be re-evaluated after drilling results from Target 1 are available.

Target 3, lying within the outline of Magnetic Anomaly "P", will require a 2000-foot hole to test what we interpret as a favorable northeast structural trend. The factual support for this recommendation is perhaps not as compelling as that which we have for Target 1, and the element of risk is correspondingly greater.

The above targets are covered in detail in the following report.

Yours very truly,

PARSONS-JURDEN CORPORATION

Max J. Kennard
Vice-President

MJK/RS:mec

INTRODUCTION

The concept of exploration targets discussed in the following report was developed in the Parsons-Jurden Corporation report titled A Geologic Reconnaissance of the Aravaipa Mining District, Graham County, Arizona.

The reader is referred to the above for an understanding of the work which preceeded, and led to Phase II.

Appended to the Phase II Report are two reports from McPhar Geophysics Incorporated which should be referred to for a detailed description of the Induced Polarization work.

The appendix of the Phase II Report also contains data on the Geochemical Sampling work.

OBJECTIVE

The objective of the Phase II program was the carrying out of certain geologic and geophysical exploration work in target areas outlined in the Parsons-Jurden Corporation's report titled A Geologic Reconnaissance of the Aravaipa Mining District, Graham County, Arizona.

This latter report, submitted on May 3, 1968, described work performed for Joseph Muller Corporation Zurich under a letter of agreement dated November 21, 1967. Authorization to proceed with Phase II was received on July 12, 1968, and work was started at once.

It will be seen by comparing the following excerpt from the May 3 Report titled Conclusions and Recommendations, with the Plan of Approach for Phase II, that the latter does not follow the previous recommendations in exact detail. This does not reflect any change in thinking as to the merits of the targets, but was done instead to budget for those items which seemed to stand the best chance of answering certain basic geologic questions and thus providing immediately useful exploration results.

Section B of the May 3 Report titled Conclusions and Recommendations states as follows:

Geologic reconnaissance of the approximately 11,000-acre block of mineral property has pointed out two areas which have good exploration possibilities. These areas, referred to as the North Zone and the South Zone, are discussed below.

NORTH ZONE

This area is outlined by the northeast structural trend which takes in the Paleozoic limestone block in which the Iron Cap ore body occurs and extends into the Goodwin Canyon Quartz Monzonite. A hidden apophysis of intrusive is inferred to occur within this zone. Such an intrusive body would be an excellent exploration target. Evidence of this hidden intrusive includes the following:

1. The suggestion of a projection of Goodwin Canyon Quartz Monzonite at the northeast corner of the map area. This is along the general direction of schistosity and bedding in the Pinal Schist and would be a likely path for an intrusive to follow.

2. Tactite development in the limestone of this zone - while not intense - is somewhat more than can be accounted for by the known rhyolite and latite dikes.

3. The ore mineral showings require a source other than the rhyolite and latite dikes.

4. A dome-like structure is suggested by the scattered Paleozoic outcrops around a central outcrop of Pinal Schist. This doming could be the result of, or favorable to, the emplacement of an intrusive body.

5. Magnetic Anomaly "P" is interpreted as being due to a deep intrusive.

RECOMMENDATIONS - NORTH ZONE

An exploration program is recommended in the north zone. The target is a mineralized intrusive. Indications are that it is a deep target. A suggested program should include the following:

1. Detailed geologic mapping
2. Petrographic study - geochemical sampling
3. Geophysics

Such a program would narrow down the rather broad zone to one or two prime target areas and a diamond drilling program could then be proposed.

In view of the nature of the target, it will probably be possible to test it with a minimum program of three 2000-foot holes.

SOUTH ZONE

This zone is shown by the faults bounding the projecting arm of Santa Teresa Granite intruded between Precambrian Laurel Canyon Granodiorite on the north, and Precambrian Pinal Schist on the south. These faults strike northeast in the general direction of schistosity and bedding in the Pinal. There is a good possibility that the abrupt termination of the granite along the Grand Reef fault does not show the true extent of this projecting arm and that there are offshoots underlying the Horse Mountain Volcanics on the west [down-dropped] side of the Grand Reef fault.

The geologic evidence suggests that the stratigraphic throw on the Grand Reef fault is at least equal to the total thickness of Paleozoic strata, or something over 1000 feet. Paleozoic strata may underlie the Horse Mountain Volcanics on the west side of the fault. The combination of Paleozoic carbonate rocks and buried intrusive give this zone a good exploration potential.

Magnetic Anomalies "G" and "H" are reportedly due to polarization in Horse Mountain Volcanics, but it is suggested here that a buried skarn could be in part responsible.

RECOMMENDATIONS - SOUTH ZONE

An exploration program is recommended in the south zone whose target would be the Paleozoic carbonate rock-skarn section and related intrusive. Such a program should include the following:

1. Detailed geologic mapping
2. Geophysics

If the above provide some narrowing down of the zone to a reasonably well defined target area, it should be possible to test the target with one 2000-foot diamond drill hole.

PLAN OF APPROACH

It was decided that Induced Polarization [I.P.] surveys would provide the most ready means of finding the hidden intrusives postulated in the reconnaissance report. McPhar Geophysics Incorporated was retained to carry out the program of I.P. work. The I.P. geophysical method is generally accepted as being capable of detecting disseminated sulfide mineralization of the porphyry copper type. The theory behind the method and the mechanics of carrying out the survey are described in the appended McPhar reports. It should be pointed out that the I.P. method is not generally considered to be effective much beyond 1000 feet of depth. It was felt that even though the hidden intrusive might be as deep as 2000 feet, the expected halo of alteration and associated mineralization might extend upward into the effective depth of penetration of the survey.

A program of collecting rock-chip samples for geochemical determination of copper and molybdenum content was carried out in the two main areas of interest. Data from such a survey can be of value in defining zones and trends of dispersed mineralization, thus augmenting geologic interpretation. The sampling program was carried out under the direction of Dr. Charles L. Fair of Computec Research, Ltd., Tucson, Arizona.

Sample preparation and metal determinations were done by Rocky Mountain Geochemical Corporation of Tucson, Arizona.

Details of the geochemical work can be found in the Appendix.

DETAIL OF WORK

NORTH ZONE INDUCED POLARIZATION

Approximately 34 miles of Induced Polarization [I.P.] line was run in this area to test for a possible body of buried intrusive extending southwestward from the Goodwin Canyon Quartz Monzonite. The lines were run due east - west one-quarter mile apart, using Brunton compass and tape control. [An exception to the one-quarter mile line spacing was employed between L-5280S and L-8400S, in order to extend the budgeted I.P. coverage southward into the Tule Spring area.] A dipole spread of 1000 feet was used, in keeping with the idea that the target was located at a considerable depth.

NORTH ZONE GEOCHEMICAL SURVEY

A 2-square-mile area was sampled on a 500-foot grid system in this area. Rock-chip samples were taken uniformly within a 30-foot radius of each point indicated on the grid, in order to lessen the possibility of erratic high values which might occur with small samples. Soil-covered areas were not sampled. Samples were analyzed for copper and molybdenum. Copper was determined by atomic absorption and molybdenum was determined colorimetrically.

SOUTH ZONE INDUCED POLARIZATION

Approximately 19 line miles of Induced Polarization [I.P.] survey were run in this area: 16 line miles in the original survey, and approximately three line miles in a followup survey. As in the north area, a 1000-foot dipole spacing was used and the original lines were one-quarter mile apart and run in an east - west direction. After the completion of this work, one line was extended and closer dipole spreads and line spacing were used in the followup work in two anomalous areas. The target in the south area was an apophysis of porphyry and possible Paleozoic sedimentary rocks on the west side of the Grand Reef fault, west of the Grand Reef mine. This target was considered to lie at a considerable depth.

SOUTH ZONE GEOCHEMICAL SURVEY

An area of approximately three-quarters of a square mile was sampled on a 500-foot grid. Rock-chip samples were collected and copper and molybdenum determinations made as described for the north area. The limited area of rock outcrop compared to alluvium in the south area of interest did not lend itself to establishing definite trends, but it was felt that the data could be meaningful.

SOUTH ZONE GRAVITY SURVEY

The initial Induced Polarization [I.P.] coverage of the south area was followed by a recommendation that an east - west gravity profile be run across the broad probable I.P. anomaly west of the Grand Reef mine. The purpose of the gravity survey was to determine the approximate thickness of alluvium as an aid to interpretation of the I.P. results.

RESULTS OF WORK

NORTH ZONE INDUCED POLARIZATION

(Refer to McPhar Report on Grand Central, Tule Grids)

Induced Polarization [I.P.] results in this area do not seem to show any indication of the inferred apophysis of mineralized intrusive. The minor I.P. affects which seem to be related to narrow near-surface sources were anticipated and are not considered to be of interest at this point.

The effective depth factor of this I.P. work must be assumed to be no greater than the electrode interval of 1000 feet.

NORTH ZONE GEOCHEMICAL SURVEY

Results of the rock-chip geochemical sampling in this area show a concentration of copper values within the Pinal Schist along the northern margin of the Tule - Copper Bar block of Paleozoic rocks. Several nearby copper prospects occur near the Bolsa - Pinal contact, but copper showings in the Pinal itself are less common.

The large block of Paleozoic rocks of the Iron Cap area with its numerous patches of tactite shows relatively low copper values. An exception is the Lead Saddle area [NE Cor. Sec. 30], again near the Bolsa - Pinal contact.

Between the Paleozoic block of the Iron Cap and that of the Tule - Copper Bar is a small copper anomaly in Pinal Schist. Overlapping the copper anomaly is a molybdenum anomaly which trends toward the southwest, then turns and parallels the copper anomaly at the north margin of the Tule - Copper Bar block. This molybdenum anomaly is roughly shaped like the letter "C" - with the open part to the east. Related to the geology, this "C" shaped anomaly roughly defines the Pinal Schist block of the Tule Canyon area.

SOUTH ZONE INDUCED POLARIZATION

(Refer to McPhar Report on Grand Reef Grid)

Results of the Induced Polarization [I.P.] survey indicate a broad probable I.P. anomaly with a north - south trend, beginning approximately one mile west of the Grand Reef mine. The anomalous situation was detected on all east - west lines from L-31200S through L-36400S, giving an indicated north - south length of one mile. L-33800S, which appears to define the western limits of the anomalous area, indicates an east - west dimension of possibly one mile. The source of the anomaly is considered to be shallow, relative to the 1000-foot electrode spread.

A second probable I.P. anomaly was detected approximately 1500-feet southwest of the Grand Reef mine. The source of this anomaly is considered to be narrow, and deep, relative to the 1000-foot electrode spread.

SOUTH ZONE GEOCHEMICAL SURVEY

The area sampled was rather small and no anomalous trends can be detected. Higher copper values do show up in the zone of metamorphic rock between Santa Teresa Granite and the Grand Reef structure. Also, based on the limited data, it appears that both copper and molybdenum values are higher in Santa Teresa Granite than in Horse Mountain Volcanics, in the area sampled.

SOUTH ZONE GRAVITY PROFILE

A gravity profile was run along L-33800S to help in interpreting the I.P. anomaly described previously. The results indicate an alluvial cover of only 400 or 500 feet over the I.P. anomaly and thus indicate a bedrock source for the I.P. effect.

CONCLUSIONS

NORTH ZONE

Results of the Induced Polarization [I.P.] coverage do not seem to show any evidence of the postulated intrusive through the effective depth of coverage which is estimated to be approximately 1000 feet.

Possible significance should be attached to the fact that a large area of Pinal Schist between the Iron Cap and Tule - Copper Bar blocks contains anomalous copper and molybdenum trends. [The question arises as to what constitutes background copper or molybdenum values. It would seem that any given district must be considered as a separate case. In the areas covered by our present work in the Aravaipa District we consider copper values above 50 parts per million and molybdenum values above five parts per million to be anomalous.]

An inferred regional structure whose topographic expression is Tule Canyon cuts through the copper - molybdenum anomaly area, continuing northeastward into Goodwin Canyon Quartz Monzonite.

A third factor to be considered in this area is Magnetic Anomaly "P" [see Figure 1].

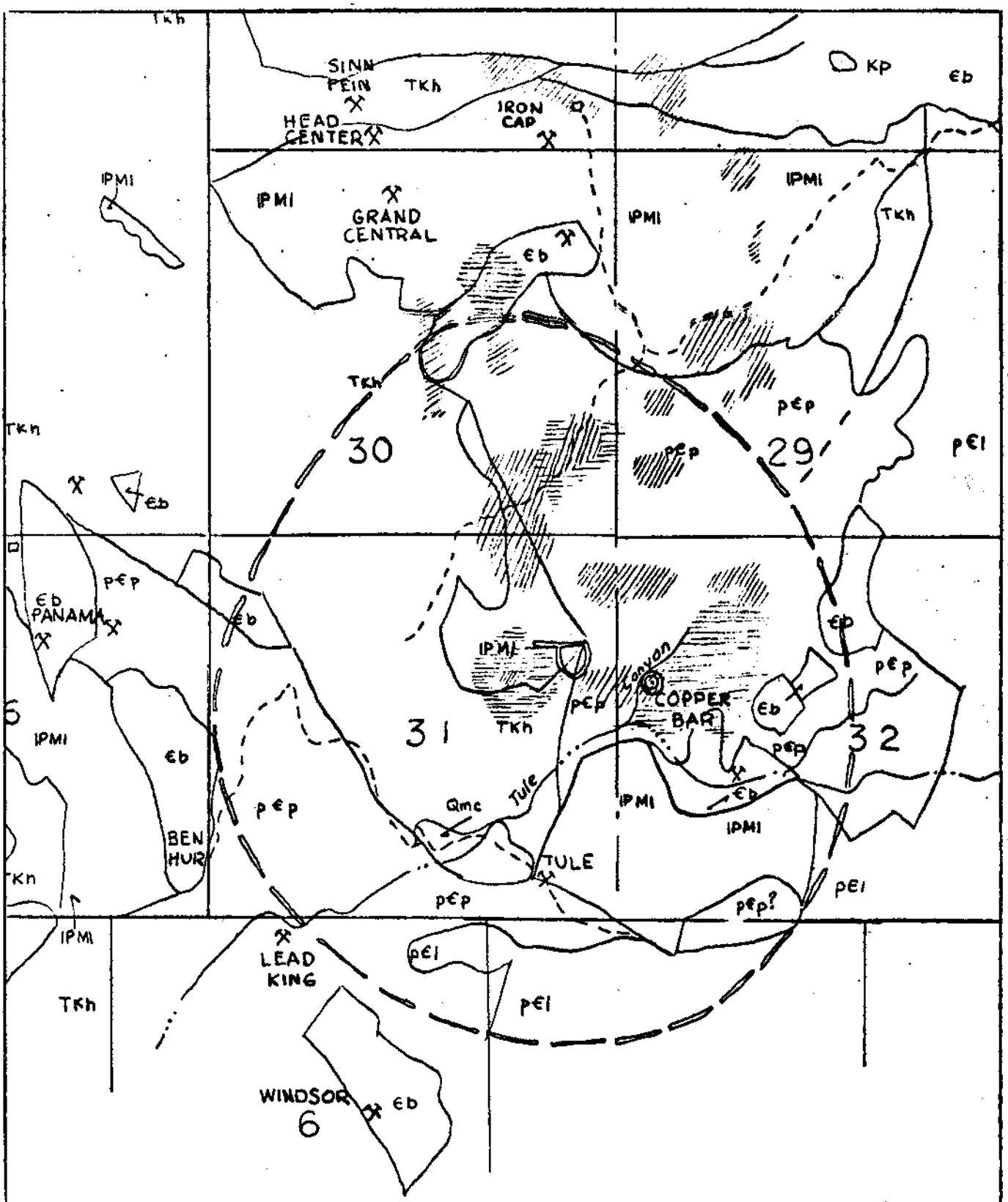

FIGURE 1.- NORTH ZONE

MAGNETIC HIGH 'P'

COPPER +50 PPM MOLYBDENUM +6PPM

PROPOSED DRILL HOLE

The source of this magnetic anomaly is interpreted as being possibly 2000 feet in depth and was one of the features considered in the original postulation of a hidden intrusive.

In view of the foregoing, and despite the lack of favorable I.P. results, the area at depth beneath Magnetic Anomaly "P" represents a favorable drilling target.

SOUTH ZONE

The source of the broad probable I.P. anomaly lying approximately one mile west of the Grand Reef mine is - according to Dr. R. A. Bell of McPhar Geophysics Incorporated - "a large volume of weak metallic mineralization in the bedrock."

To put this in perspective, it should be pointed out that this anomaly, although large in areal extent, is a rather weak one. Apparent I.P. effects of this magnitude could originate in a thick layer of conductive alluvium. The gravity profile, however, indicates an alluvial cover of no more than 500 feet and suggests that the source of the I.P. effect is in the bedrock.

A second possible cause of I.P. effects of this magnitude could conceivably be inductive coupling. The usual method of determining the effects, if any, of inductive coupling is to check a number of stations with low frequency: i.e., at 0.125 and 1.25 cycles per second, instead of the regular frequencies [used in this survey] of 0.31 and 2.5 cycles per second. This check was attempted but was inconclusive because of the volume of noise encountered. Such noise might originate from telluric currents or from a massive sulfide conductor - but the latter would not be suspected in this case.

Analyzing this broad I.P. effect in relation to the geology, it would seem that the source [if it is in bedrock] would most likely be in Tertiary volcanic rocks. This follows from the assumption that the down-drop on the west side of the Grand Reef fault is something like 1000 feet - which should put any possible Paleozoic strata considerably beneath the estimated source of the anomaly.

There is a general coincidence of this broad, weak I.P. anomaly with Magnetic Anomaly "H" which was interpreted as being rather shallow and due to polarization in the volcanics. [See Figure 2.] These features do not necessarily reinforce the thesis developed in the Reconnaissance Report for this area, mainly because of the indicated shallow source for both the I.P. and magnetic anomaly.

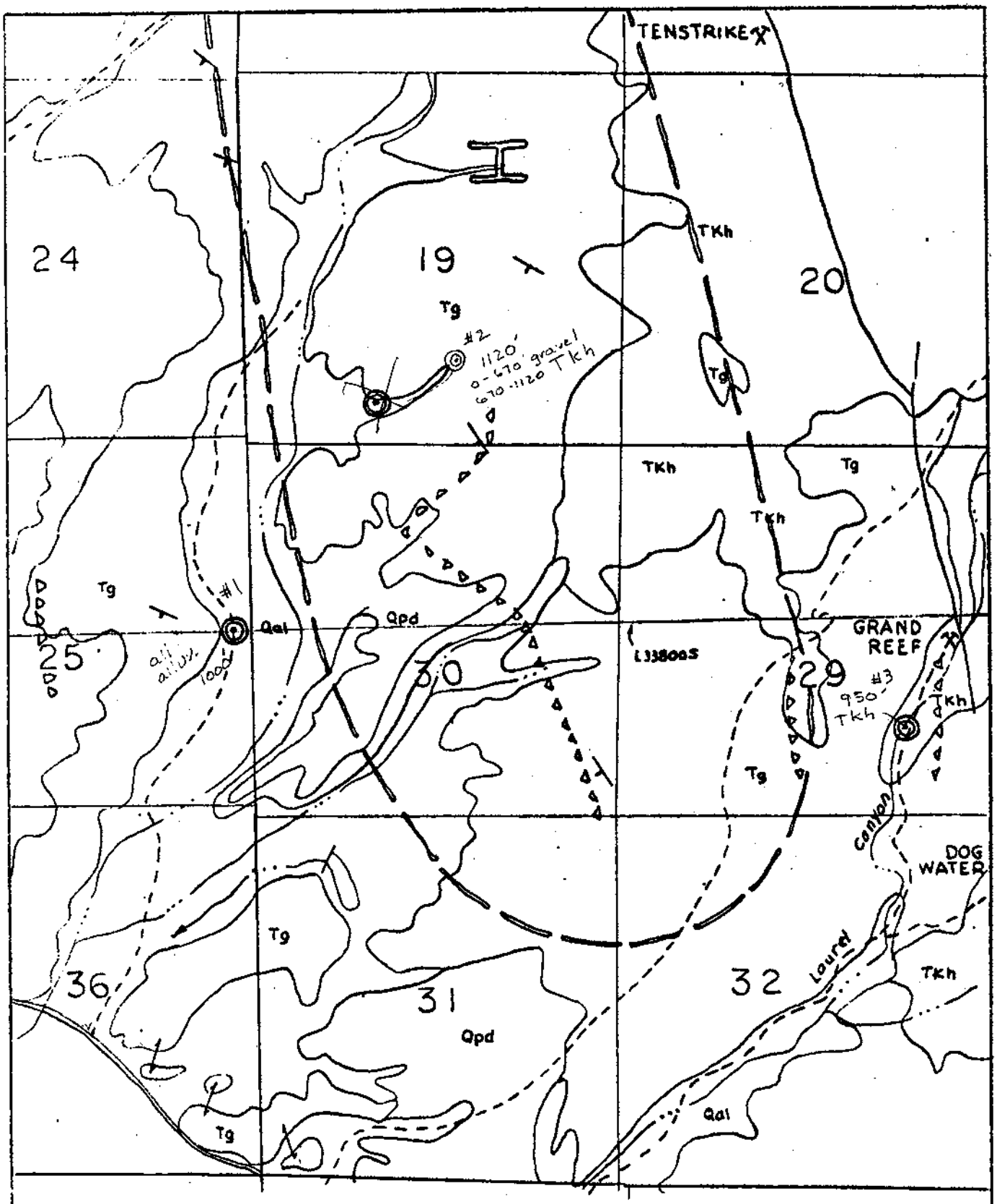

FIGURE 2 - SOUTH ZONE

MAGNETIC HIGH - 'H'

INDUCED POLARIZATION ANOMALY

PROPOSED DRILL HOLE

Despite the somewhat ambiguous nature of the I.P. anomaly, it is of sufficient interest to merit testing of the source of drilling.

The second probable I.P. anomaly, located about 1500 feet southwest of the Grand Reef mine, is smaller in areal extent but with about the same magnitude of I.P. effect as for the anomaly discussed above. The source is considered to be deep with respect to the electrode spacing, or something greater than 1000 feet. The data suggests a narrow, deep source with some minor effects reaching to near surface. Again, the probable host rock would seem to be Tertiary volcanics. Based on the known ore occurrences in the area, this source might be a Grand Reef type vein-like ore shoot.

Another possibility which should be given some consideration is that the deep narrow source could be related to the top of the inferred mineralized intrusive.

RECOMMENDATIONS

Based on the foregoing, drill testing of target areas is recommended in the following order of priority:

1. The broad I.P. anomaly whose eastern edge is approximately one mile west of the Grand Reef mine.

2. The smaller I.P. anomaly located approximately 1500 feet southwest of the Grand Reef mine.

3. The area of Magnetic Anomaly "P".

TARGET AREA 1

This broad zone should be tested by a minimum of two holes drilled to at least 1000 feet of depth. Proposed hole locations are shown on Figure 2 which can be related to the areal geologic map. Both locations are well within the eastern boundary of the I.P. anomaly. The southernmost hole is off the west edge of Magnetic Anomaly "H" - while the hole to the north is located on Magnetic Anomaly "H". The locations are situated in areas where a minimum of drill site preparations will be necessary.

It is recommended that a rotary drill rig be used to penetrate the alluvial section to bedrock. The predicted depth of alluvium is something less than

500 feet. It should be possible to rotary drill the alluvial section with air. Cuttings should be collected and examined at 5-foot intervals. If water is encountered within the alluvial section so that it is necessary to drill with mud, the same procedure should be followed with cuttings from the mud trough. The bedrock section should be diamond drilled [NX core size] with a rig capable of coring to beyond 2000 feet of depth, in the event that early coring results indicate that deeper penetration is necessary.

TARGET AREA 2

This target should be tested with a minimum of one hole drilled to a depth of at least 2000 feet. The proposed location shown on Figure 2 places the hole slightly to the east of the center of the anomaly. The choice of this location was influenced in part by the topography. To move the hole farther west to the exact center of the I.P. anomaly would require considerable road construction in Gila Conglomerate. It seems doubtful that the added expense would be warranted.

This hole will collar in Horse Mountain [Tertiary] volcanics. It should be diamond drilled [NX core size] all the way, and a drill rig capable of drilling in excess of 2000 feet should be used.

TARGET AREA 3

The target outlined by Magnetic Anomaly "P" seems, at this point, to have less merit than Target 1. However, in the event that drilling results on Target 1 are negative, a case could be made for testing Target 3 rather than Target 2. The reason for this is that Targets 1 and 2 are in a similar environment, while Target 3 - approximately five miles to the north - derives its drilling potential from a completely different set of geologic circumstances.

It is recommended that a minimum of one hole, drilled to a depth of at least 2000 feet, be drilled to test Target Area 3. The hole location, as shown on Figure 1, is near the center of the magnetic anomaly and within the copper - molybdenum geochemical trend.

The hole will collar in Pinal Schist and should be diamond drilled with NX coring tools as described for the previous holes.

APPENDIX A

McPHAR GEOPHYSICS INCORPORATED REPORTS

PARSONS

APPENDIX A

McPHAR GEOPHYSICS INCORPORATED REPORTS

PARSONS

REPORT ON
INDUCED POLARIZATION
AND RESISTIVITY SURVEY
ON THE
GRAND CENTRAL,
TULE AND GRAND REEF GRIDS
MUELLER PROJECT, GRAHAM CO., ARIZONA
FOR
THE RALPH M. PARSONS COMPANY

McPHAR GEOPHYSICS

NOTES ON THE THEORY, METHOD OF FIELD OPERATION, AND PRESENTATION OF DATA FOR THE INDUCED POLARIZATION METHOD

Induced Polarization as a geophysical measurement refers to the blocking action or polarization of metallic or electronic conductors in a medium of ionic solution conduction.

This electro-chemical phenomenon occurs wherever electrical current is passed through an area which contains metallic minerals such as base metal sulphides. Normally, when current is passed through the ground, as in resistivity measurements, all of the conduction takes place through ions present in the water content of the rock, or soil, i.e. by ionic conduction. This is because almost all minerals have a much higher specific resistivity than ground water. The group of minerals commonly described as "metallic", however, have specific resistivities much lower than ground waters. The induced polarization effect takes place at those interfaces where the mode of conduction changes from ionic in the solutions filling the interstices of the rock to electronic in the metallic minerals present

in the rock.

The blocking action or induced polarization mentioned above, which depends upon the chemical energies necessary to allow the ions to give up or receive electrons from the metallic surface, increases with the time that a d. c. current is allowed to flow through the rock; i. e. as ions pile up against the metallic interface the resistance to current flow increases. Eventually, there is enough polarization in the form of excess ions at the interfaces, to appreciably reduce the amount of current flow through the metallic particle. This polarization takes place at each of the infinite number of solution-metal interfaces in a mineralized rock.

When the d. c. voltage used to create this d. c. current flow is cut off, the Coulomb forces between the charged ions forming the polarization cause them to return to their normal position. This movement of charge creates a small current flow which can be measured on the surface of the ground as a decaying potential difference.

From an alternate viewpoint it can be seen that if the direction of the current through the system is reversed repeatedly before the polarization occurs, the effective resistivity of the system as a whole will change as the frequency of the switching is changed. This is a consequence of the fact that the amount of current flowing through each metallic interface depends upon the length of time that current has been passing through it in one direction.

The values of the per cent frequency effect or F. E. are a measurement of the polarization in the rock mass. However, since the measurement of the degree of polarization is related to the apparent resistivity of the rock mass it is found that the metal factor values or M. F. are the most useful values in determining the amount of polarization present in the rock mass. The MF values are obtained by normalizing the F. E. values for varying resistivities.

The induced polarization measurement is perhaps the most powerful geophysical method for the direct detection of metallic sulphide mineralization, even when this mineralization is of very low concentration. The lower limit of volume per cent sulphide necessary to produce a recognizable IP anomaly will vary with the geometry and geologic environment of the source, and the method of executing the survey. However, sulphide mineralization of less than one per cent by volume has been detected by the IP method under proper geological conditions.

The greatest application of the IP method has been in the search for disseminated metallic sulphides of less than 20% by volume. However, it has also been used successfully in the search for massive sulphides in situations where, due to source geometry, depth of source, or low resistivity of surface layer, the EM method can not be successfully applied. The ability to differentiate ionic conductors, such as water filled shear zones, makes the IP method a useful tool in checking EM

anomalies which are suspected of being due to these causes.

In normal field applications the IP method does not differentiate between the economically important metallic minerals such as chalcopyrite, chalcocite, molybdenite, galena, etc., and the other metallic minerals such as pyrite. The induced polarization effect is due to the total of all electronic conducting minerals in the rock mass. Other electronic conducting materials which can produce an IP response are magnetite, pyrolusite, graphite, and some forms of hematite.

In the field procedure, measurements on the surface are made in a way that allows the effects of lateral changes in the properties of the ground to be separated from the effects of vertical changes in the properties. Current is applied to the ground at two points in distance (X) apart. The potentials are measured at two other points (X) feet apart, in line with the current electrodes is an integer number (n) times the basic distance (X).

The measurements are made along a surveyed line, with a constant distance (nX) between the nearest current and potential electrodes. In most surveys, several traverses are made with various values of (n); i.e. (n) = 1, 2, 3, 4, etc. The kind of survey required (detailed or reconnaissance) decides the number of values of (n) used.

In plotting the results, the values of the apparent resistivity, apparent per cent frequency effect, and the apparent metal factor

measured for each set of electrode positions are plotted at the intersection of grid lines, one from the center point of the current electrodes and the other from the center point of the potential electrodes. (See Figure A.) The resistivity values are plotted above the line as a mirror image of the metal factor values below. On a second line, below the metal factor values, are plotted the values of the per cent frequency effect. In some cases the values of per cent frequency effect are plotted as superscripts of the metal factor value. In this second case the frequency effect values are not contoured. The lateral displacement of a given value is determined by the location along the survey line of the center point between the current and potential electrodes. The distance of the value from the line is determined by the distance (nX) between the current and potential electrodes when the measurement was made.

The separation between sender and receiver electrodes is only one factor which determines the depth to which the ground is being sampled in any particular measurement. The plots then, when contoured, are not section maps of the electrical properties of the ground under the survey line. The interpretation of the results from any given survey must be carried out using the combined experience gained from field results, model study results and theoretical investigations. The position of the electrodes when anomalous values are measured is important in the interpretation.

In the field procedure, the interval over which the potential differences are measured is the same as the interval over which the electrodes are moved after a series of potential readings has been made. One of the advantages of the induced polarization method is that the same equipment can be used for both detailed and reconnaissance surveys merely by changing the distance (X) over which the electrodes are moved each time. In the past, intervals have been used ranging from 25 feet to 2000 feet for (X). In each case, the decision as to the distance (X) and the values of (n) to be used is largely determined by the expected size of the mineral deposit being sought, the size of the expected anomaly and the speed with which it is desired to progress.

The diagram in Figure A demonstrates the method used in plotting the results. Each value of the apparent resistivity, apparent metal factor, and apparent per cent frequency effect is plotted and identified by the position of the four electrodes when the measurement was made. It can be seen that the values measured for the larger values of (n) are plotted farther from the line indicating that the thickness of the layer of the earth that is being tested is greater than for the smaller values of (n); i. e. the depth of the measurement is increased. When the F. E. values are plotted as superscripts to the MF values the third section of data values is not presented and the F. E. values are not contoured.

METHOD USED IN PLOTTING DIPOLE-DIPOLE INDUCED POLARIZATION AND RESISTIVITY RESULTS

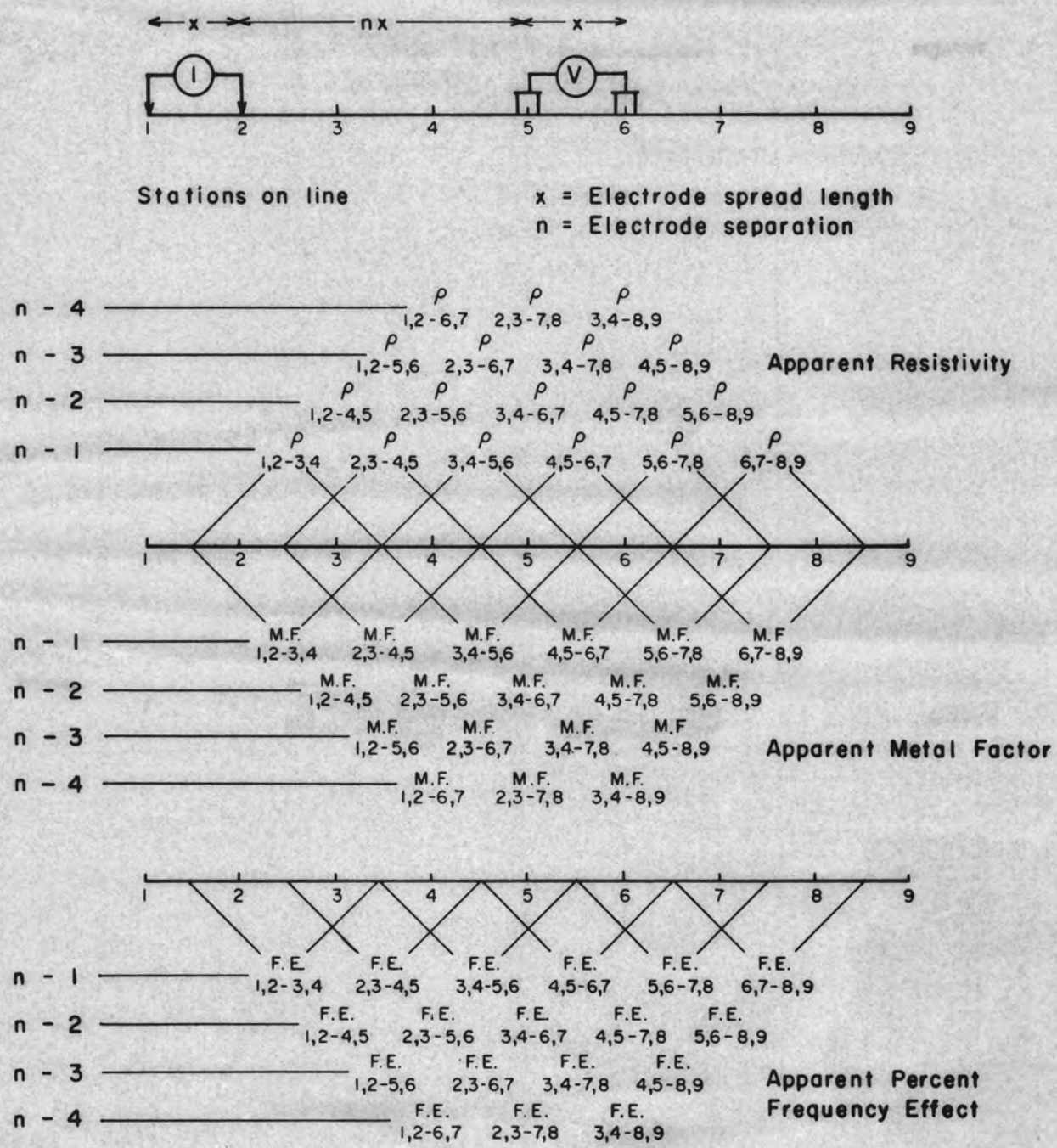

Fig. A

McPHAR GEOPHYSICS

REPORT ON INDUCED POLARIZATION AND RESISTIVITY SURVEY ON THE GRAND CENTRAL, TULE AND GRAND REEF GRIDS MUELLER PROJECT, GRAHAM CO., ARIZONA FOR THE RALPH M. PARSONS COMPANY

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1. INTRODUCTION

At the request of the Ralph M. Parsons Company, reconnaissance induced polarization and resistivity surveys have been carried out on the Mueller Project in Graham County, Arizona. The Project area is situated midway between Florence and Safford, about 100 miles SSE from Phoenix.

Geological maps supplied by the Ralph M. Parsons Company indicate a complex geological history. Generally, the eastern part of the area is underlain by Precambrian granite and schist, with small sections of Paleozoic sediments and larger areas of Tertiary extrusives and intrusives. The western and northwestern sections are covered by an unknown thickness of Tertiary and Quaternary continental clastic sediments. Apparently a major fault or fault zone trends NNW through the Project area, separating the older formations to the east from the younger sediments to the west. There is some indication from local wells that the throw on this fault may be relatively minor and therefore the sediments may be thin.

The region has undergone intensive folding, faulting and fracturing and contains several copper occurrences. These conditions are frequently indicative of a favourable locus for "porphyry copper" type mineralization and hence the area is of considerable interest.

Parts of three grids were surveyed, identified as the Grand Central, Tule and Grand Reef. Lines were run east-west at quarter mile spacings using 1,000 foot electrode intervals, to search for any large disseminated sulphide deposits that might be present.

2. PRESENTATION OF RESULTS

The Induced Polarization and Resistivity results are shown on the following data plots in the manner described in the notes preceding this report.

A) Grand Central Grid

Line 1320N	1,000 foot spreads	Dwg. IP 5164-1
Line 0	1,000 foot spreads	Dwg. IP 5164-2
Line 1320S	1,000 foot spreads	Dwg. IP 5164-3
Line 2640S	1,000 foot spreads	Dwg. IP 5164-4
Line 3960S	1,000 foot spreads	Dwg. IP 5164-5
Line 5280S	1,000 foot spreads	Dwg. IP 5164-6

B) Tule Grid

Line 8400S	1,000 foot spreads	Dwg. IP 5166-1
Line 9700S	1,000 foot spreads	Dwg. IP 5166-2
Line 11,000S	1,000 foot spreads	Dwg. IP 5166-3

C) Grand Reef Grid

Line 31,200S	1,000 foot spreads	Dwg. IP 5165-1
Line 32,500S	1,000 foot spreads	Dwg. IP 5165-2
Line 33,800S	1,000 foot spreads	Dwg. IP 5165-3
Line 35,100S	1,000 foot spreads	Dwg. IP 5165-4
Line 36,400S	1,000 foot spreads	Dwg. IP 5165-5

Enclosed with this report are Dwgs. I.P.P. 4440 and 4441 plan maps of the grids at a scale of 1" = 1,000' showing the geophysical results in relation to the geology, as provided by the Company. The definite and possible induced polarization anomalies are indicated by solid and broken bars respectively on this plan map as well as the data plots. These bars represent the surface projection of the anomalous zones as interpreted from the location of the transmitter and receiver electrodes when the anomalous values were measured.

Since the induced polarization measurement is essentially an averaging process, as are all potential methods, it is frequently difficult to exactly pinpoint the source of an anomaly. Certainly, no anomaly can be located with more accuracy than the spread length; i.e. when using 1,000' spreads the position of a narrow sulphide body can only be determined to lie between two stations 1,000' apart. In order to locate sources at some depth, larger spreads must be used, with a corresponding increase in the uncertainties of location. Therefore, while the centre of the indicated anomaly probably corresponds fairly well with source, the length of the indicated anomaly along the line should not be taken to represent the exact edges of the anomalous material.

3. DISCUSSION OF RESULTS

A) Grand Central Grid

Line 1320N

The results from this traverse indicate a possible weak anomaly extending from about station 65E to station 90E. The source is shallow relative to the electrode interval (i.e. less than 1,000 feet deep) and must contain only a minor amount of metallic mineralization.

There is also a possible shallow narrow feature between 10W and 20W.

Line 0

Here there is a possible anomaly centred at about station 60E, immediately east of the Iron Cap prospect, that probably correlates with the anomaly on Line 1320N.

Line 1320S

A possible shallow weak source is indicated at 10W to 20W. Minor increases in the Metal Factor values occur elsewhere on the traverse but they do not seem to be important.

Line 2640S

Possible anomalies occur at the east and west ends of these lines but the contour patterns are incomplete. The western anomaly may correlate with the series of prospects between Line 2640S and Line 3960S and therefore it may be advisable to extend the traverse to the west in order to complete the anomaly.

Line 3960S

A possible weak source is present on the east part of this line, comparable to the feature on Line 2640S.

B) Tule Grid

Line 5280S

On this line there is a possible, but incomplete, anomaly at 30W to 50W.

Line 8400S

Possible shallow weak features occur at 10E to 20E and 80E to 90E; the latter may be related to the Copper Bar prospect.

Line 9700S

Weak features are present at 20E to 30E and 40E to 50E, the latter correlating with the Tule Prospect. These appear to represent shallow, narrow sources and could be better evaluated by detailing with shorter electrode intervals, as described in the Appendix following this report.

Line 11,000S

Minor increases in the Metal Factor values were measured on the western part of this line but the patterns are not definite enough to be considered anomalous.

C) Grand Reef Grid

Line 31,200S

A possible weak source, with some depth to the top, is indicated

from 100E to 120E.

The entire western part of the traverse is anomalous from about station 40E. The section between 20E and 30W contains the highest Metal Factor values encountered so far in this area and the anomaly is still open to the west. This area is mapped as Quaternary and Tertiary gravels and alluvium.

Line 32, 500S

Similar results were obtained on the western part of this traverse but the anomaly is stronger, especially the section from 15W to 15E.

Line 33, 800S

Again there is a probable anomaly on the west part of the line but the data does not extend far enough to complete the pattern. In addition there is a possible narrow feature at 70E to 80E.

Line 35, 100S

The western zone is still present but again is incomplete. There is also a moderate magnitude anomaly centred at 80E, correlating with weaker anomalies on the two adjacent lines. This is one of the most definite features encountered during the survey and appears to represent a relatively narrow concentrated source. If the geological data indicates that this type of source could be of interest, then further work should be carried out. First the anomaly should be detailed with shorter electrode intervals, as described in the Appendix on Narrow Sources, and then intermediate lines should be surveyed to determine the optimum location for a drill test.

Line 36,400S

As on the three preceding traverses, the western anomaly is present but incomplete. A possible anomaly occurs at 80E but it is not as strong or definite as on Line 35,100S.

4. SUMMARY AND RECOMMENDATIONS

No strong or definite anomalies were found on the Grand Central and Tule Grids. Weak IP effects were encountered on every traverse and these are shown as possible anomalies on the data plots and plan map. These features are of two types: 1) broad zones suggesting areas of sparsely dispersed metallic mineralization; and 2) relatively narrow sources, possibly concentrated. Anomalies of the first type are too weak to be of immediate interest. The second type may be of interest but require detailing with shorter electrode intervals in order to evaluate them more completely. This would not be warranted unless the geology indicates that vein or replacement type deposits of economic interest may be present.

Stronger and more definite anomalies were located on the Grand Reef Grid and these can be correlated into continuous zones. Broad anomalies of moderate magnitude occur on the west part of all five lines, suggesting an extensive zone of disseminated mineralization. The zone is open to the north, west and east hence the grid should be extended to delimit this feature. It is recommended that Line 33,800S be extended to the west using 1,000 foot dipoles, to complete the pattern from the anomaly. A check should then be carried out at low frequencies (i.e. 0.1 and 1.25 cps) to ascertain the effects, if any, due to inductive coupling.

It would also be advisable to run a gravity profile across this part of the grid in order to estimate the thickness of the clastics. This profile should be run on Line 33,800S from station 13E to station 10W, with observations every 500 feet.

The anomalies centred at 80E on the three southern traverses suggest a narrow, more concentrated, source. This should be evaluated by detailing with shorter electrode intervals (i.e. 750 foot and perhaps 500 foot) and if confirmed then parallel lines should be run, say 500 and 1,000 feet to the north and south of Line 35,100S.

On completion of this additional work, the results would be re-evaluated and a drill test planned if so warranted.

McPHAR GEOPHYSICS INCORPORATED

Robert A. Bell.

Robert A. Bell,
Geologist.

Philip G. Hallof

Philip G. Hallof,
Geophysicist.

Dated: September 30, 1968

APPENDIX

THE INTERPRETATION OF INDUCED POLARIZATION ANOMALIES FROM RELATIVELY SMALL SOURCES

The induced polarization method was originally developed to detect disseminated sulphides and has proven to be very successful in the search for "porphyry copper" deposits. In recent years we have found that the IP method can also be very useful in exploring for more concentrated deposits of limited size. This type of source gives sharp IP anomalies that are often difficult to interpret.

The anomalous patterns that develop on the contoured data plots will depend on the size, depth and position of the source and the relative size of the electrode interval. The data plots are not sections showing the electrical parameters of the ground. When the electrode interval (X) is appreciably greater than the width of the source, a large volume of unmineralized rock is averaged into each measurement. This is particularly true for the large values of the electrode separation (n).

The theoretical scale model results shown in Figure 1 and Figure 2 indicate the effect of depth. If the depth to the top of the source is small compared to the electrode interval (i. e. d X) the measurement for n = 1 will be anomalous. In Figure 1 the depth is 0. 5 units (X = 1. 0 units) and the n = 1 value is definitely anomalous; the pattern on the contoured data plot is typical for a relatively shallow, narrow, near-vertical tabular source. The results in Figure 2 are for the same source with the depth increased to 1. 5 units. Here the n = 1 value is not anomalous; the larger values of (n) are anomalous but the magnitudes are much lower than for the source at less depth.

When the electrode interval is greater than the width of the source, it is not possible to determine its width or exact position between the electrodes. The true IP effect within the source is also indeterminate; the anomaly from a very narrow source with a very large true IP effect will be much the same as that from a zone with twice the width and 1/2 the true IP effect. The theoretical scale model data shown in Figure 3 and Figure 4 demonstrate this problem. The depth and position of the source are unchanged but the width and true IP effect are varied. The anomalous patterns and magnitudes are essentially the same, hence the data are insufficient to evaluate the source completely.

The normal practise is to indicate the IP anomalies by solid, broken, or dashed bars, depending upon their degree of distinctiveness. These bars represent the surface projection of the anomalous zones as interpreted from the location of the transmitter and receiver electrodes

when the anomalous values were measured. As illustrated in Figure 1, Figure 2, Figure 3 and Figure 4, no anomaly can be located with more accuracy than the spread length. While the centre of the solid bar indicating the anomaly corresponds fairly well with the source, the length of the bar should not be taken to represent the exact edges of the anomalous material.

If the source is shallow, the anomaly can be better evaluated using a shorter electrode interval. When the electrode interval used approaches the width of the source, the apparent effects measured will be nearly equal to the true effects within the source. When there is some depth to the top of the source, it is not possible to use electrode intervals that are much less than the depth to the source. In this situation, one must realize that a definite ambiguity exists regarding the width of the source and the IP effect within the source.

Our experience has confirmed the desirability of doing detail. When a reconnaissance IP survey using a relatively large electrode interval indicates the presence of a narrow, shallow source, detail with shorter electrode intervals is necessary in order to better locate, and evaluate, the source. The data of most usefulness is obtained when the maximum apparent IP effect is measured for n = 2 or n = 3. For instance, an anomaly originally located using X = 300' may be checked with X = 200' and then X = 100'. The data with X = 100' will be quite different from the original reconnaissance results with X = 300'.

The data shown in Figure 5 and Figure 6 are field results from a greenstone area in Quebec. The expected sources were narrow (less than 30' in width) zones of massive, high-grade, zinc-silver ore. An electrode interval of 200' was used for the reconnaissance survey in order to keep the rate of progress at an acceptable level. The anomalies located were low in magnitude.

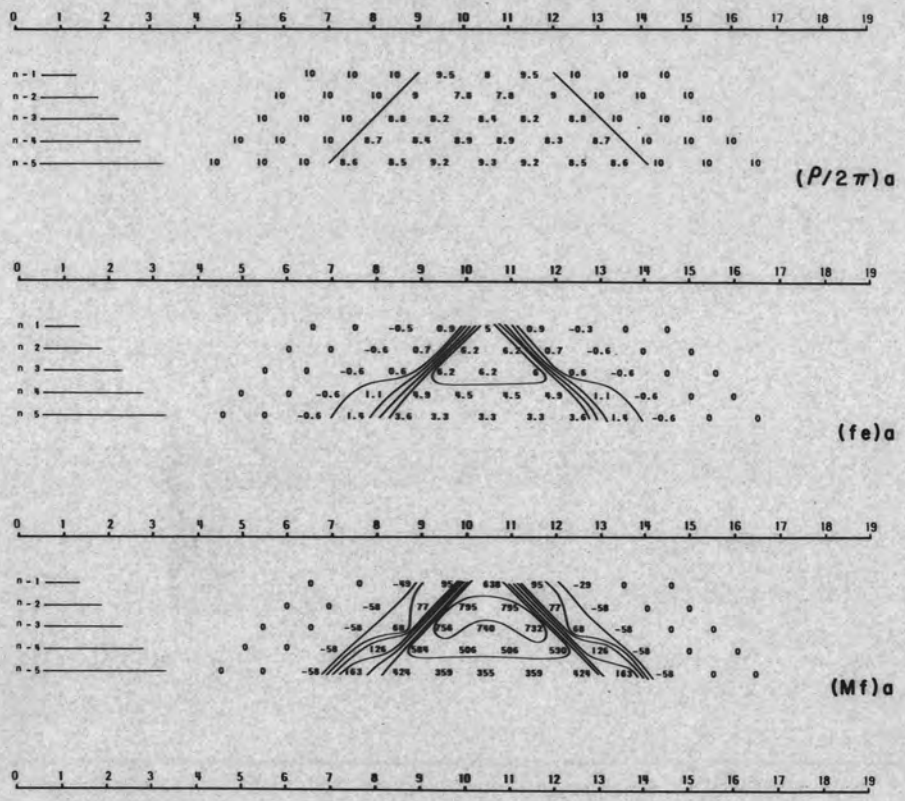
The very weak, shallow anomaly shown in Figure 5 is typical of those located by the X = 200' reconnaissance survey. Several anomalies of this type were detailed using shorter electrode intervals. In most cases the detail measurements suggested broad zones of very weak mineralization. However, in the case of the source at 20N to 22N, the measurements with shorter electrode intervals confirmed the presence of a strong, narrow source. The X = 50' results are shown in Figure 6. Subsequent drilling has shown the source to be 12.5' of massive sulphide mineralization containing significant zinc and silver values.

The change in the anomaly that results when the electrode interval is reduced is not unusual. The X = 50' data more accurately locates the narrow source, and permits the geophysicist to make a better evaluation of its importance. The completion of this type of detail is very important, in order to get the maximum usefulness from a reconnaissance IP survey.

McPHAR GEOPHYSICS LIMITED

Theoretical Induced Polarization and Resistivity Studies

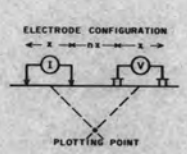
Scale Model Cases



$(\rho/2\pi)_1 = 10$ $(\rho/2\pi)_2 = 2{\cdot}51$

$(Mf)_1 = 0$ $(Mf)_2 = 10000$

$(fe)_2 = 25\%$



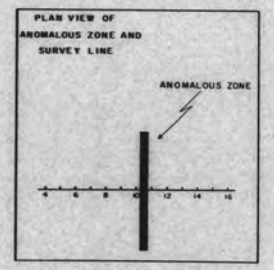


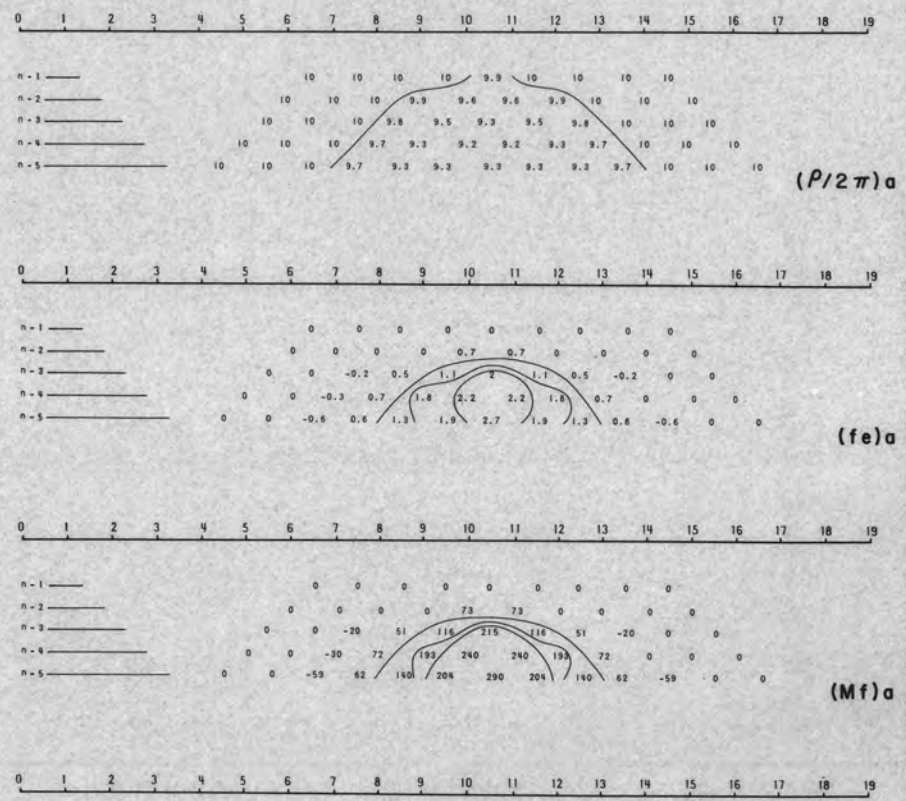
FIG. 1

CASE II-0·5-BU-10-a

McPHAR GEOPHYSICS LIMITED

Theoretical Induced Polarization and Resistivity Studies

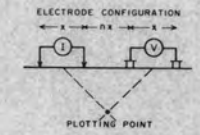
Scale Model Cases



$(\rho/2\pi)_1 = 10$ $(\rho/2\pi)_2 = 2{\cdot}6$

$(Mf)_1 = 0$ $(Mf)_2 = 9250$

$(fe)_2 = 24\%$



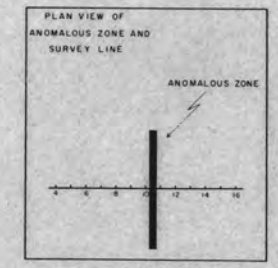


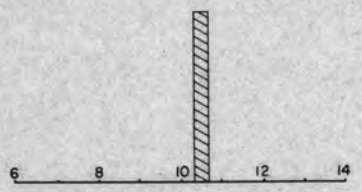
FIG. 2

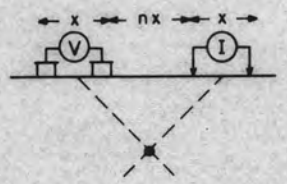
CASE II-1·5-BU-10-a

THEORETICAL INDUCED POLARIZATION AND RESISTIVITY STUDIES

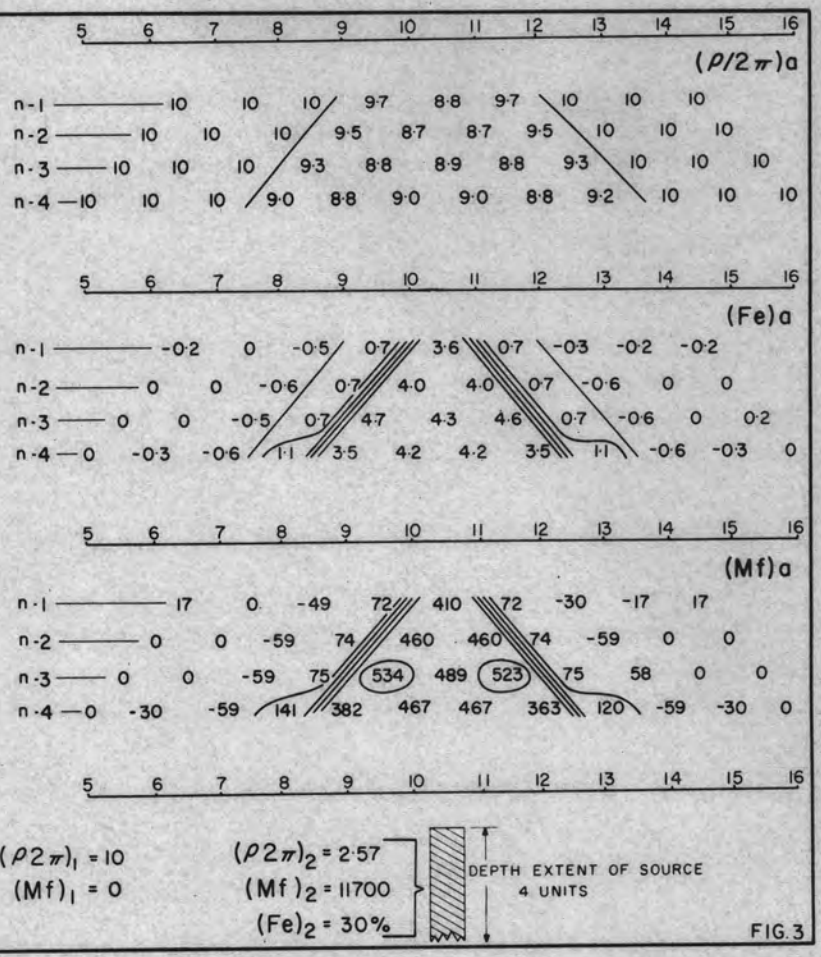
SCALE MODEL CASE

PLAN VIEW





X EQUALS 1 UNIT



$(\rho 2\pi)_1 = 10$

$(Mf)_1 = 0$

$(\rho 2\pi)_2 = 2.57$

$(Mf)_2 = 11700$

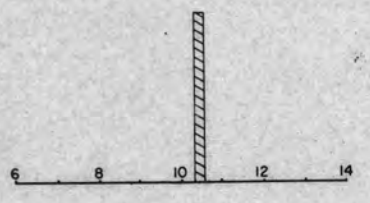
$(Fe)_2 = 30\%$

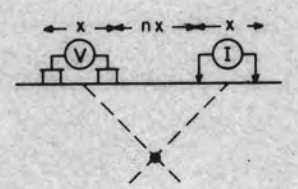
FIG. 3

THEORETICAL INDUCED POLARIZATION AND RESISTIVITY STUDIES

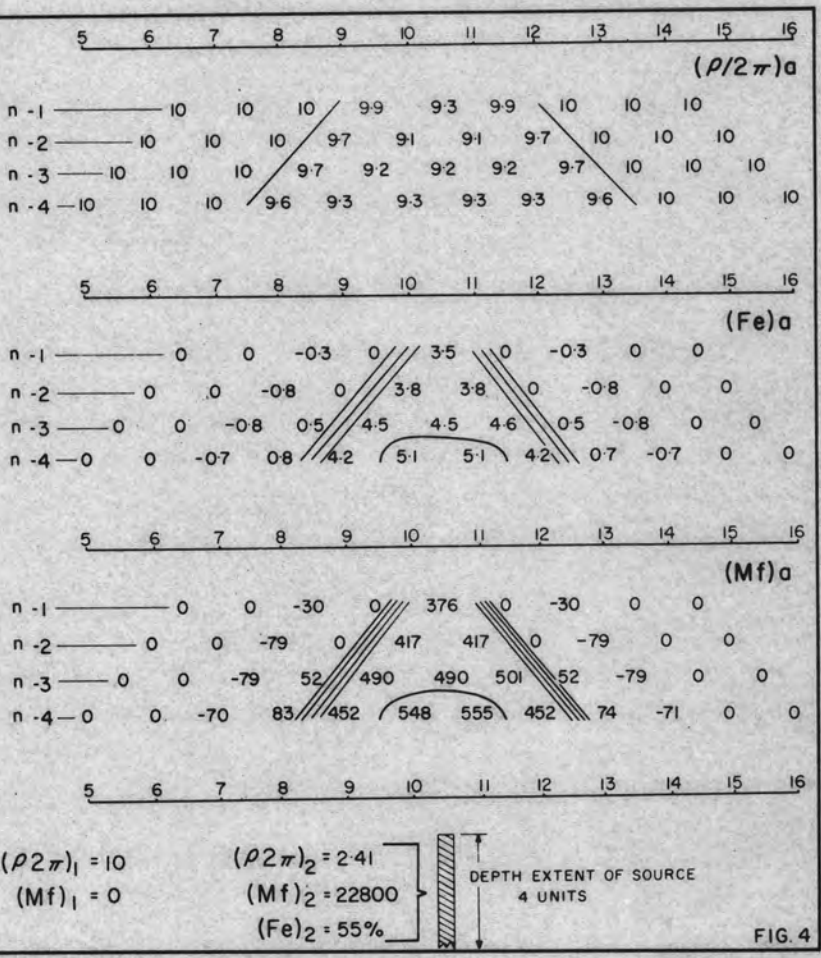
SCALE MODEL CASE

PLAN VIEW





X EQUALS 1 UNIT



$(\rho 2\pi)_1 = 10$

$(Mf)_1 = 0$

$(\rho 2\pi)_2 = 2.41$

$(Mf)_2 = 22800$

$(Fe)_2 = 55\%$

FIG. 4

INDUCED POLARIZATION AND RESISTIVITY RESULTS
BATCHELOR LAKE AREA, QUEBEC.

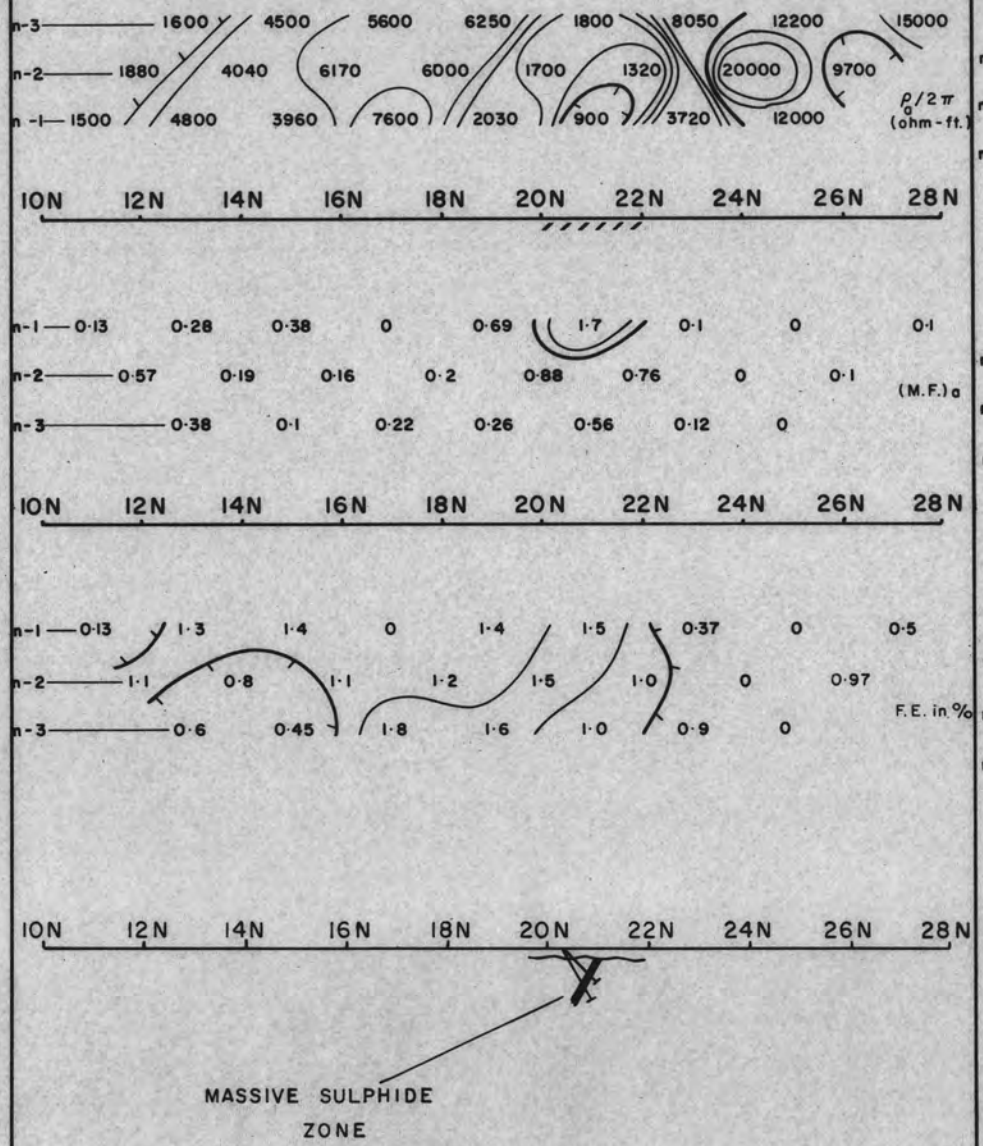


FIG. 5

INDUCED POLARIZATION AND RESISTIVITY RESULTS
BATCHELOR LAKE AREA, QUEBEC.

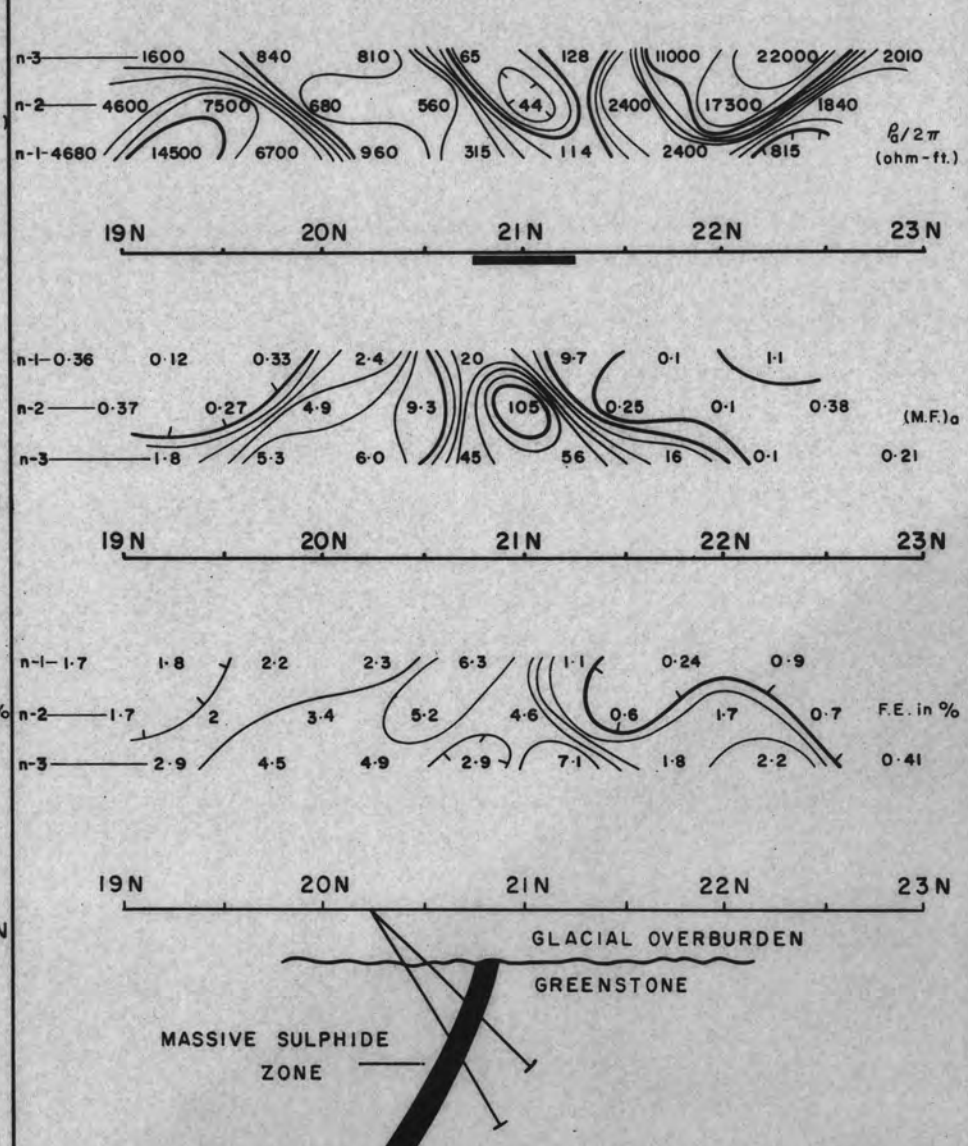


FIG. 6

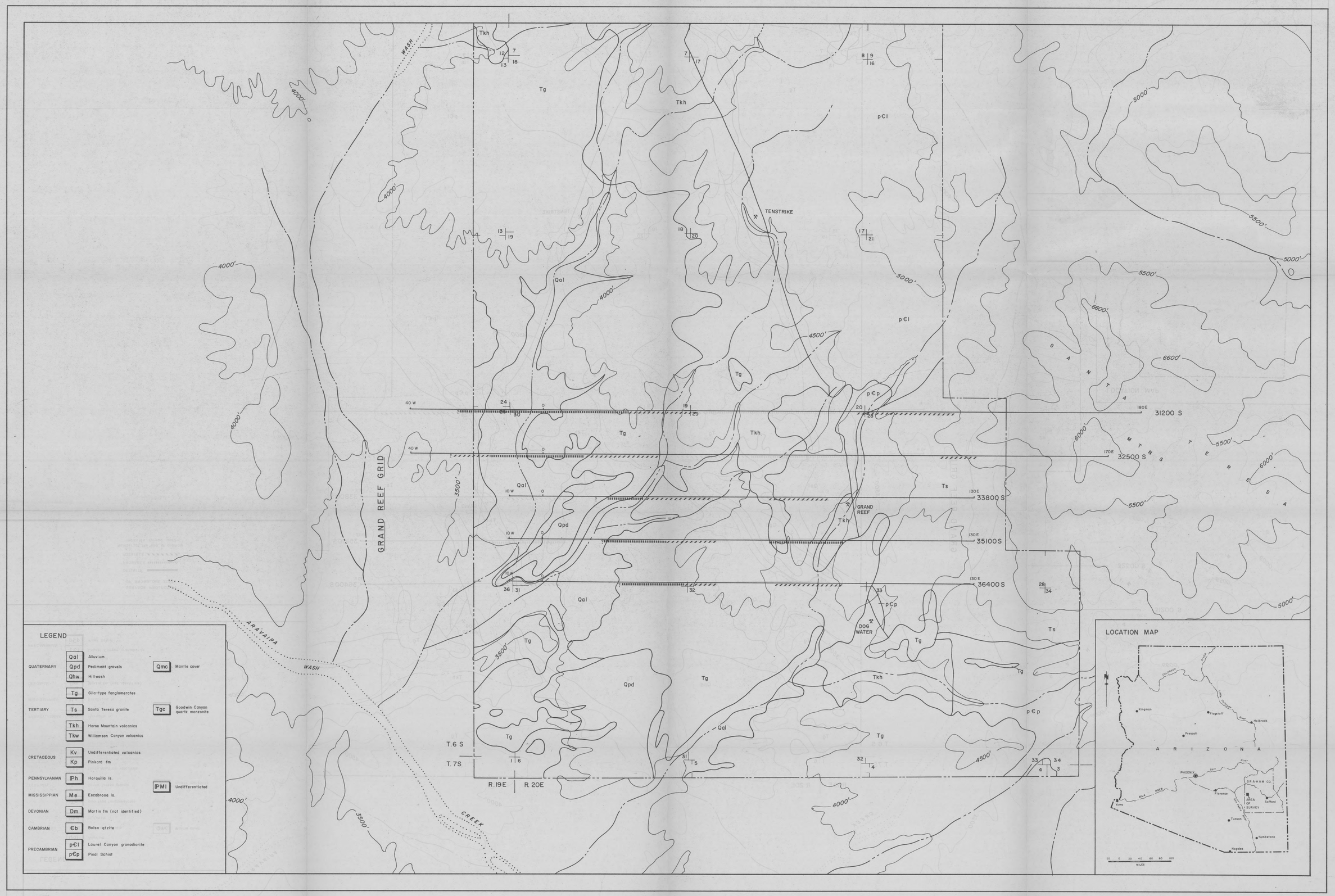
Dwg. I.P.P. 4440

DWG. IPP-4440

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

PLAN MAP



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE

PROBABLE

POSSIBLE

Number at the end of anomaly indicates spread used

THE RALPH M. PARSONS COMPANY

SHEET B - GRAND REEF GRID

MUELLER (ARAVAIPA) PROJECT, GRAHAM CO. ARIZONA

SCALE

FEET 1000 0 1000 2000 3000 4000 5000 FEET

1 INCH EQUALS 1000 FEET

SHEET LAYOUT

A

THIS B SHEET

DRAWN: MCC

DATE: 1968

APPROVED: R.A. Bell

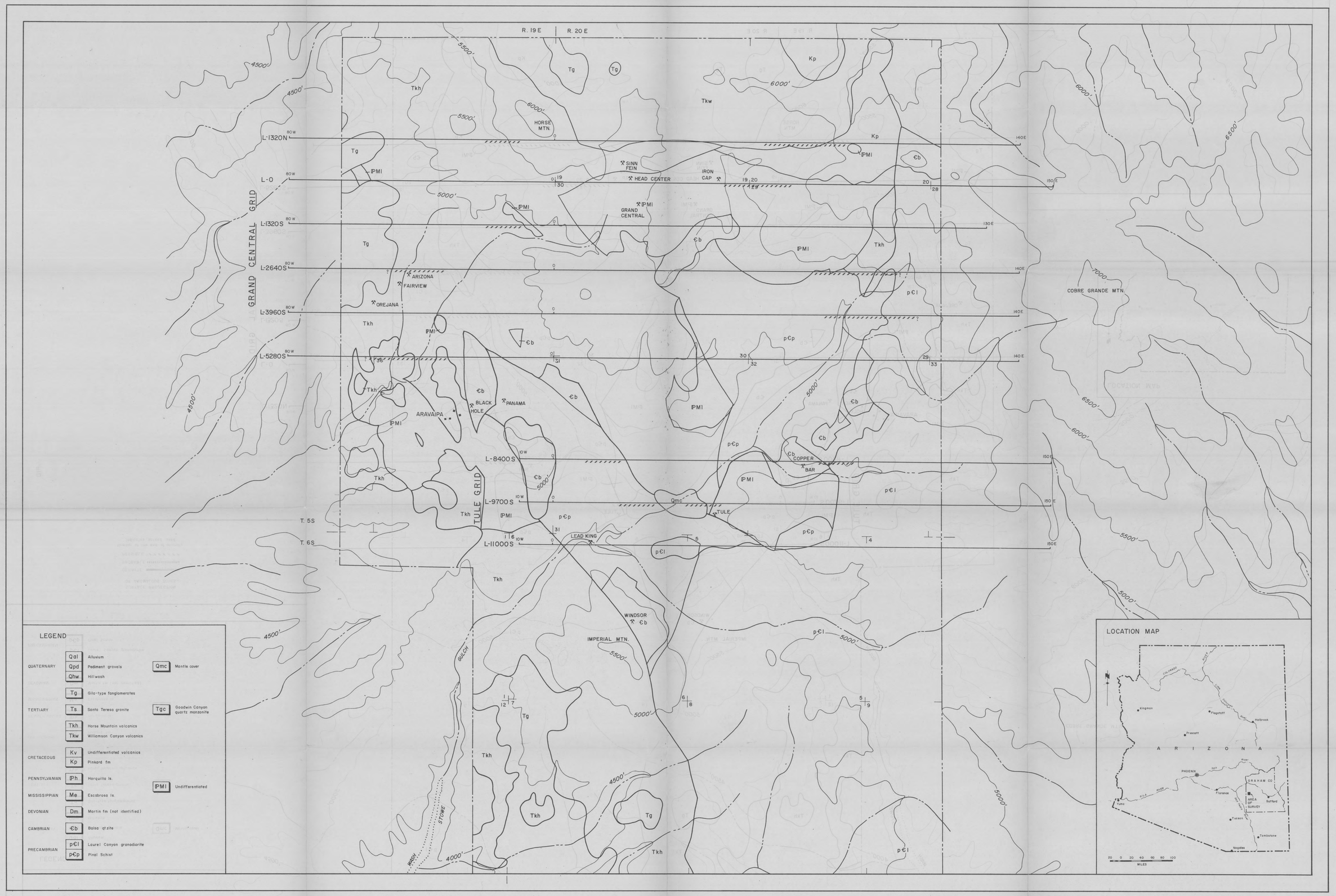
DATE: Sept. 26/68.

DWG. IPP-4440

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

PLAN MAP



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE

PROBABLE

POSSIBLE

Number at the end of anomaly indicates spread used

THE RALPH M. PARSONS COMPANY

SHEET A - GRAND CENTRAL & TULE GRIDS

MUELLER (ARAVAIPA) PROJECT, GRAHAM CO. ARIZONA

SCALE

FEET 1000 0 1000 2000 3000 4000 5000 FEET

1 INCH EQUALS 1000 FEET

SHEET LAYOUT

THIS SHEET A

B

DRAWN: MCC

DATE: AUG. 1968

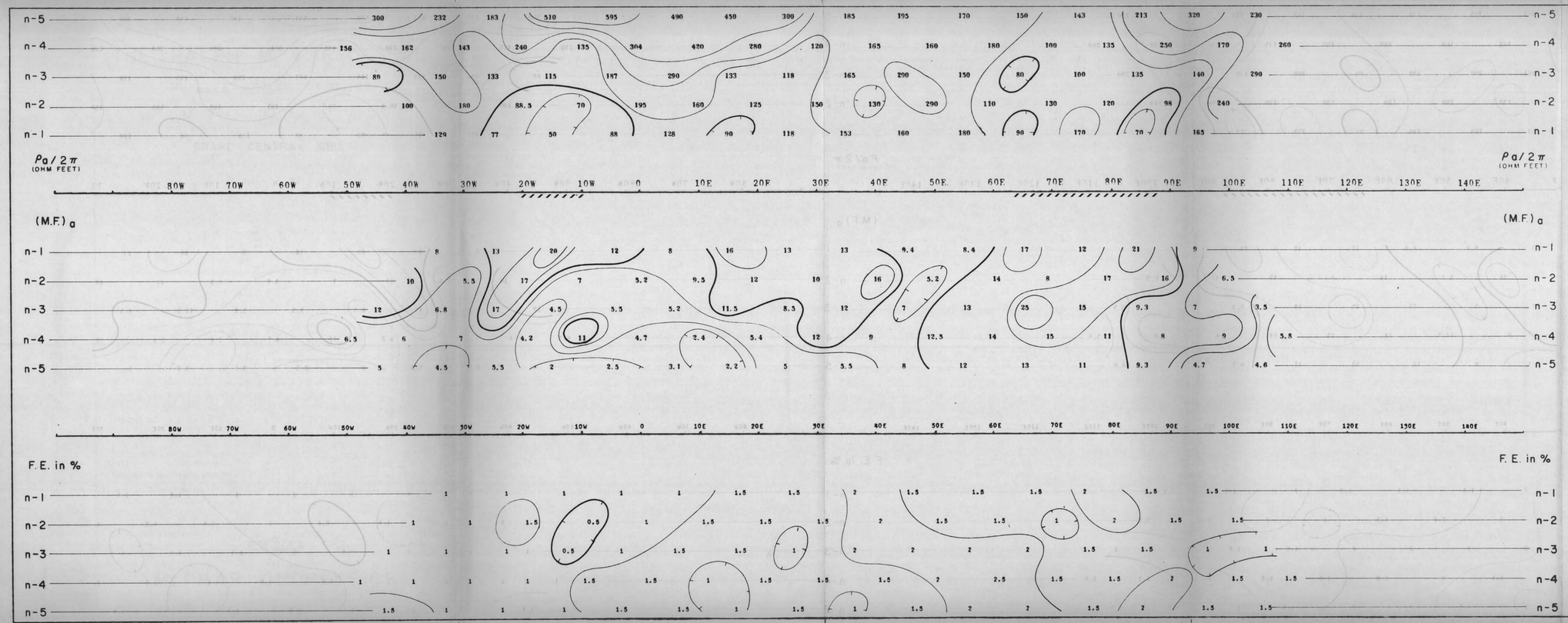
APPROVED: R.A. Bell

DATE: Sept. 26/68.

REGISTERED GEOLOGIST

DWG. IPP - 4441

Dwg. I.P.P. 4441



DWG NO.-I.P.-5164-1

THE RALPH M. PARSONS CO.

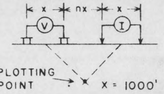
MUELLER ARAVAIPA PROJECT

SAFFORD AREA GRAHAM CO. ARIZONA

GRAND CENTRAL GRID

LINE NO.- 1320 N

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES 0.125-125 cps

DATE SURVEYED JULY 8 SEPT / 68

APPROVED R. B. Bell

DATE Sept. 12/68

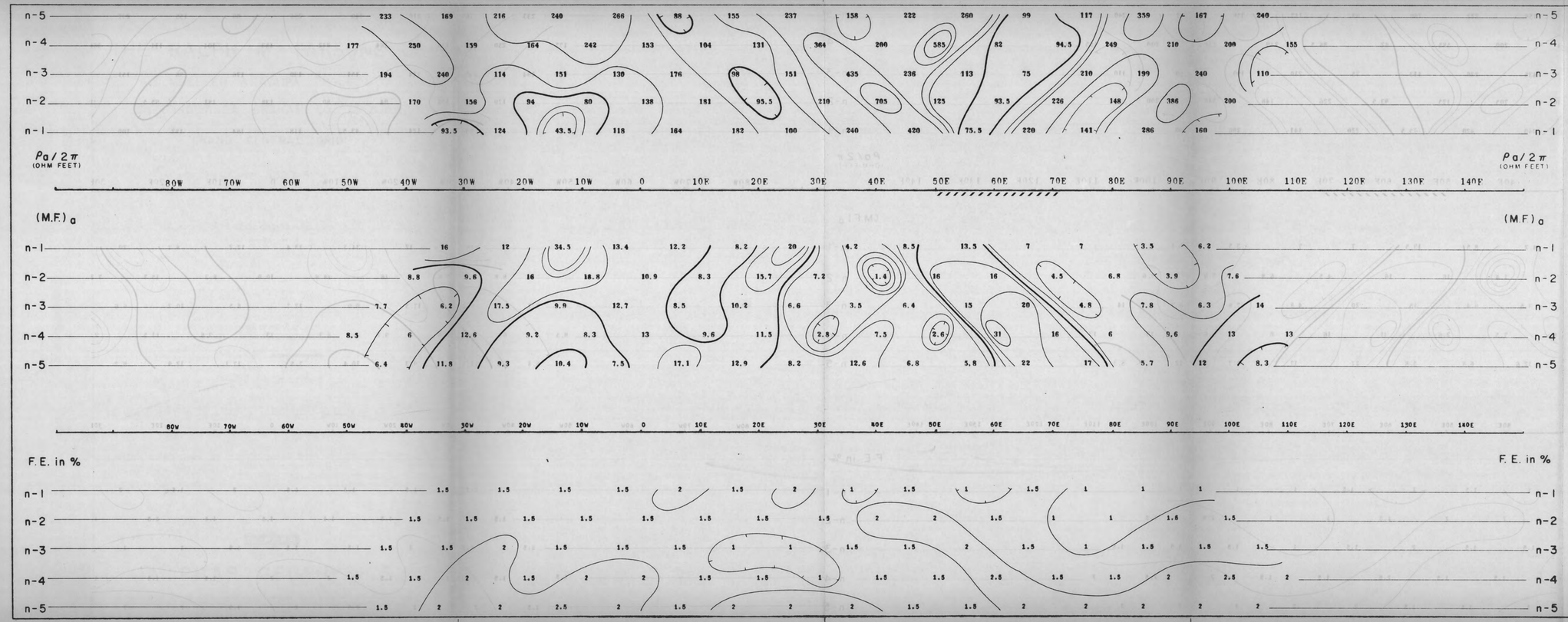
REGISTERED GEOLOGIST CERTIFICATE NO. HOBERT ALAN BELL STATE OF ARIZONA

NOTE CONTOURS AT LOGARITHMIC INTERVALS 1-1.5-2-3-5-7.5-10

McPHAR

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY



DWG. NO.-I.P.-5164-2

THE RALPH M. PARSONS CO.

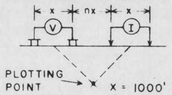
MUELLER ARAVAIPA PROJECT

SAFFORD AREA GRAHAM CO. ARIZONA

GRAND CENTRAL GRID

LINE NO.- 0

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES 0·31 - 2·5 cps

DATE SURVEYED JULY & SEPT / 68

APPROVED R. G. Bell

DATE Sept. 12, 68

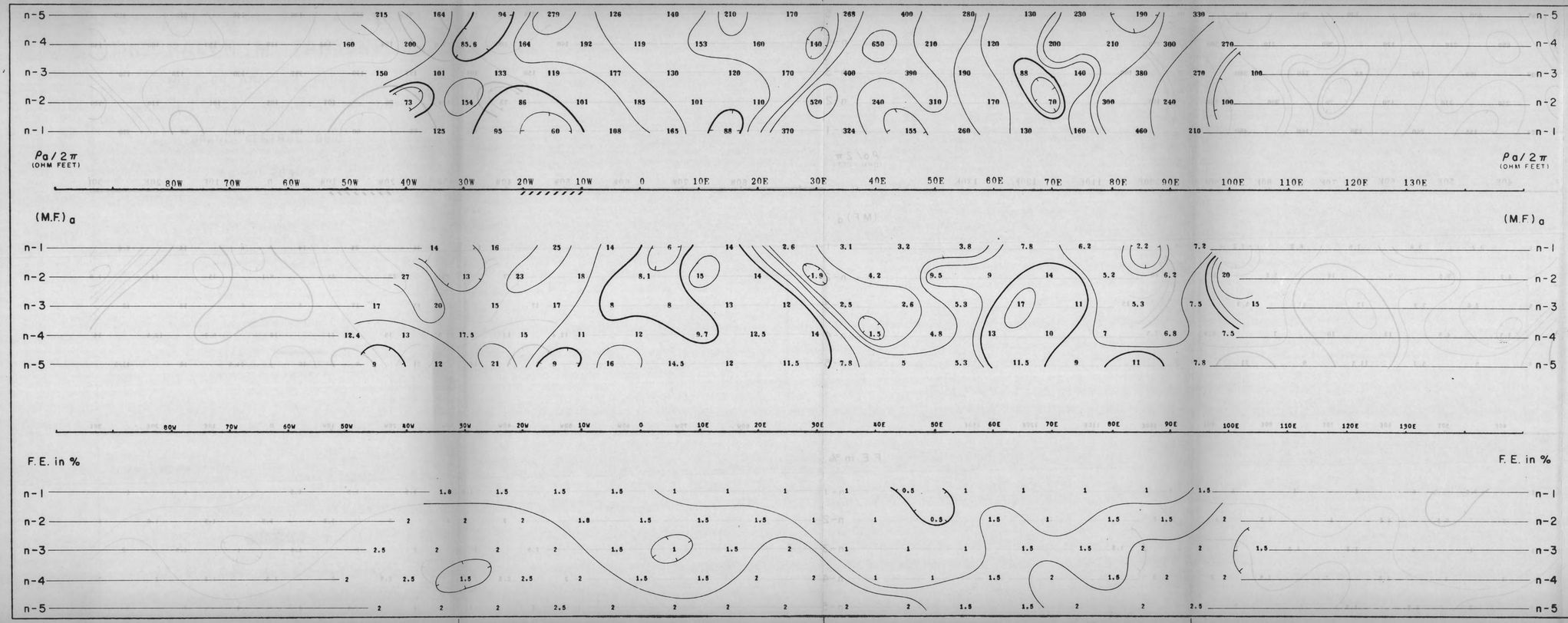
REGISTERED GEOLOGIST CERTIFICATE NO. ROBERT ALAN BELL ARIZONA U.S.A.

NOTE CONTOURS AT LOGARITHMIC INTERVALS 1-1·5-2-3-5-7·5-10

McPHAR

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY



DWG. NO.- I.P.- 5164-3

THE RALPH M. PARSONS CO.

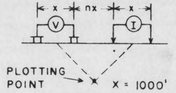
MUELLER ARAVAIPA PROJECT

SAFFORD AREA GRAHAM CO. ARIZONA

GRAND CENTRAL GRID

LINE NO.- 1320 S

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES 0·31 - 2·5 cps

DATE SURVEYED JULY & SEPT / 68

APPROVED R. C. Bell

DATE Sept. 12/68

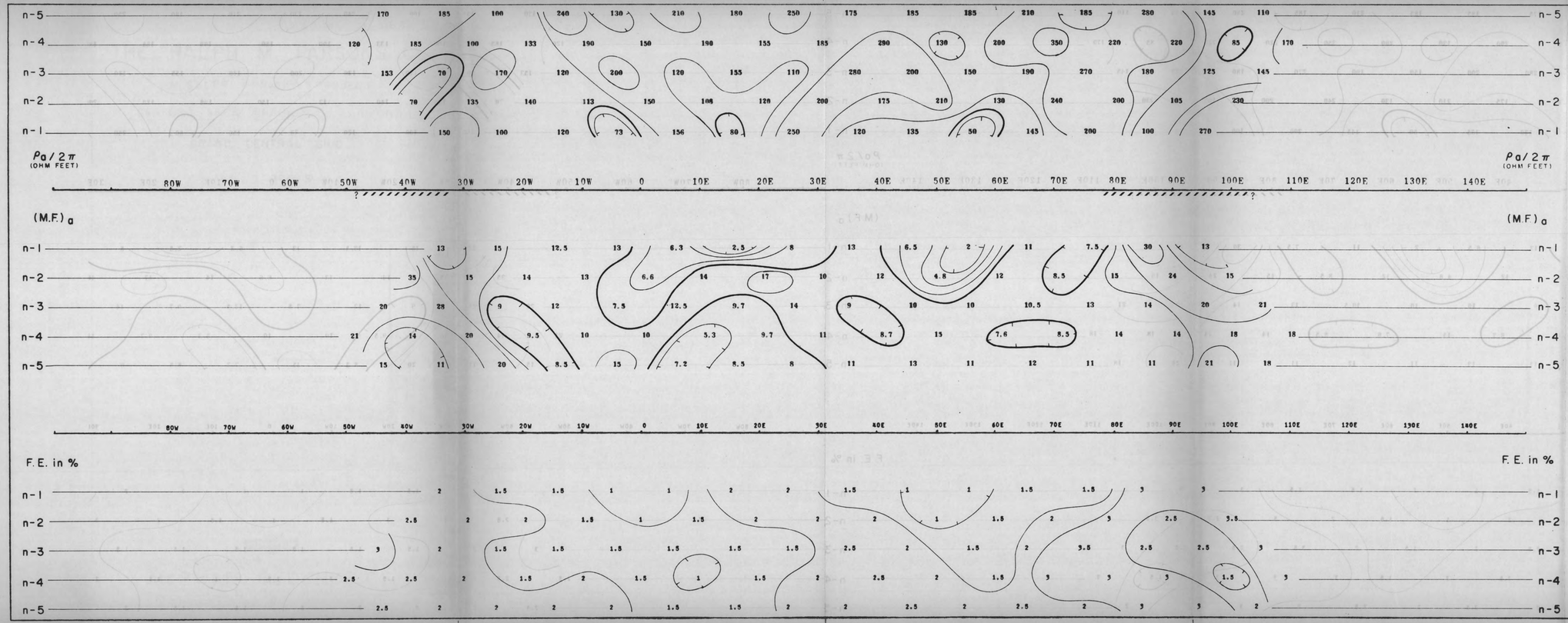
REGISTERED GEOLOGIST CERTIFICATE NO. ROBERT ALAN BELL ARIZONA, U.S.A.

NOTE: CONTOURS AT LOGARITHMIC INTERVALS 1-1·5-2-3-5-7·5-10

McPHAR

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY



DWG. NO.- I.P - 5164-4

THE RALPH M. PARSONS CO.

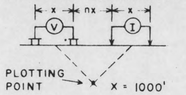
MUELLER ARAVAIPA PROJECT

SAFFORD AREA GRAHAM CO. ARIZONA

GRAND CENTRAL GRID

LINE NO.- 2640 S

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES 0·31 - 2·5 cps

DATE SURVEYED JULY & SEPT / 68

APPROVED: R. A. Bell

DATE: Sept. 12/68

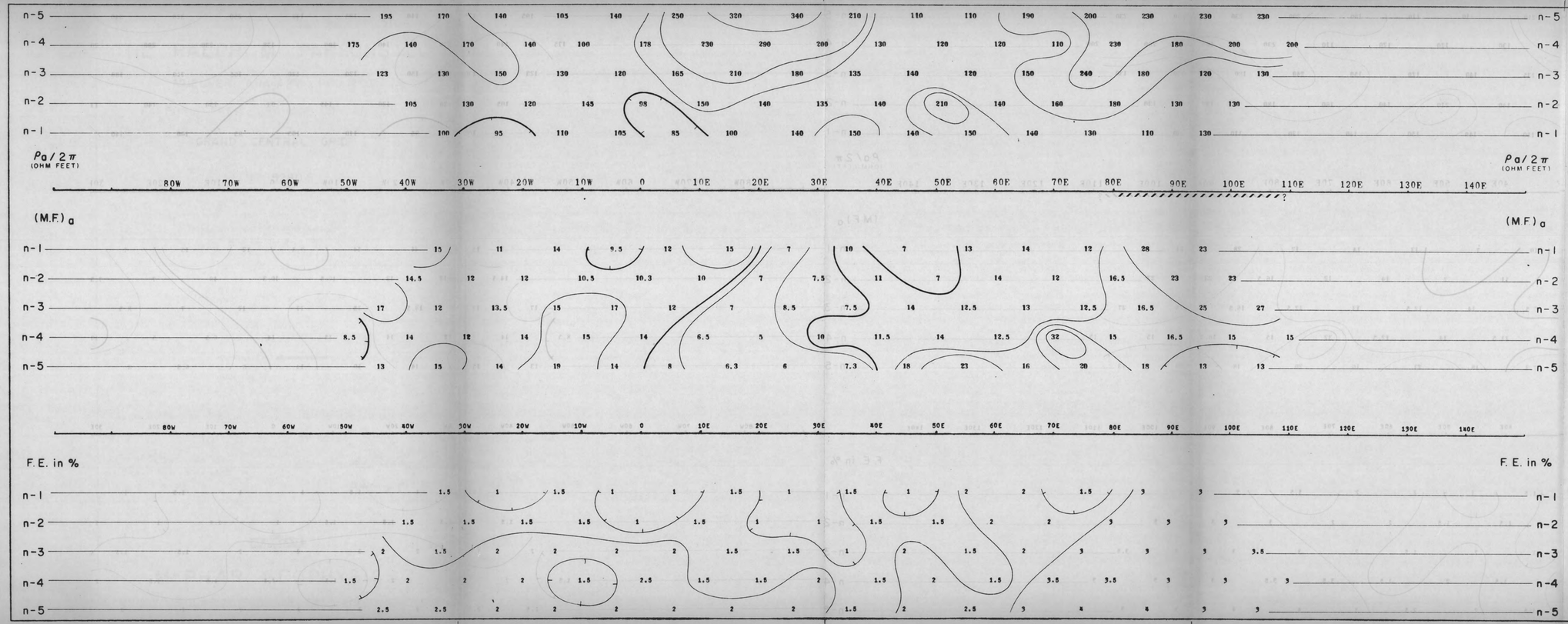
REGISTERED GEOLOGIST CERTIFICATE NO. ROBERT ALAN BELL ARIZONA, U.S.A.

NOTE CONTOURS AT LOGARITHMIC INTERVALS 1-1·5-2-3-5-7·5-10

McPHAR

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY



DWG. NO.-I.P-5164-5

THE RALPH M. PARSONS CO.

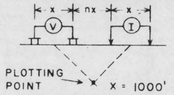
MUELLER ARAVAIPA PROJECT

SAFFORD AREA GRAHAM CO. ARIZONA

GRAND CENTRAL GRID

LINE NO.- 3960 S

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES 0.31 - 2.5 cps

DATE SURVEYED JULY & SEPT / 68

APPROVED R. G. Bell

DATE Sept. 12, 68

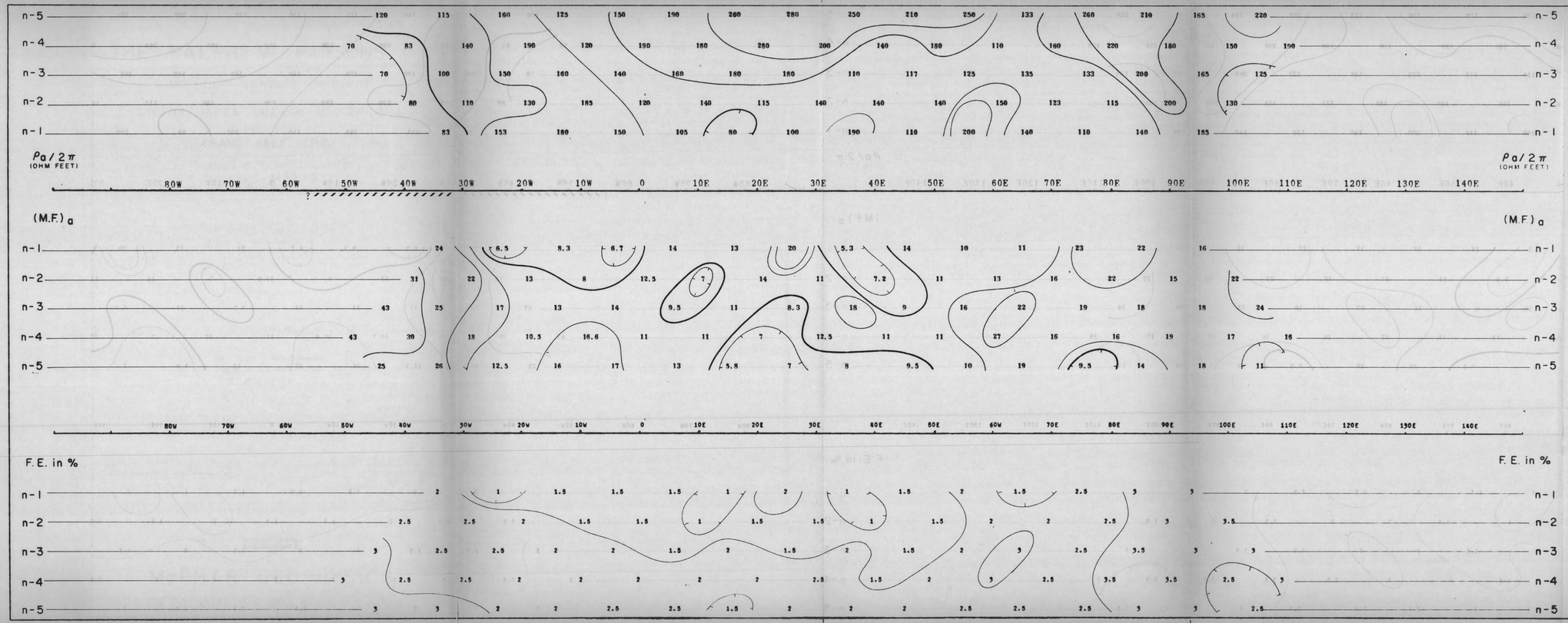
NOTE CONTOURS AT LOGARITHMIC INTERVALS 1-1.5-2-3-5-7.5-10

REGISTERED GEOLOGIST CERTIFICATE NO. ROBERT ALAN BELL ARIZONA, U.S.A.

McPHAR

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY



DWG. NO.-I.P-5164-6

THE RALPH M. PARSONS CO.

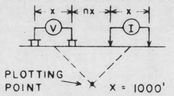
MUELLER ARAVAIPA PROJECT

SAFFORD AREA GRAHAM CO. ARIZONA

GRAND CENTRAL GRID

LINE NO.-5280 S

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES 0·31 - 2·5 cps

DATE SURVEYED JULY & SEPT / 68

APPROVED: R. C. Bell

DATE: Sept. 12/68

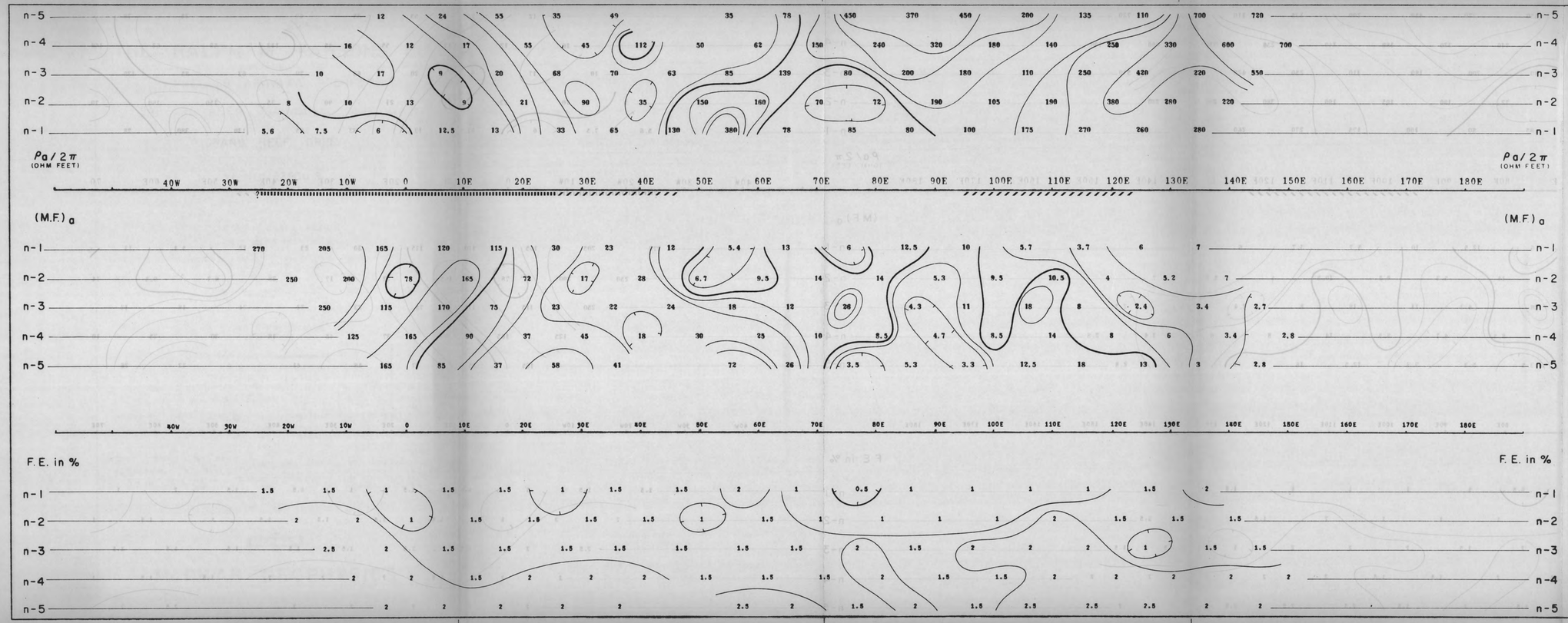
NOTE: CONTOURS AT LOGARITHMIC INTERVALS 1-1·5-2-3-5-7·5-10

REGISTERED GEOLOGIST VIRTUALLY NO. ROBERT ALAN BELL ARIZONA, U.S.A.

McPHAR

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY



DWG. NO.-I.P-5165-1

THE RALPH M. PARSONS CO.

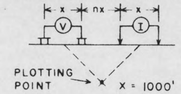
MUELLER ARAVAIPA PROJECT

SAFFORD AREA GRAHAM CO. ARIZONA

GRAND REEF GRID

LINE NO.-31200 S

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES: 0.31 - 2.5 cps

DATE SURVEYED: JULY & SEPT / 68

APPROVED: R. A. Bell

DATE: Sept. 12/68

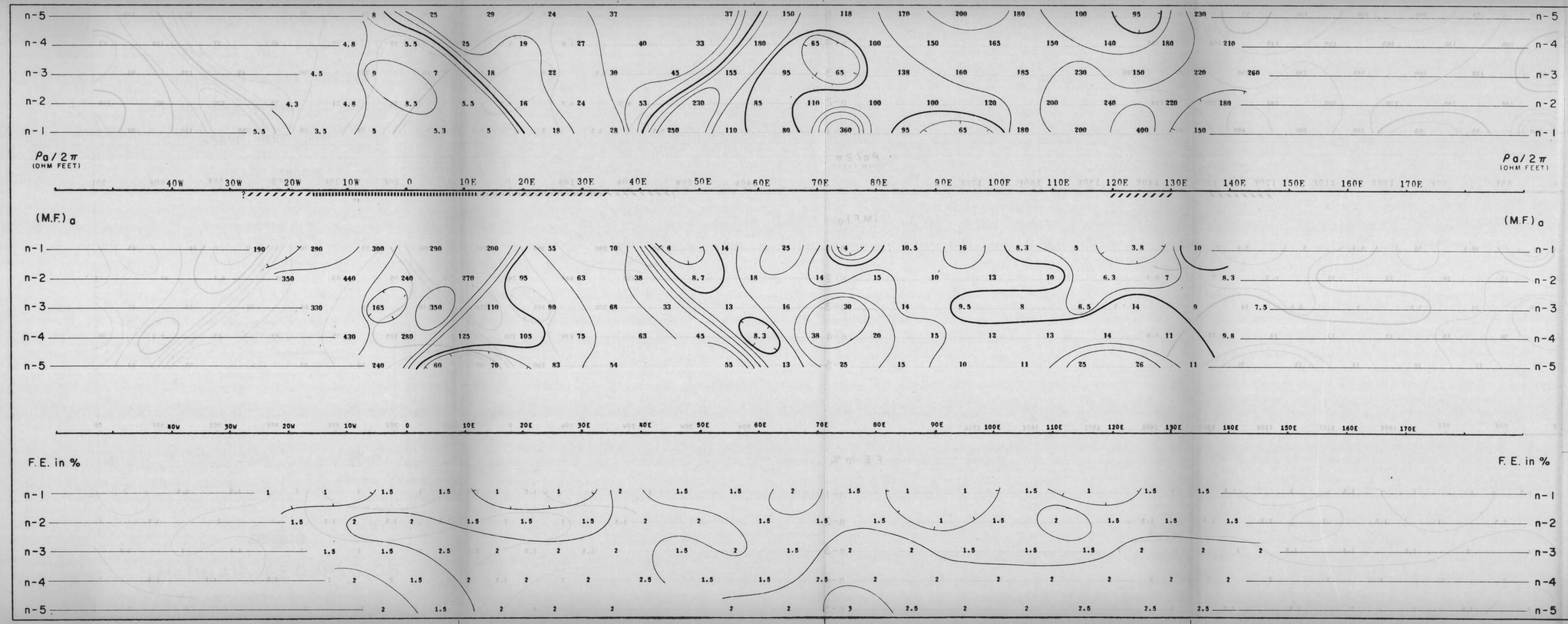
REGISTERED GEOLOGIST ROBERT ALAN BELL ARIZONA, U.S.A.

NOTE: CONTOURS AT LOGARITHMIC INTERVALS 1-1.5-2-3-5-7.5-10

McPHAR

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY



DWG. NO.- I.P - 5165 - 2

THE RALPH M. PARSONS CO.

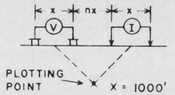
MUELLER ARAVAIPA PROJECT

SAFFORD AREA GRAHAM CO. ARIZONA

GRAND REEF GRID

LINE NO.- 32500 S

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES 0·31 - 2·5 cps

DATE SURVEYED JULY & SEPT / 68

APPROVED R. C. Bell

DATE Sept. 12/68

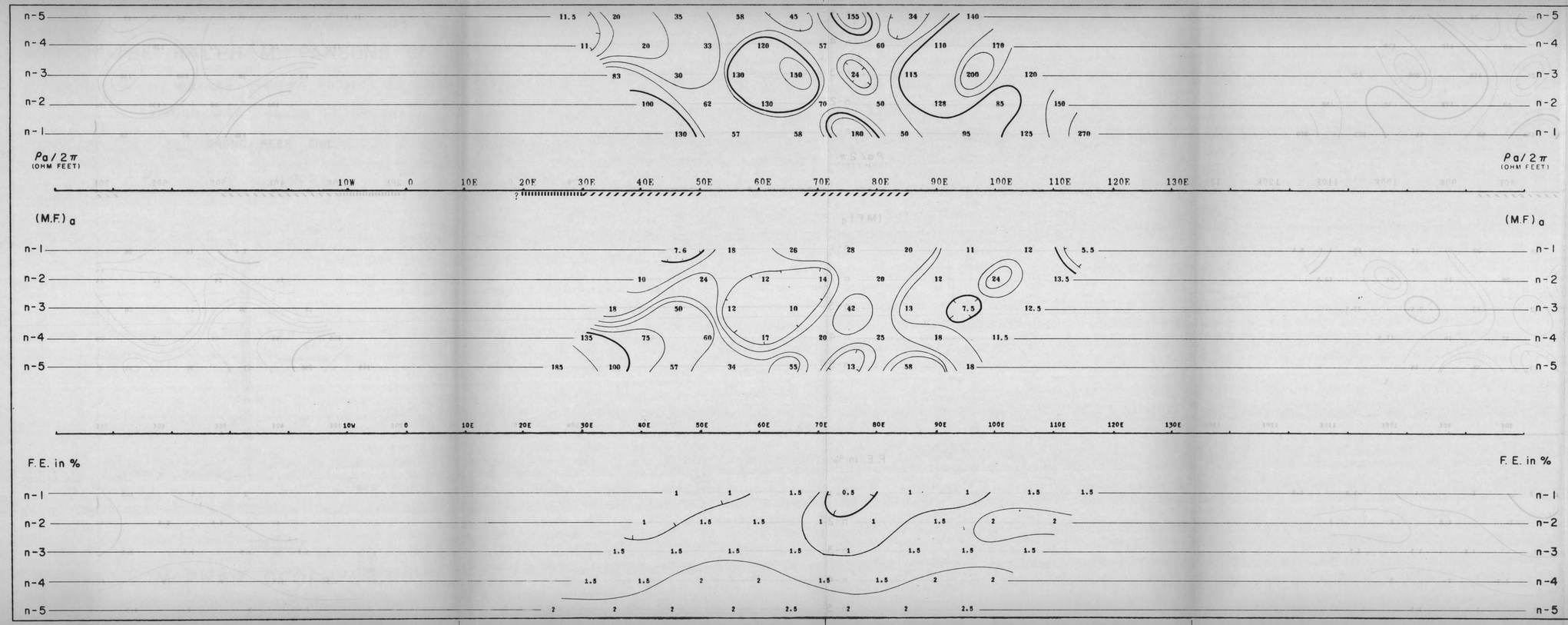
REGISTERED GEOLOGIST CERTIFICATE NO. ROBERT ALAN BELL ARIZONA, U.S.A.

NOTE: CONTOURS AT LOGARITHMIC INTERVALS 1-1·5-2-3-5-7·5-10

McPHAR

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY



DWG. NO.-I.P-5165-3

THE RALPH M. PARSONS CO.

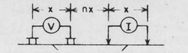
MUELLER ARAVAIPA PROJECT

SAFFORD AREA GRAHAM CO. ARIZONA

GRAND REEF GRID

LINE NO.- 33800 S

ELECTRODE CONFIGURATION



PLOTTING POINT X = 1000'

SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES 0·31 - 2·5 cps

DATE SURVEYED JULY & SEPT / 68

APPROVED R. G. Bell

DATE Sept 12/68

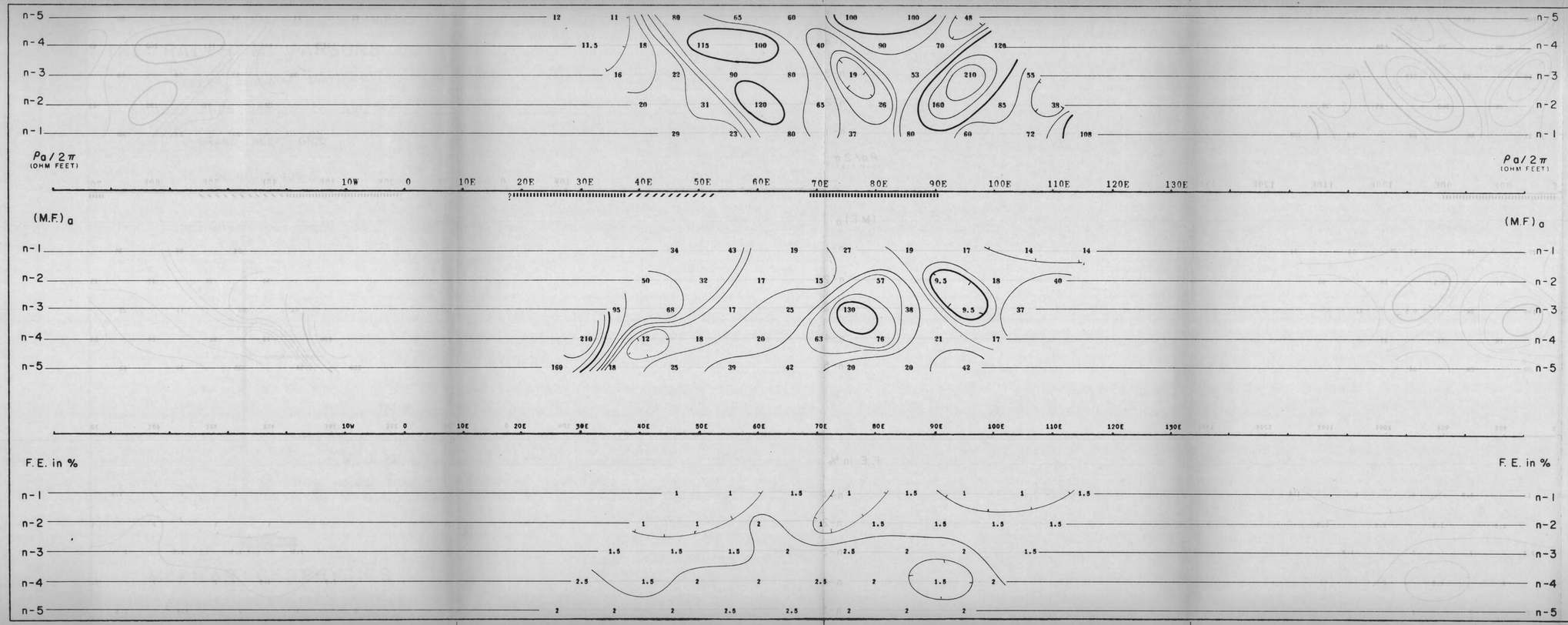
REGISTERED GEOLOGIST CERTIFICATE NO. ROBERT ALAN BELL ARIZONA U.S.A.

NOTE CONTOURS AT LOGARITHMIC INTERVALS 1-1·5-2-3-5-7·5-10

McPHAR

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY



DWG. NO.-I.P.-5165-4

THE RALPH M. PARSONS CO.

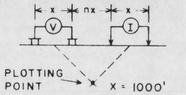
MUELLER ARAVAIPA PROJECT

SAFFORD AREA GRAHAM CO. ARIZONA

GRAND REEF GRID

LINE NO.- 35100 S

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES 0·31 - 2·5 cps

DATE SURVEYED JULY & SEPT / 68

APPROVED R. A. Bell

DATE Sept. 12/68

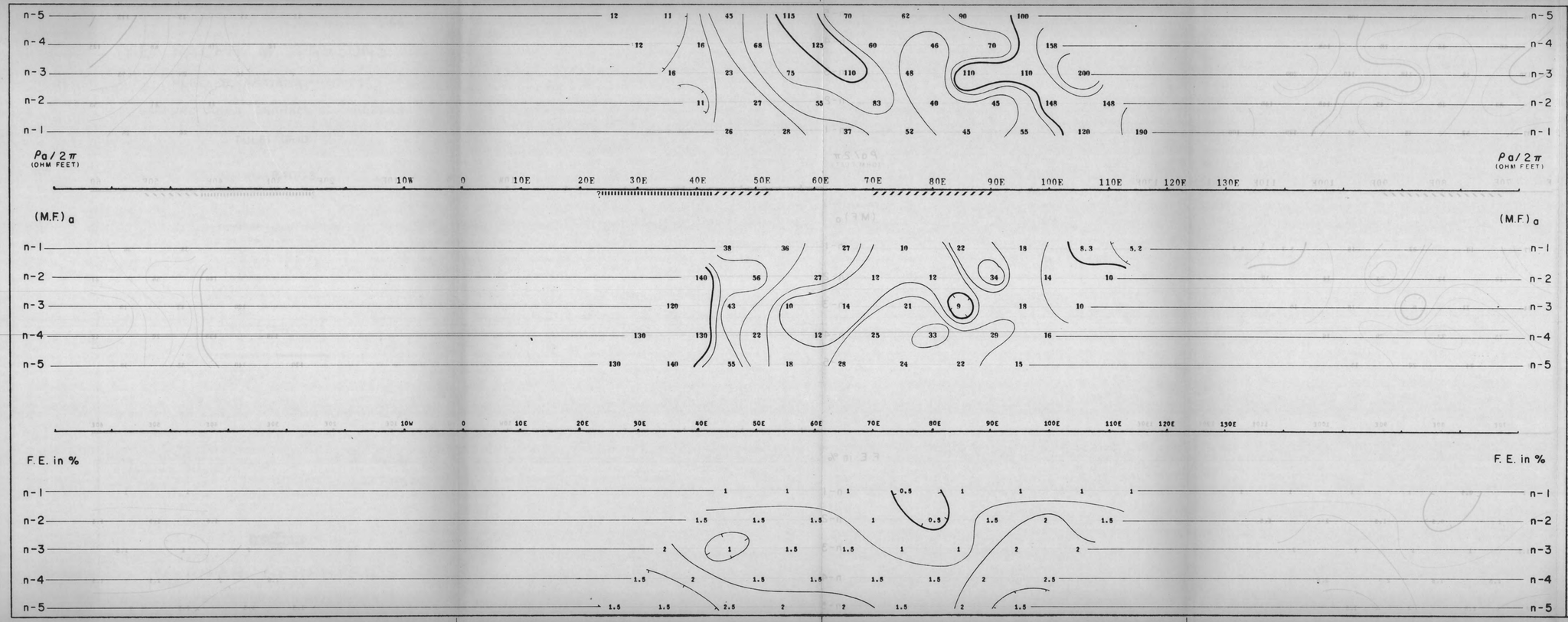
REGISTERED GEOLOGIST CERTIFICATE NO. ROBERT ALAN BELL ARIZONA, U.S.A.

NOTE - CONTOURS AT LOGARITHMIC INTERVALS 1-1·5-2-3-5-7·5-10

McPHAR

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY



DWG. NO.-I.P-5165-5

THE RALPH M. PARSONS CO.

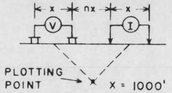
MUELLER ARAVAIPA PROJECT

SAFFORD AREA GRAHAM CO. ARIZONA

GRAND REEF GRID

LINE NO.-36400 S

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES: 0·31 – 2·5 cps

DATE SURVEYED: JULY & SEPT / 68

APPROVED: R. C. Bell

DATE: Sept. 12/68

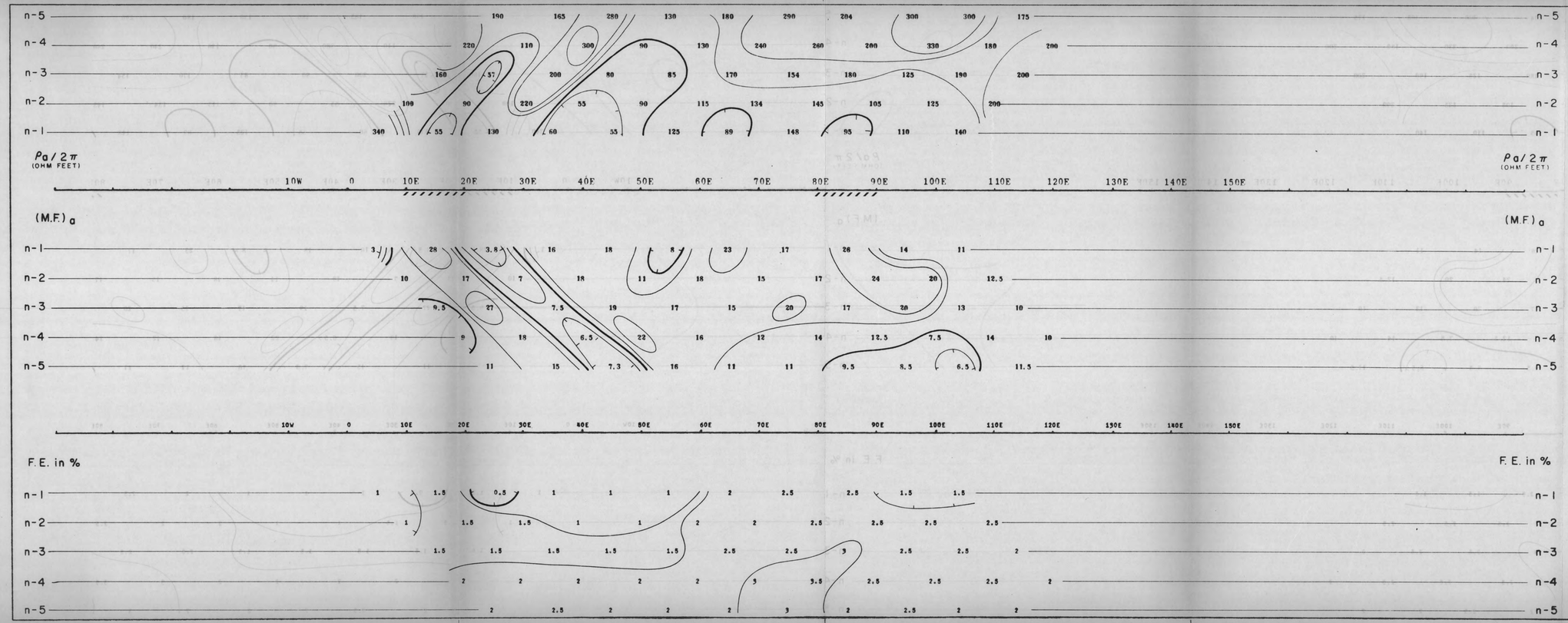
REGISTERED GEOLOGIST ROBERT ALAN BELL ARIZONA, U.S.A.

NOTE: CONTOURS AT LOGARITHMIC INTERVALS 1-1·5-2-3-5-7·5-10

McPHAR

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY



DWG. NO.-I.P.-5166-1

THE RALPH M. PARSONS CO.

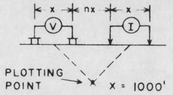
MUELLER ARAVAIPA PROJECT

SAFFORD AREA GRAHAM CO. ARIZONA

TULE GRID

LINE NO.-8400S

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES 0.31 - 2.5 cps

DATE SURVEYED JULY & SEPT / 68

APPROVED R. C. Bill

DATE Sept. 12/68

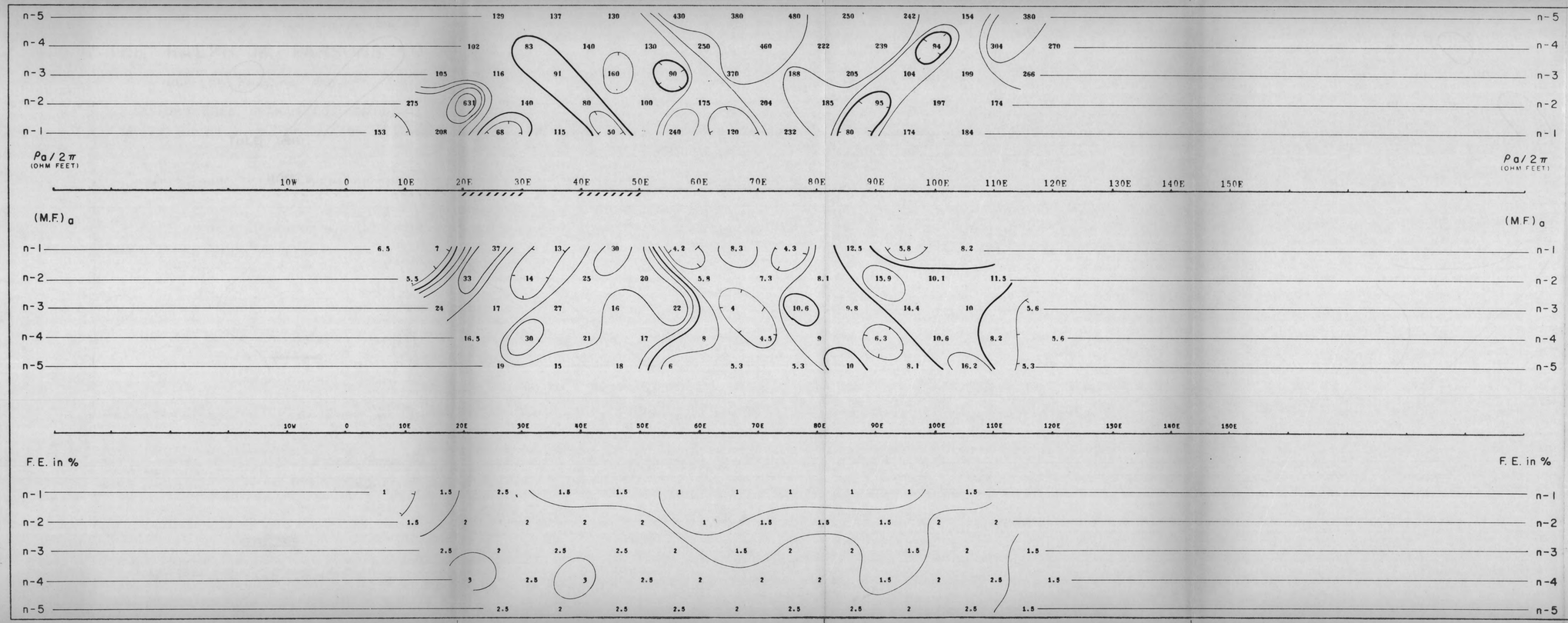
NOTE: CONTOURS AT LOGARITHMIC INTERVALS 1-1.5-2-3-5-7.5-10

REGISTERED GEOLOGIST CERTIFICATE NO. ROBERT ALAN BELL ARIZONA U.S.A.

McPHAR

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY



DWG. NO.-I.P.-5166-2

THE RALPH M. PARSONS CO.

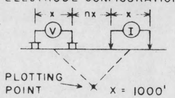
MUELLER ARAVAIPA PROJECT

SAFFORD AREA GRAHAM CO. ARIZONA

TULE GRID

LINE NO.-9700S

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES 0·31 - 2·5 cps

DATE SURVEYED JULY & SEPT / 68

APPROVED R. A. Bell

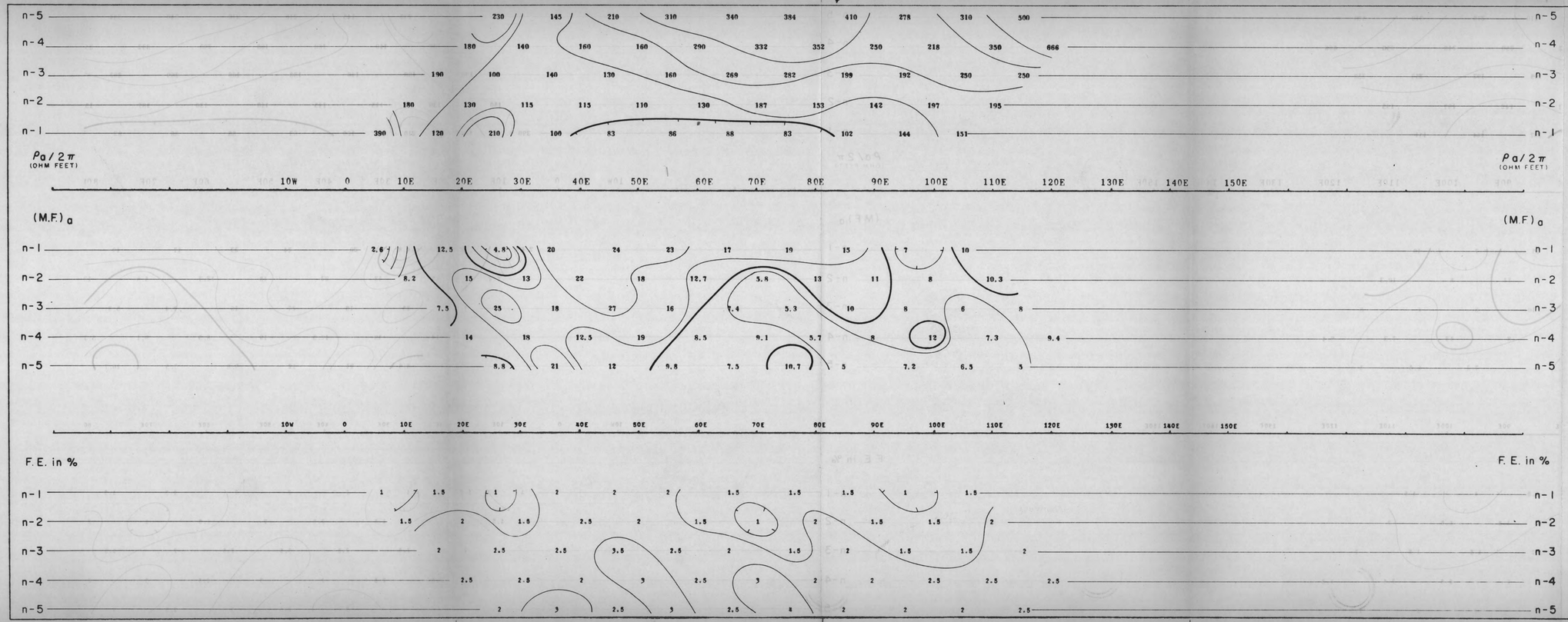
DATE Sept. 12/68

NOTE CONTOURS AT LOGARITHMIC INTERVALS 1-1·5-2-3-5-7·5-10

McPHAR

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY



DWG. NO.- I.P.- 5166-3

THE RALPH M. PARSONS CO.

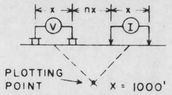
MUELLER ARAVAIPA PROJECT

SAFFORD AREA GRAHAM CO. ARIZONA

TULE GRID

LINE NO.- 11000 S

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES 0.31 - 2.5 cps

DATE SURVEYED: JULY & SEPT / 68

APPROVED: R. A. Bell

DATE: Sept. 12/68

NOTE: CONTOURS AT LOGARITHMIC INTERVALS 1-1.5-2-3-5-7.5-10

REGISTERED GEOLOGIST ROBERT ALAN BELL ARIZONA U.S.A.

McPHAR

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

REPORT ON
ADDITIONAL GEOPHYSICAL INVESTIGATIONS
ON THE
GRAND REEF GRID
MUELLER PROJECT, GRAHAM CO., ARIZONA
FOR
THE RALPH M. PARSONS COMPANY

McPHAR GEOPHYSICS

NOTES ON THE THEORY, METHOD OF FIELD OPERATION, AND PRESENTATION OF DATA FOR THE INDUCED POLARIZATION METHOD

Induced Polarization as a geophysical measurement refers to the blocking action or polarization of metallic or electronic conductors in a medium of ionic solution conduction.

This electro-chemical phenomenon occurs wherever electrical current is passed through an area which contains metallic minerals such as base metal sulphides. Normally, when current is passed through the ground, as in resistivity measurements, all of the conduction takes place through ions present in the water content of the rock, or soil, i.e. by ionic conduction. This is because almost all minerals have a much higher specific resistivity than ground water. The group of minerals commonly described as "metallic", however, have specific resistivities much lower than ground waters. The induced polarization effect takes place at those interfaces where the mode of conduction changes from ionic in the solutions filling the interstices of the rock to electronic in the metallic minerals present

in the rock.

The blocking action or induced polarization mentioned above, which depends upon the chemical energies necessary to allow the ions to give up or receive electrons from the metallic surface, increases with the time that a d. c. current is allowed to flow through the rock; i. e. as ions pile up against the metallic interface the resistance to current flow increases. Eventually, there is enough polarization in the form of excess ions at the interfaces, to appreciably reduce the amount of current flow through the metallic particle. This polarization takes place at each of the infinite number of solution-metal interfaces in a mineralized rock.

When the d. c. voltage used to create this d. c. current flow is cut off, the Coulomb forces between the charged ions forming the polarization cause them to return to their normal position. This movement of charge creates a small current flow which can be measured on the surface of the ground as a decaying potential difference.

From an alternate viewpoint it can be seen that if the direction of the current through the system is reversed repeatedly before the polarization occurs, the effective resistivity of the system as a whole will change as the frequency of the switching is changed. This is a consequence of the fact that the amount of current flowing through each metallic interface depends upon the length of time that current has been passing through it in one direction.

The values of the per cent frequency effect or F. E. are a measurement of the polarization in the rock mass. However, since the measurement of the degree of polarization is related to the apparent resistivity of the rock mass it is found that the metal factor values or M. F. are the most useful values in determining the amount of polarization present in the rock mass. The MF values are obtained by normalizing the F. E. values for varying resistivities.

The induced polarization measurement is perhaps the most powerful geophysical method for the direct detection of metallic sulphide mineralization, even when this mineralization is of very low concentration. The lower limit of volume per cent sulphide necessary to produce a recognizable IP anomaly will vary with the geometry and geologic environment of the source, and the method of executing the survey. However, sulphide mineralization of less than one per cent by volume has been detected by the IP method under proper geological conditions.

The greatest application of the IP method has been in the search for disseminated metallic sulphides of less than 20% by volume. However, it has also been used successfully in the search for massive sulphides in situations where, due to source geometry, depth of source, or low resistivity of surface layer, the EM method can not be successfully applied. The ability to differentiate ionic conductors, such as water filled shear zones, makes the IP method a useful tool in checking EM

anomalies which are suspected of being due to these causes.

In normal field applications the IP method does not differentiate between the economically important metallic minerals such as chalcopyrite, chalcocite, molybdenite, galena, etc., and the other metallic minerals such as pyrite. The induced polarization effect is due to the total of all electronic conducting minerals in the rock mass. Other electronic conducting materials which can produce an IP response are magnetite, pyrolusite, graphite, and some forms of hematite.

In the field procedure, measurements on the surface are made in a way that allows the effects of lateral changes in the properties of the ground to be separated from the effects of vertical changes in the properties. Current is applied to the ground at two points in distance (X) apart. The potentials are measured at two other points (X) feet apart, in line with the current electrodes is an integer number (n) times the basic distance (X).

The measurements are made along a surveyed line, with a constant distance (nX) between the nearest current and potential electrodes. In most surveys, several traverses are made with various values of (n); i.e. (n) = 1, 2, 3, 4, etc. The kind of survey required (detailed or reconnaissance) decides the number of values of (n) used.

In plotting the results, the values of the apparent resistivity, apparent per cent frequency effect, and the apparent metal factor

measured for each set of electrode positions are plotted at the intersection of grid lines, one from the center point of the current electrodes and the other from the center point of the potential electrodes. (See Figure A.) The resistivity values are plotted above the line as a mirror image of the metal factor values below. On a second line, below the metal factor values, are plotted the values of the per cent frequency effect. In some cases the values of per cent frequency effect are plotted as superscripts of the metal factor value. In this second case the frequency effect values are not contoured. The lateral displacement of a given value is determined by the location along the survey line of the center point between the current and potential electrodes. The distance of the value from the line is determined by the distance (nX) between the current and potential electrodes when the measurement was made.

The separation between sender and receiver electrodes is only one factor which determines the depth to which the ground is being sampled in any particular measurement. The plots then, when contoured, are not section maps of the electrical properties of the ground under the survey line. The interpretation of the results from any given survey must be carried out using the combined experience gained from field results, model study results and theoretical investigations. The position of the electrodes when anomalous values are measured is important in the interpretation.

In the field procedure, the interval over which the potential differences are measured is the same as the interval over which the electrodes are moved after a series of potential readings has been made. One of the advantages of the induced polarization method is that the same equipment can be used for both detailed and reconnaissance surveys merely by changing the distance (X) over which the electrodes are moved each time. In the past, intervals have been used ranging from 25 feet to 2000 feet for (X). In each case, the decision as to the distance (X) and the values of (n) to be used is largely determined by the expected size of the mineral deposit being sought, the size of the expected anomaly and the speed with which it is desired to progress.

The diagram in Figure A demonstrates the method used in plotting the results. Each value of the apparent resistivity, apparent metal factor, and apparent per cent frequency effect is plotted and identified by the position of the four electrodes when the measurement was made. It can be seen that the values measured for the larger values of (n) are plotted farther from the line indicating that the thickness of the layer of the earth that is being tested is greater than for the smaller values of (n); i. e. the depth of the measurement is increased. When the F. E. values are plotted as superscripts to the MF values the third section of data values is not presented and the F. E. values are not contoured.

METHOD USED IN PLOTTING DIPOLE-DIPOLE INDUCED POLARIZATION AND RESISTIVITY RESULTS

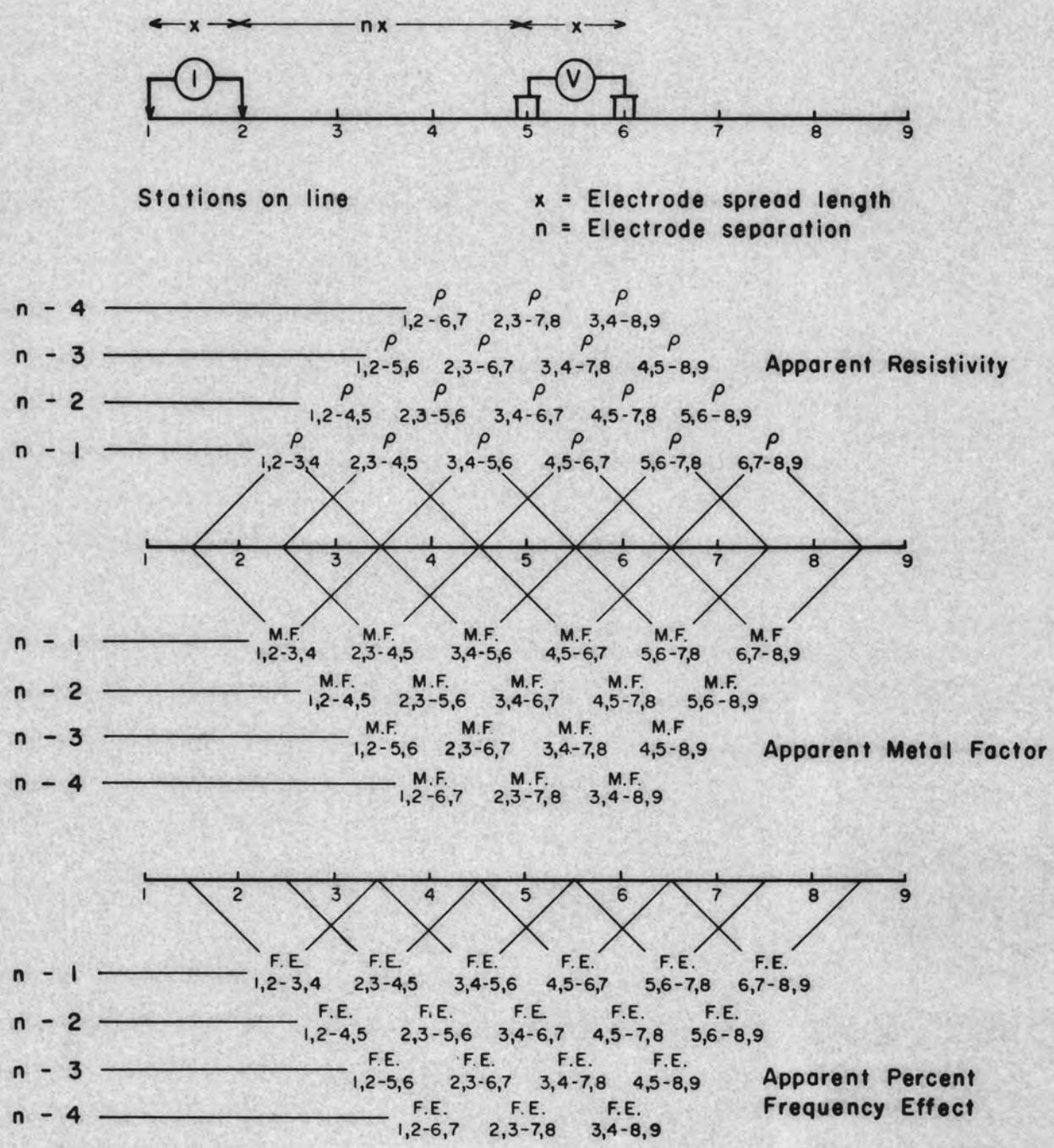


Fig. A

McPHAR GEOPHYSICS

REPORT ON

ADDITIONAL GEOPHYSICAL INVESTIGATIONS

ON THE

GRAND REEF GRID

MUELLER PROJECT, GRAHAM CO., ARIZONA

FOR

THE RALPH M. PARSONS COMPANY

---

1. INTRODUCTION

During the summer of 1968 we carried out reconnaissance induced polarization and resistivity surveys on parts of three grids in the Mueller Project area, Graham County, Arizona and the results were presented in our report dated September 30, 1968. Two zones of probable and possible anomalies were found on the Grand Reef Grid and additional work was recommended in an attempt to confirm the presence of subsurface metallic mineralization. Some additional work was completed in October and the results are presented in the following report.

2. PRESENTATION OF RESULTS

The Induced Polarization and Resistivity results are shown on the following data plots in the manner described in the notes preceding this report.

Line 33,800S	1,000 foot spreads	Dwg. IP 5197-1
Line 34,600S	750 foot spreads	Dwg. IP 5197-2

Line 35, 100S	750 foot spreads	Dwg. IP 5197-3
Line 35, 100S	750 foot spreads	Dwg. IP 5197-4
Line 35, 100S	500 foot spreads	Dwg. IP 5197-5

The gravity profile along Line 33, 800S is shown on Dwg. No. G-5198.

Enclosed with this report is Dwg. I.P.P. 4440 R, a revised plan map of the Main Grid at a scale of 1" = 1,000'. The definite and possible induced polarization anomalies are indicated by solid and broken bars respectively on this plan map as well as the data plots. These bars represent the surface projection of the anomalous zones as interpreted from the location of the transmitter and receiver electrodes when the anomalous values were measured.

Since the induced polarization measurement is essentially an averaging process, as are all potential methods, it is frequently difficult to exactly pinpoint the source of an anomaly. Certainly, no anomaly can be located with more accuracy than the spread length; i.e. when using 1,000' spreads the position of a narrow sulphide body can only be determined to lie between two stations 1,000' apart. In order to locate sources at some depth, larger spreads must be used, with a corresponding increase in the uncertainties of location. Therefore, while the centre of the indicated anomaly probably corresponds fairly well with source, the length of the indicated anomaly along the line should not be taken to represent the exact edges of the anomalous material.

3. DISCUSSION OF RESULTS

Line 33, 800S

The reconnaissance survey results indicated a probable anomaly

extending across the western part of the grid from Line 31,200S to Line 36,400S, still open to the north, south and west. It was recommended that one traverse be extended to the west to determine the full width of the zone and that the anomaly should then be checked at low frequency to test for any possible inductive coupling effects. As a further check, a gravity profile was also recommended to determine the approximate depth to bedrock.

Line 33,800S has now been extended to station 130W, using 1,000 foot dipoles and frequencies of 0.3 and 2.5 cps. The results indicate a probable shallow anomaly (relative to the electrode interval) from about 20E to 40W, with weaker extensions to 50E and 50W. The resistivity level is low from 30E to 40W and quite uniform for all five separations. The apparent frequency effects (and Metal Factor values) are about equal to the expected effects from inductive coupling. Since the anomaly has not been confirmed by checking with low frequencies it is not possible to state unequivocally whether the source is sub-surface metallic mineralization, inductive coupling or a combination of the two.

A gravity profile has also been run along this line and the results are shown on Dwg. G-5198. There is a well defined gravity low, centred at station 20W, that correlates with the gravel-filled valley. It is not possible to do an exact interpretation of bedrock depth from a single profile but a semi-quantitative analysis has been made using the formula developed by Brant (1) and assuming a certain density contrast between the basement

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1. Brant, Arthur A.; Geophysics in the Exploration for Arizona Porphyry Coppers; Geol. of the Porphyry-Coppers, Titley & Hicks, 1966.

rocks and the clastic sediments. This method suggests a depth of 400' - 500' which we understand is in general agreement with limited well data from this area. Consequently, the observed IP effects must originate from the basement rather than from a thick layer of conductive overburden.

Line 34, 600S

A second anomalous zone was indicated by the original survey just to the west of the Grand Reef prospect and further investigation was recommended. The strongest anomaly was obtained on Line 35, 100S and it was suggested that this be confirmed by detailing and intermediate parallel lines. Line 34, 600S would be 500 feet north of reconnaissance Line 35, 100S and was surveyed with 500 foot dipoles. There is a low magnitude, probable anomaly centred at station 77.5E, with considerable depth to the top of the source. This feature correlates with the previous zone.

In addition there is a possible shallow anomaly at 92.5E and an incomplete anomaly at 115E, but these indications are too weak to be of prime interest.

Line 35, 100S

This line was surveyed twice with 750 foot dipoles, using different stations, and also with 500 foot dipoles. The results with 750 foot dipoles indicate a probable deep source of low to moderate magnitude centred at about 80E, confirming the original data.

With 500 foot dipoles there is a narrow shallow anomaly at 70E to 75E that increases in magnitude with depth. The shallow part of the anomaly is not too apparent with the larger electrode intervals, presumably

because of the size factor.

4. SUMMARY AND RECOMMENDATIONS

The additional IP work on Line 33,800S has defined the western edge of the IP zone but the anomaly has still not been confirmed by checking with low frequencies. A single gravity profile has been surveyed along this traverse and there is a distinct low over the alluvium filled valley. Semi-quantitative analysis of the gravity data suggests only a few hundred feet of overburden, which we believe is consistant with local well data. From this it seems reasonable to conclude that the probable IP anomaly represents a large volume of weak metallic mineralization in the bedrock.

Additional investigations in the vicinity of the Grand Reef prospect have confirmed the presence of a narrow, low magnitude zone trending in a north-south direction. The main source appears to be at considerable depth although there is a weak extension of the anomaly to shallow depth. The anomaly is not strong and therefore would not be of prime interest unless the geological conditions suggest the possibility of vein or replacement type deposits.

McPHAR GEOPHYSICS INCORPORATED

Robert A. Bell

Robert A. Bell,
Geologist.

David K. Fountain

David K. Fountain, pu SRP
Geophysicist.

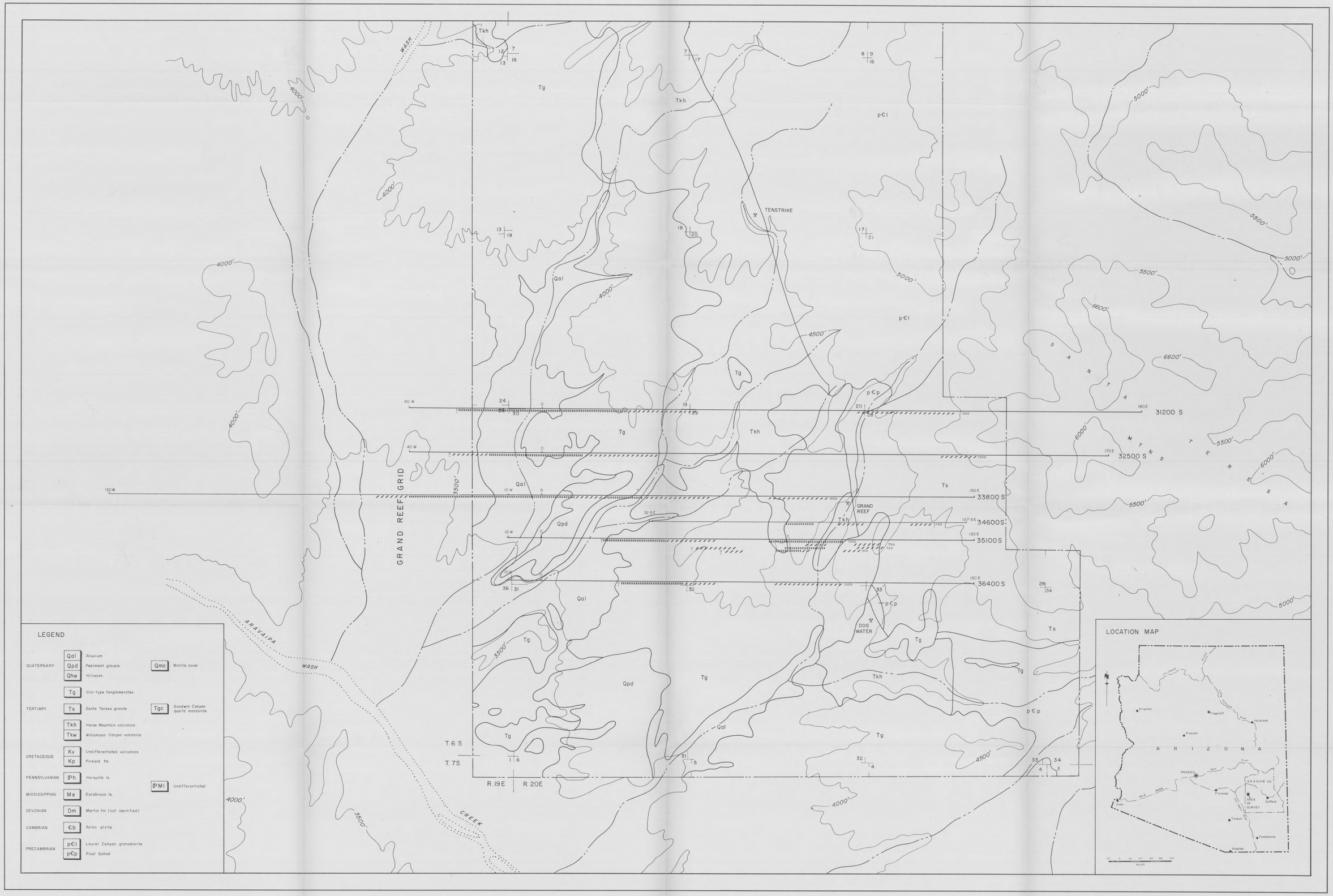
Dated: November 13, 1968

Dwg. I.P.P. 4440 R

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY

PLAN MAP



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE

PROBABLE

POSSIBLE

Number at the end of anomaly indicates spread used

THE RALPH M. PARSONS COMPANY

SHEET B - GRAND REEF GRID

MUELLER (ARAVAIPA) PROJECT, GRAHAM CO. ARIZONA

SCALE

FEET 1000 0 1000 2000 3000 4000 5000 FEET

1 INCH EQUALS 1000 FEET

SHEET LAYOUT

A

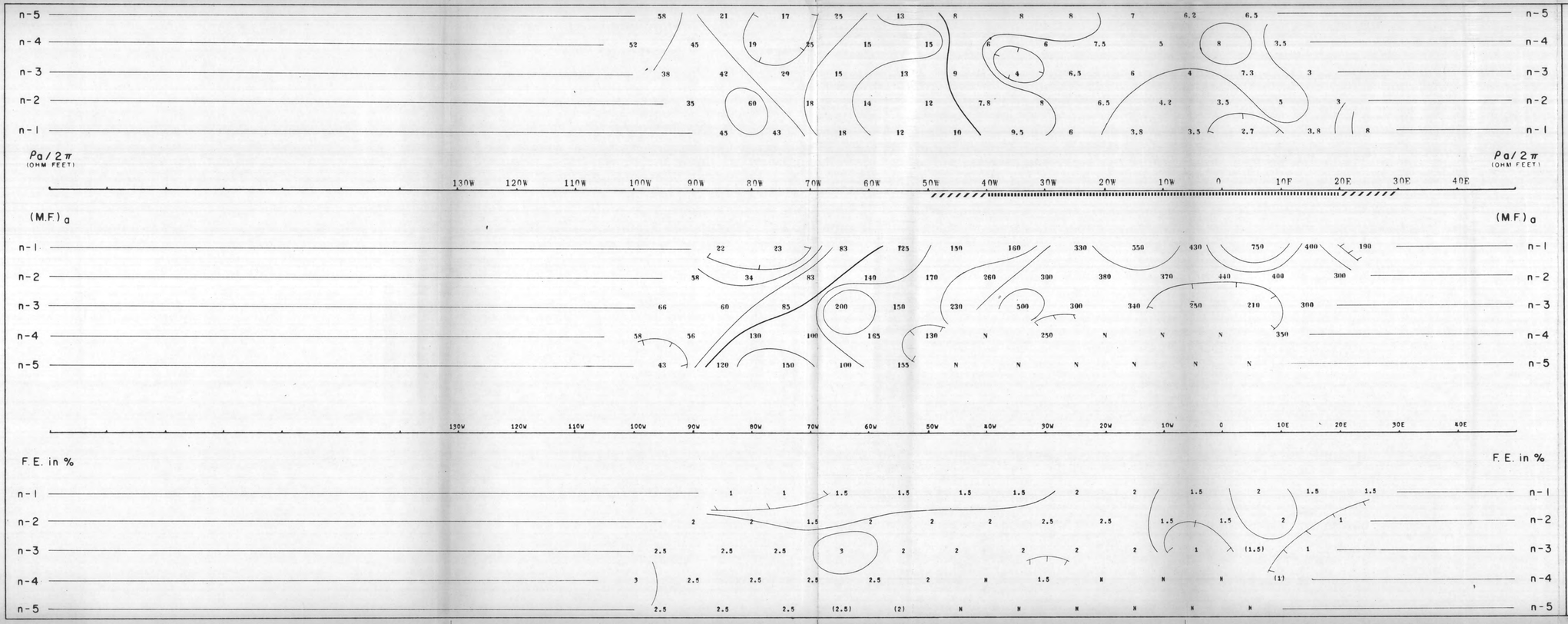
THIS SHEET B

REVISED PC DATE NOV. 1968 APPROVED R.A. Bell DATE Nov. 13/68.

DRAWN MCC DATE AUG 1968 APPROVED R.A. Bell DATE Sept. 26/68.

DWG. IPP-4440-R

DWG. IPP-4440-R



DWG NO.-IP-5197-1

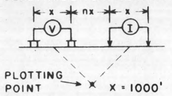
THE RALPH M. PARSONS CO.

MUELLER ARAVAIPA PROJECT

SAFFORD AREA GRAHAM CO. ARIZONA

LINE NO.- 33,800S

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES 0·31-2·5 CPS

DATE SURVEYED OCT. 1968

APPROVED

NOTE CONTOURS AT LOGARITHMIC INTERVALS 1-1·5-2-3-5-7·5-10

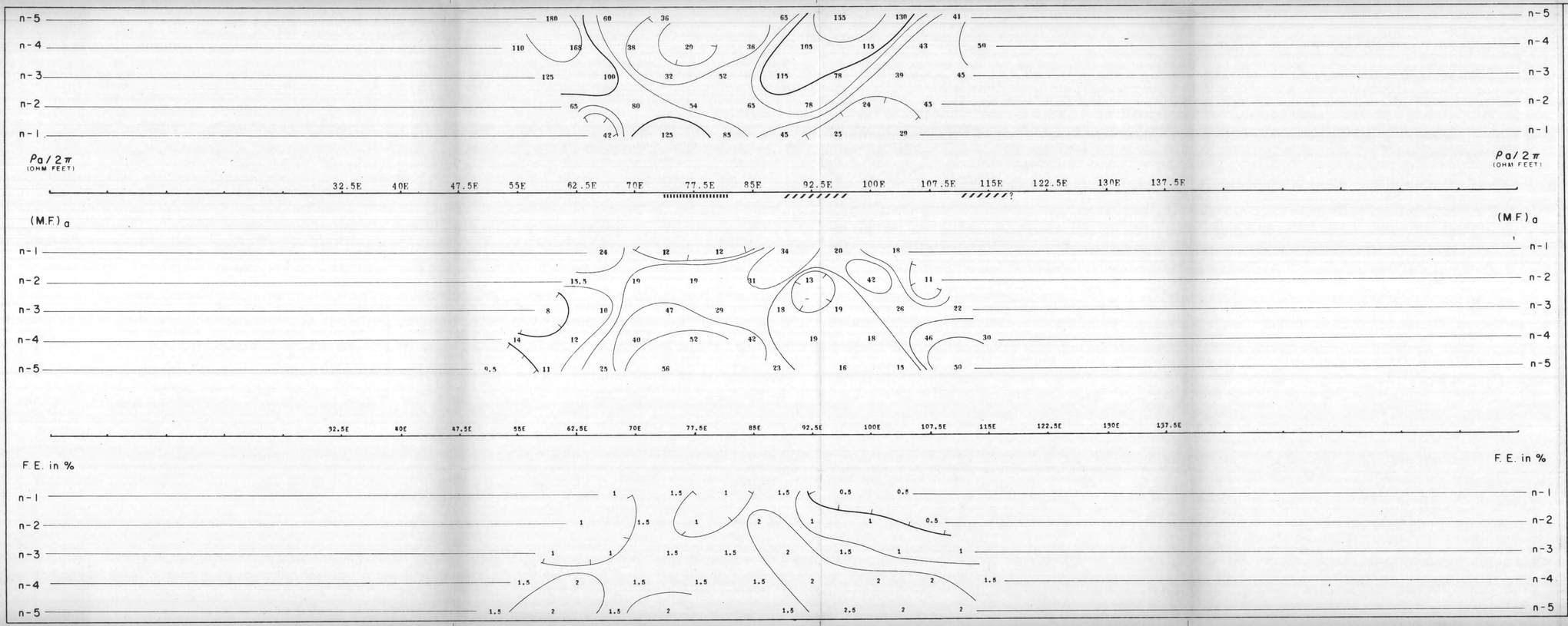
DATE

REGISTERED GEOLOGIST CERTIFICATE NO. ROBERT ALAN BELL ARIZONA, U.S.A.

McPHAR

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY



DWG NO - I.P - 5197-2

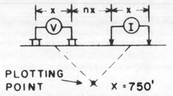
THE RALPH M. PARSONS CO.

MUELLER ARAVAIPA PROJECT

SAFFORD AREA GRAHAM CO. ARIZONA

LINE NO.- 34,600 S

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES 0·31-2·5 CPS

DATE SURVEYED OCT. 1968

APPROVED

NOTE CONTOURS AT LOGARITHMIC INTERVALS 1-1·5-2-3-5-7·5-10

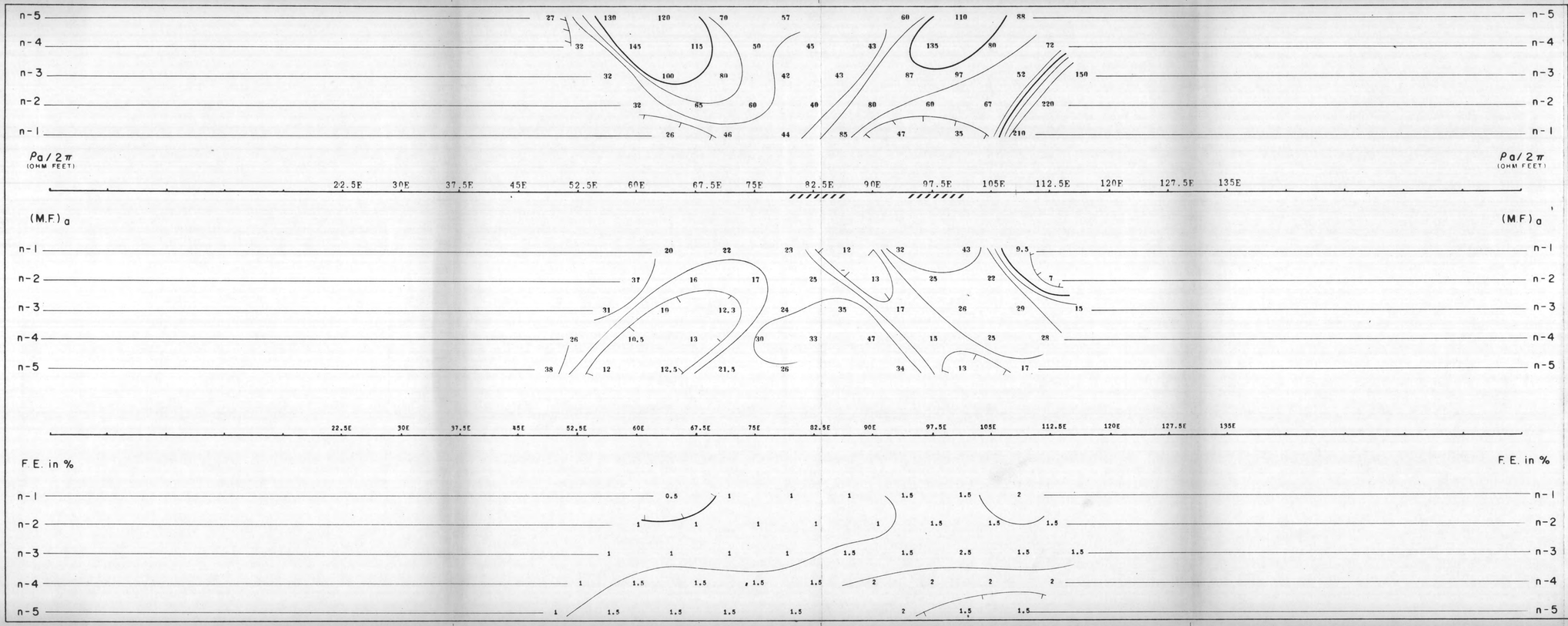
DATE

REGISTERED GEOLOGIST CERTIFICATE NO. ROBERT ALAN BELL ARIZONA, U.S.A.

McPHAR

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY



DWG NO.-IP-5197-3

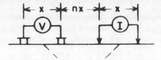
THE RALPH M. PARSONS CO.

MUELLER ARAVAIPA PROJECT

SAFFORD AREA GRAHAM CO. ARIZONA

LINE NO.- 35,100S

ELECTRODE CONFIGURATION



PLOTTING POINT X = 750'

SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES 0·31-2·5 CPS

DATE SURVEYED OCT. 1968

APPROVED

NOTE: CONTOURS AT LOGARITHMIC INTERVALS 1-1·5-2-3-5-7·5-10

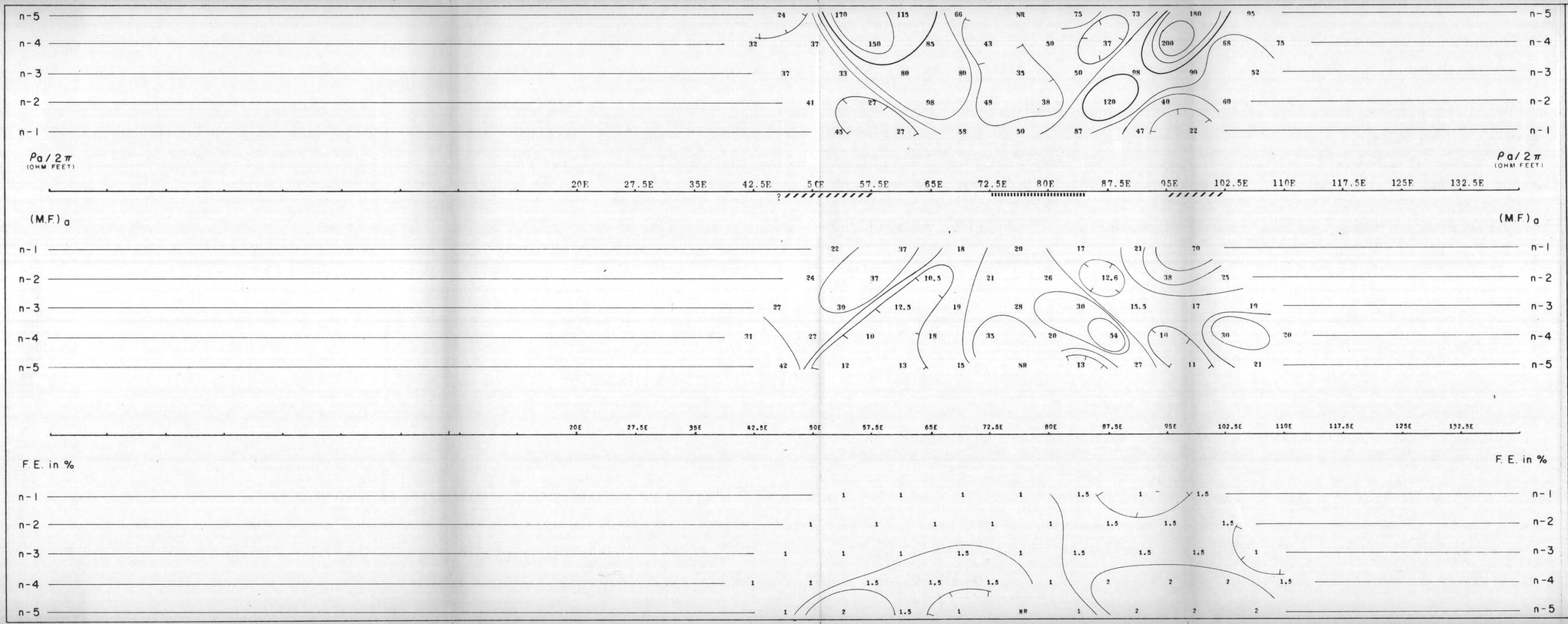
DATE

REGISTERED GEOLOGIST CERTIFICATE NO. ROBERT ALAN BELL ARIZONA U.S.A.

McPHAR

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY



DWG NO.-IP-5197-4

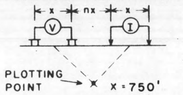
THE RALPH M. PARSONS CO.

MUELLER ARAVAIPA PROJECT

SAFFORD AREA GRAHAM CO. ARIZONA

LINE NO.- 35,100S

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE
PROBABLE
POSSIBLE

FREQUENCIES 0.31-2.5 CPS

DATE SURVEYED OCT. 1968

APPROVED

NOTE CONTOURS AT LOGARITHMIC INTERVALS 1-1.5-2-3-5-7.5-10

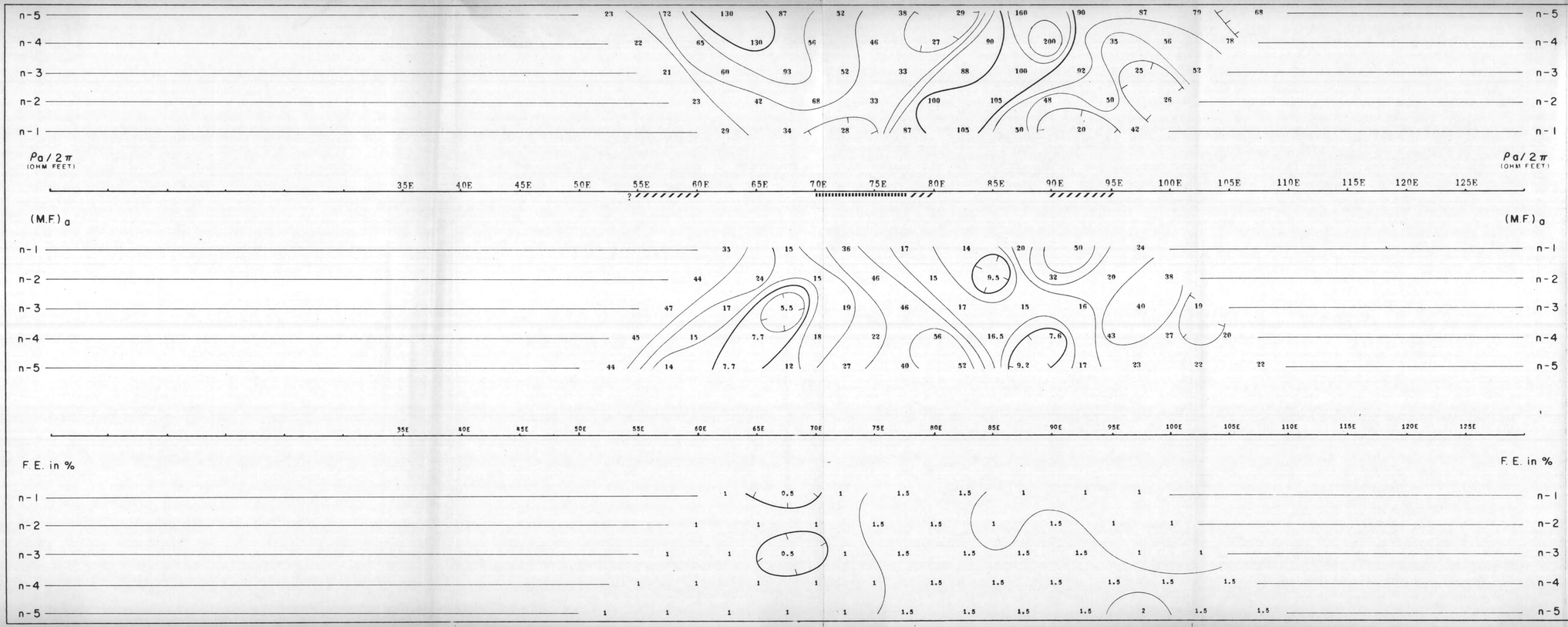
DATE

REGISTERED GEOLOGIST CERTIFICATE NO. 8511 ROBERT ALAP ARIZONA, U.S.A.

McPHAR

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY



DWG NO.-I.P-5197-5

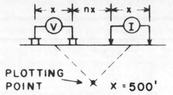
THE RALPH M. PARSONS CO.

MUELLER ARAVAIPA PROJECT

SAFFORD AREA GRAHAM CO. ARIZONA

LINE NO.- 35,100 S

ELECTRODE CONFIGURATION



SURFACE PROJECTION OF ANOMALOUS ZONES

DEFINITE

PROBABLE

POSSIBLE

FREQUENCIES 0·31-2·5 CPS

DATE SURVEYED OCT. 1968

APPROVED

DATE

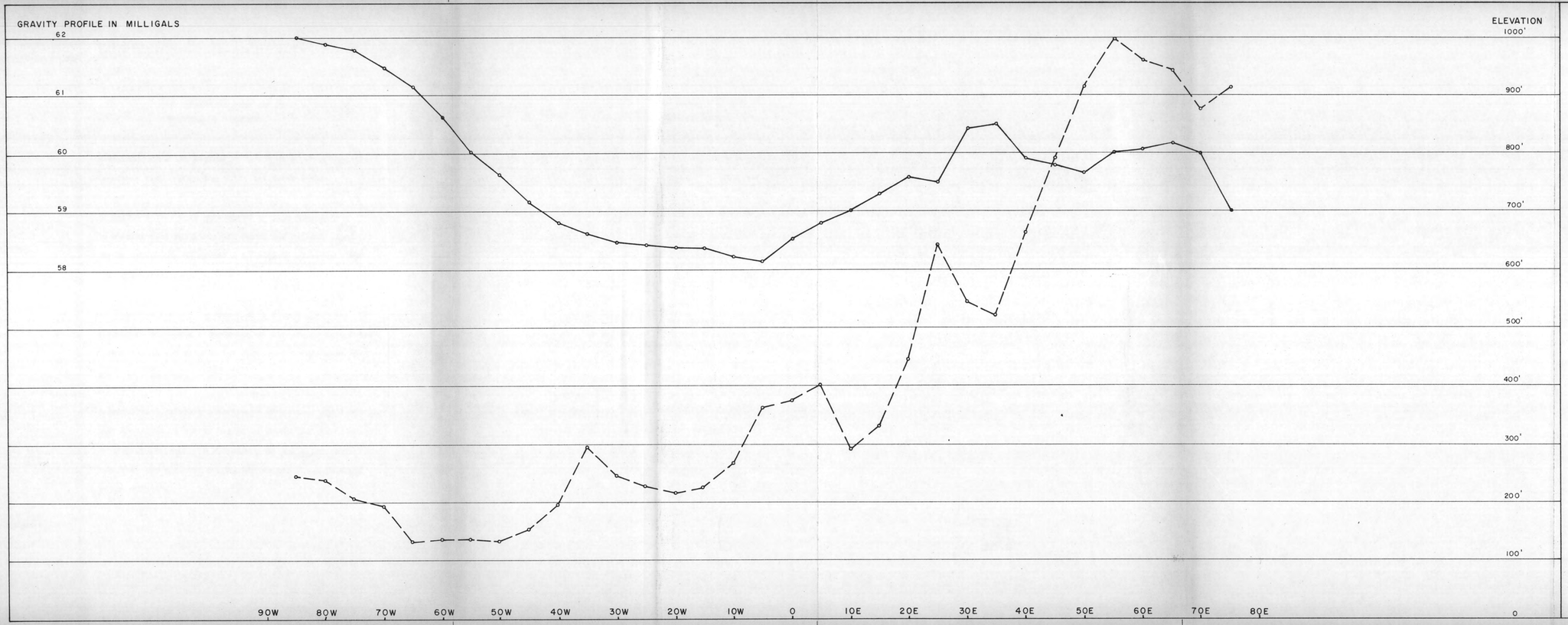
NOTE CONTOURS AT LOGARITHMIC INTERVALS 1-1·5-2-3-5-7·5-10

REGISTERED GEOLOGIST CERTIFICATE NO. ROBERT ALAN BELL ARIZONA, U.S.A.

McPHAR

McPHAR GEOPHYSICS

INDUCED POLARIZATION AND RESISTIVITY SURVEY



DWG. NO.– G-5198

THE RALPH M. PARSONS CO.

MUELLER ARAVAIPA PROJECT

SAFFORD AREA GRAHAM CO. ARIZONA

LINE NO. 33,800S

——— GRAVITY PROFILE WITH BOUGER CORRECTION.

– – – ELEVATION FROM BAROMETRIC SURVEY.

COMBINED BOUGER AND FREE-AIR CORRECTION OF 0·060 MILLIGALS PER FT.

DATE SURVEYED OCT. 1968

APPROVED R. A. Bell

DATE Nov. 11/68

REGISTERED GEOLOGIST CERTIFICATE NO. 0705 ROBERT ALAN BELL ARIZONA, U.S.A.

McPHAR GEOPHYSICS

RECONNAISSANCE GRAVITY SURVEY

APPENDIX B

GEOCHEMICAL DETAIL

PARSONS

APPENDIX B

GEOCHEMICAL SAMPLING

The following drawings show the location of, and data plots for, the rock-chip geochemical sampling in the North and South Areas.

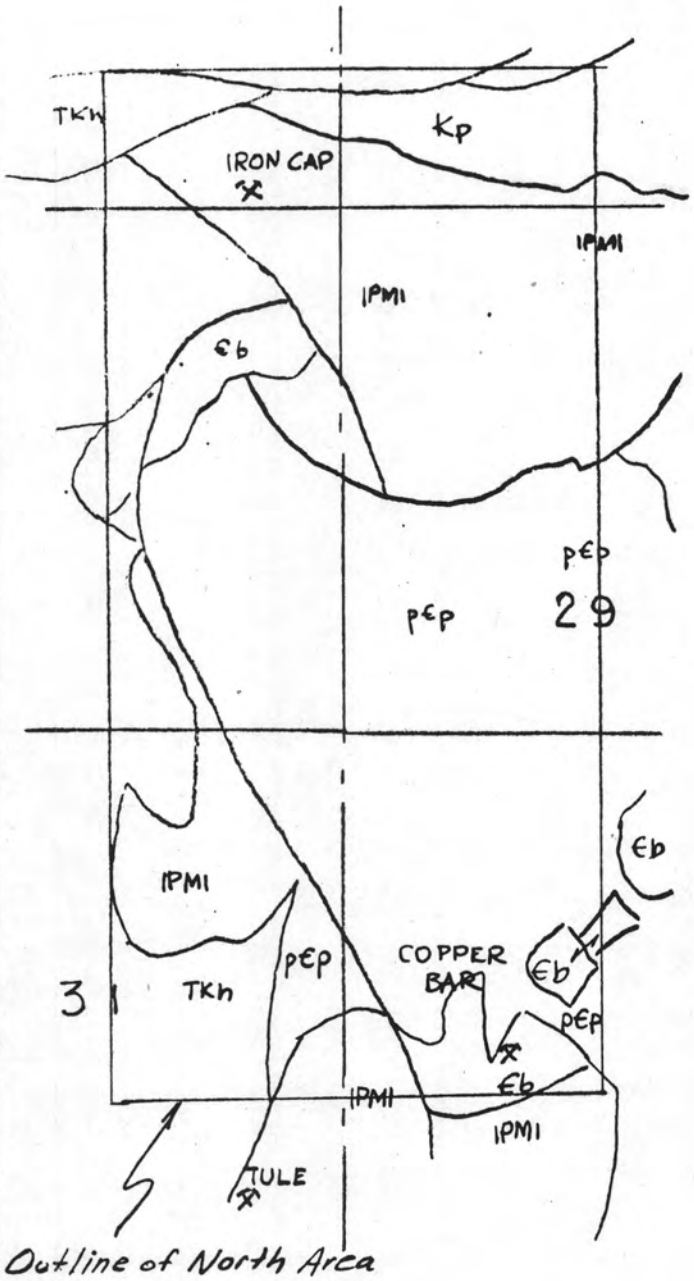
Only rock-chip sample values were considered in this evaluation; therefore, the missing data points in the parts per million [ppm] value plots may be attributed to either soil samples or areas where samples were not collected.

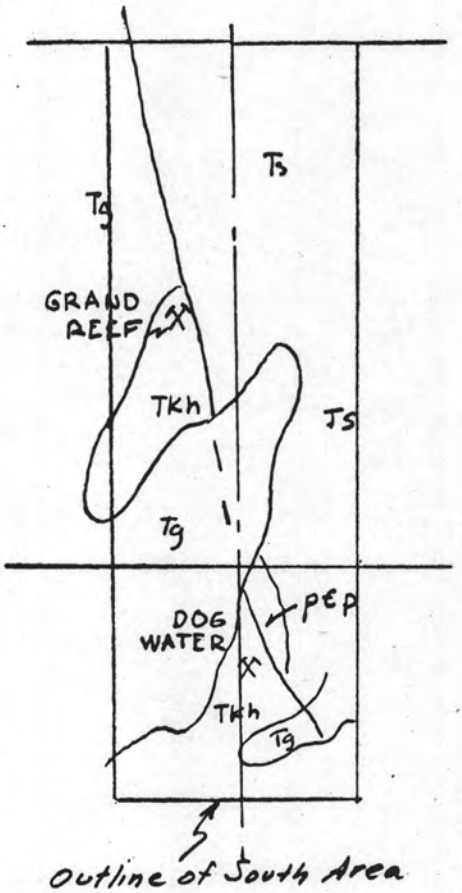
The North Area copper values are contoured at a 25 ppm interval. In this case the contours represent a smoothing of the actual data values so that absolute highs do not appear, but anomalies become more easily recognizable.

The North Area molybdenum values are contoured at a three ppm interval. Since the values are small, a higher degree of resolution is necessary to reflect the anomaly patterns. A 250-foot grid was chosen for interpolation so that the absolute molybdenum values are accurately represented by the contours.

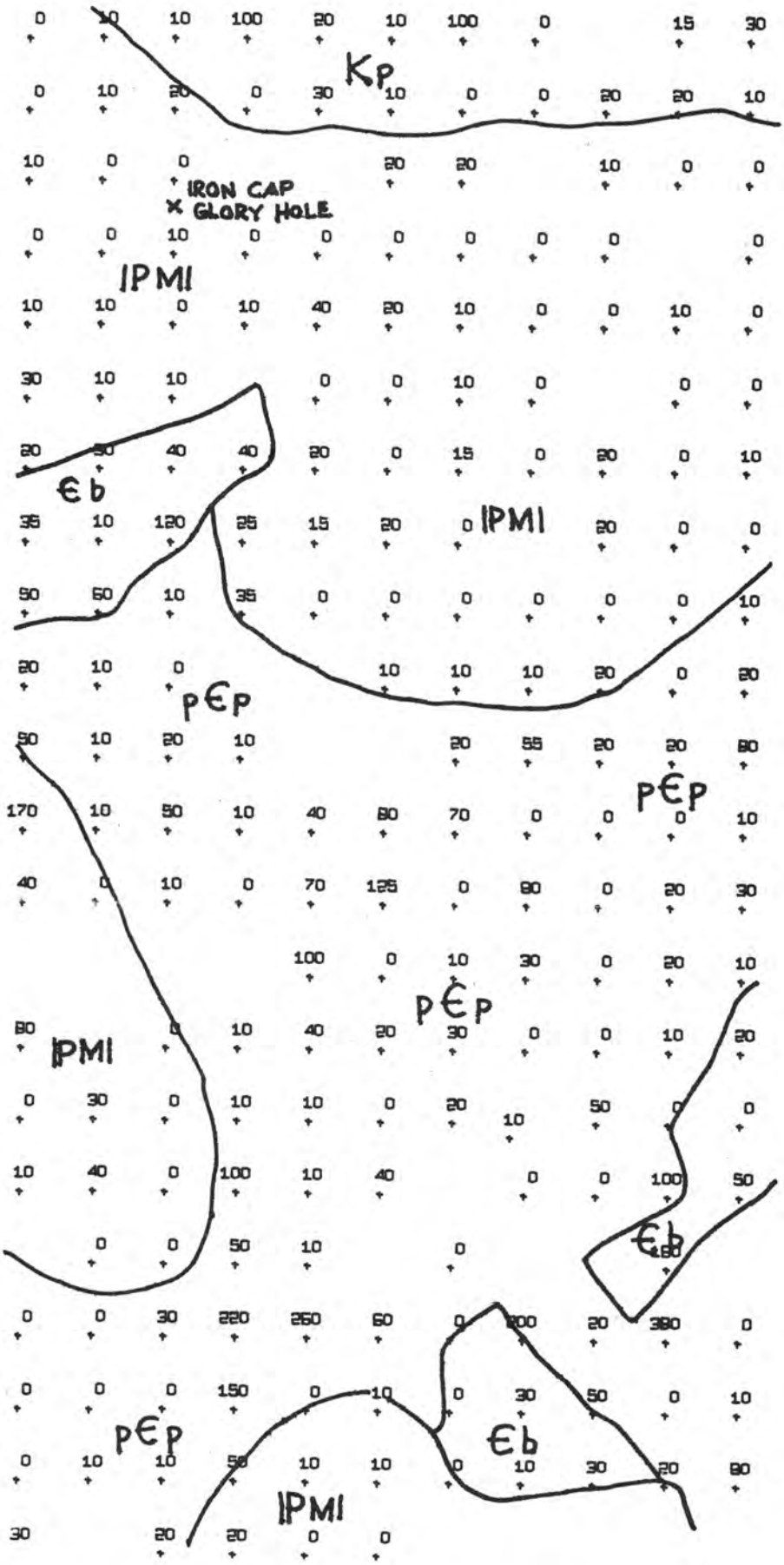
Data from the South Area is confined to a narrow strip and contouring of data points did not appear to be meaningful.

All of the data sheets have been annotated to show the rock types sampled.





LOCATION OF GEOCHEMICAL SAMPLING

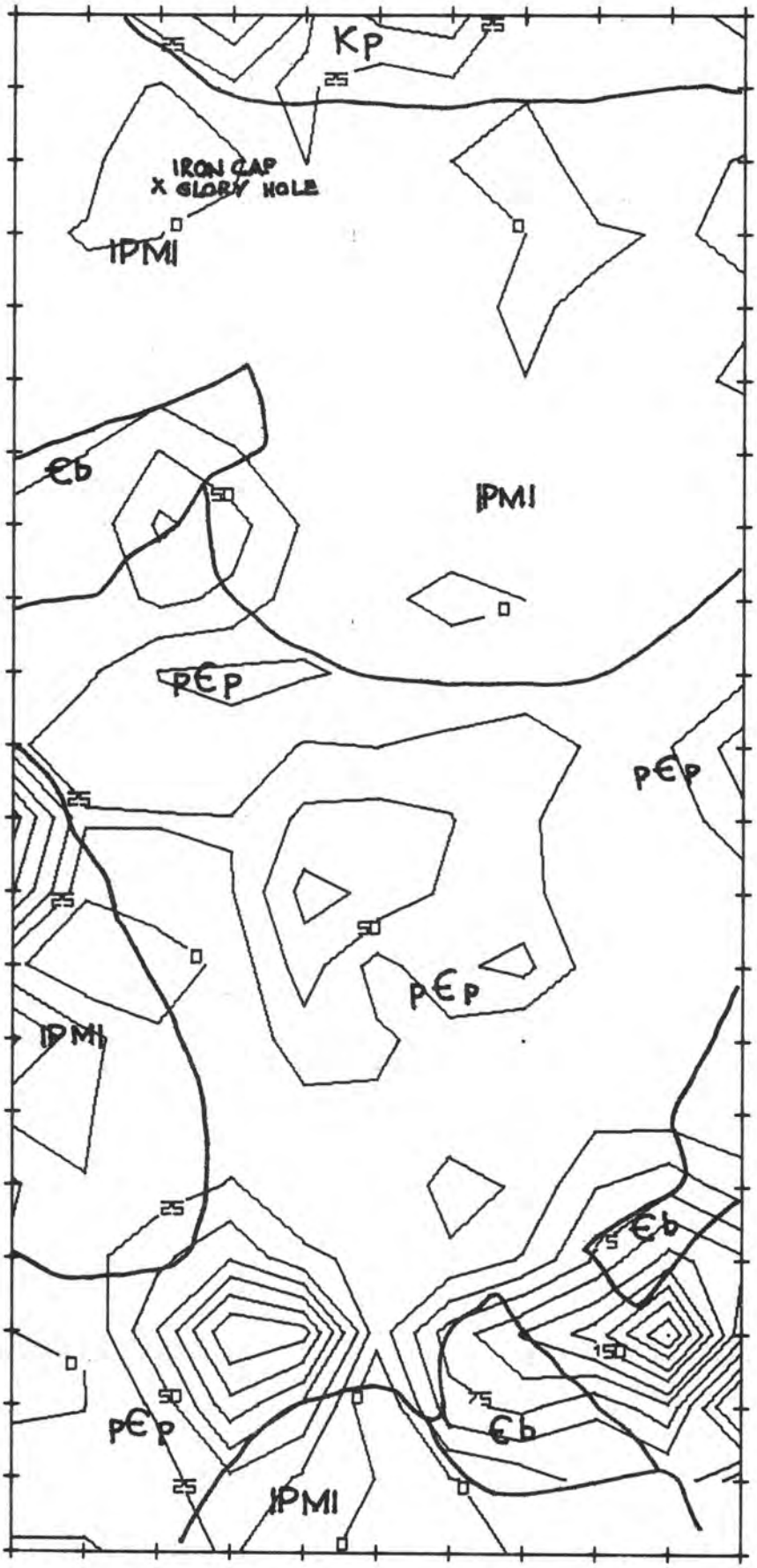


NORTH AREA COPPER VALUES PPM

~~SCALE 1 INCH 1000 FEET~~

1000 0 1000 2000 FEET

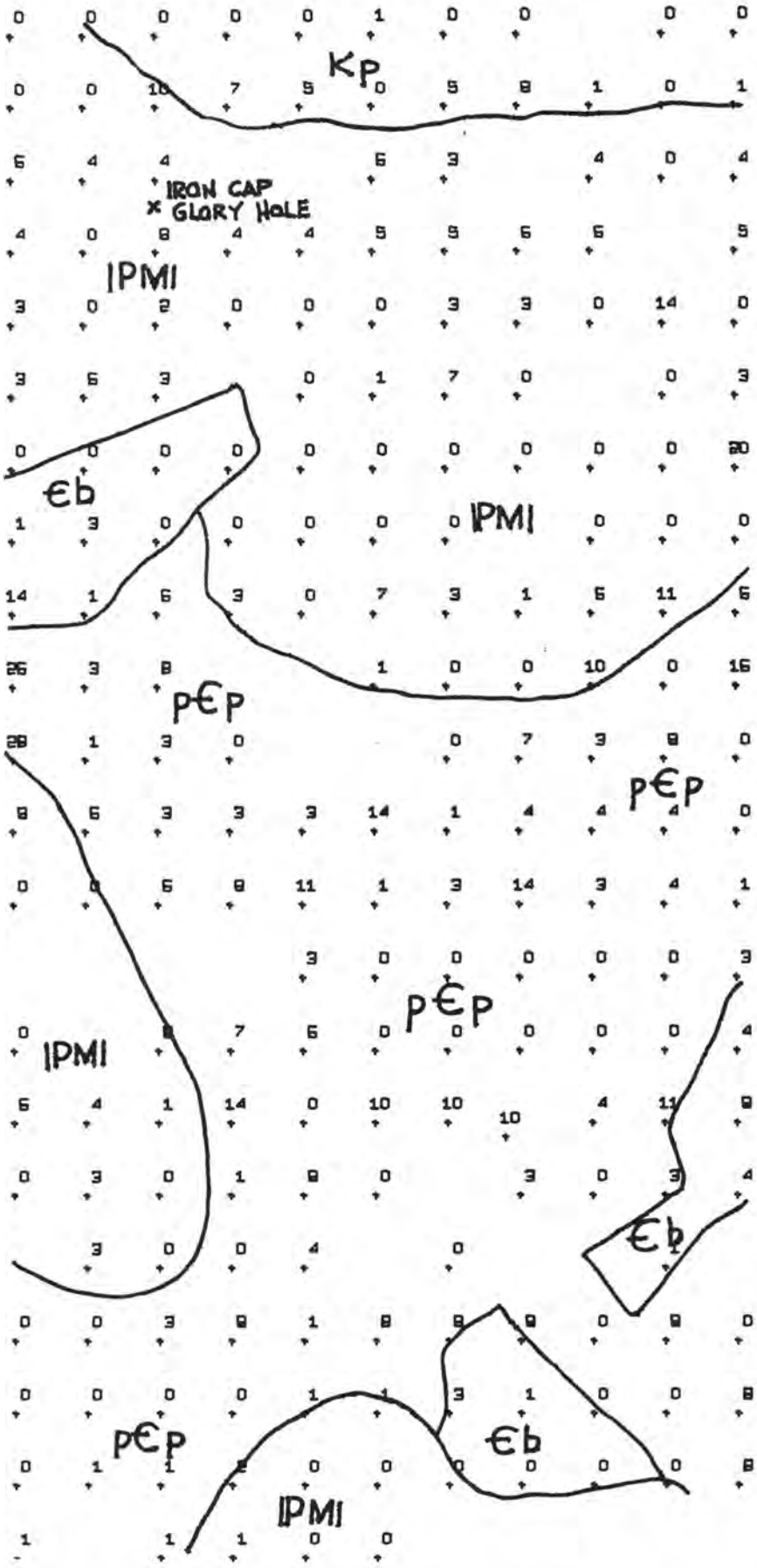
GRAPHICAL SCALE



COPPER - 25 PPM CONTOUR INTERVAL

1000 0 1000 2000 FEET

GRAPHICAL SCALE

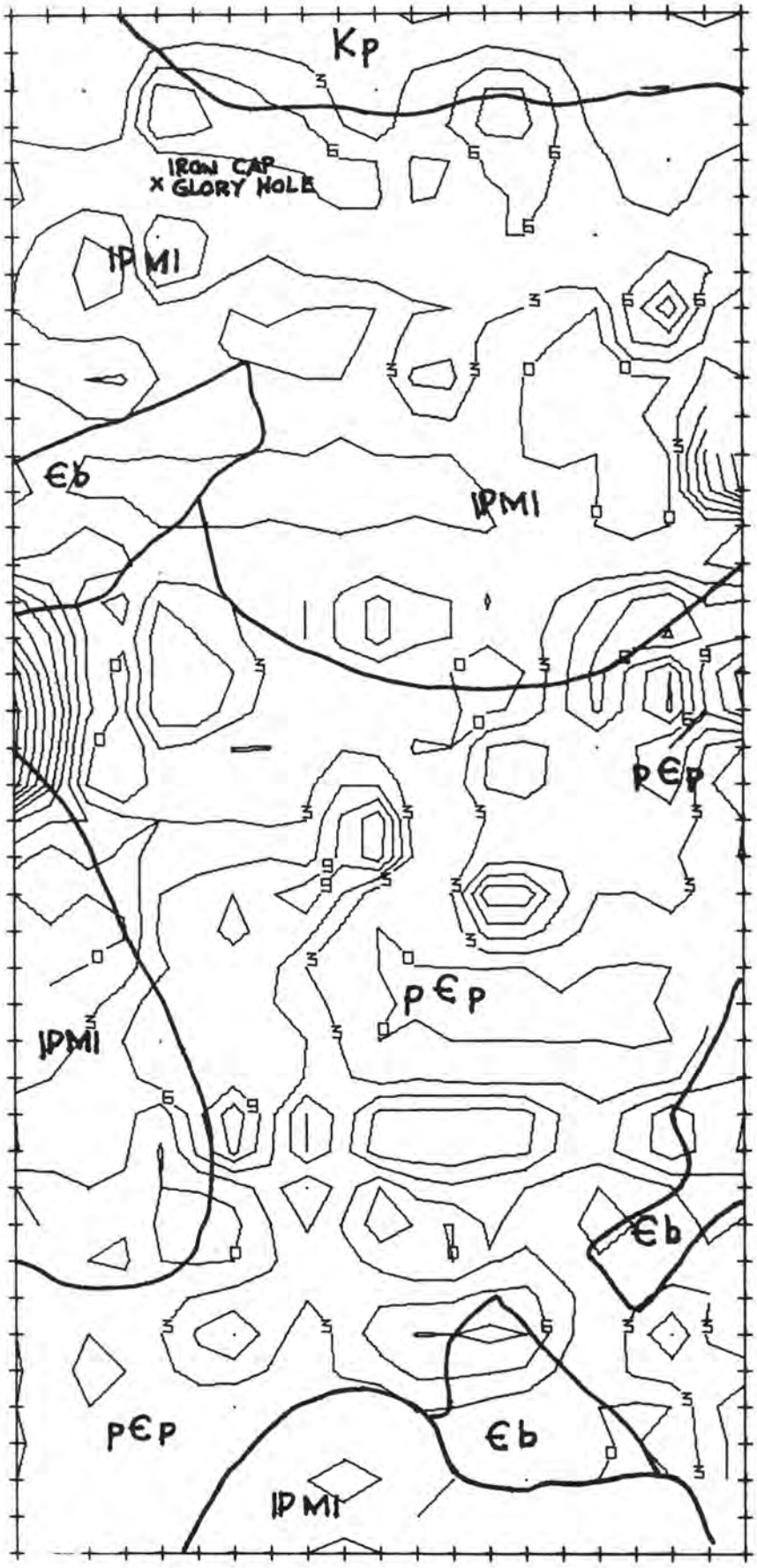


NORTH AREA MOLYBDENUM VALUES PPM

~~SCALE 1 INCH 1000 FEET~~

1000 0 1000 2000 FEET

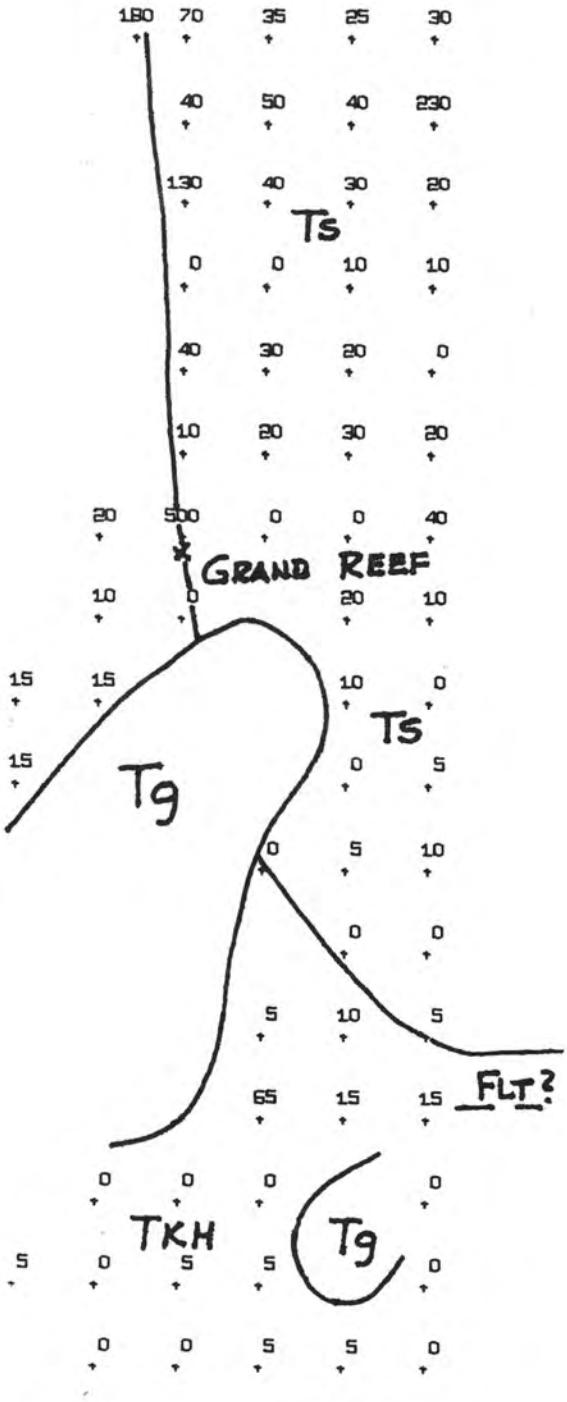
GRAPHICAL SCALE



MOLY. - 3 P.P.M. CONTOUR INTERVAL

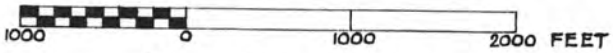
1000 0 1000 2000 FEET

GRAPHICAL SCALE

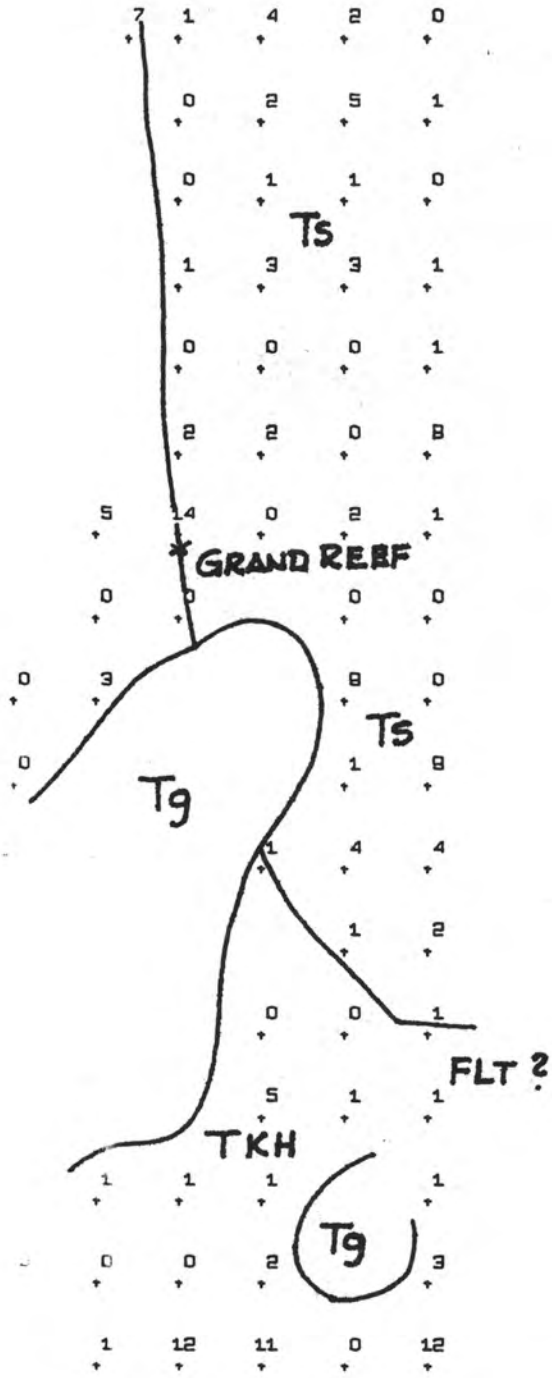


SOUTH AREA COPPER VALUES PPM

~~SCALE 1 INCH 1000 FEET~~

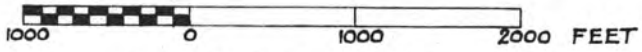


GRAPHICAL SCALE



SOUTH AREA MOLYBDENUM VALUES PPM

~~SCALE 1 INCH 1000 FEET~~



GRAPHICAL SCALE