OWNER'S CONSENT TO LIEN

WHEREAS, the undersigned, as owner, co-owner, lessor, or seller has an interest in certain property in the State of Nevada, County of Mineral, which is the subject of a proposed Exploration Project Contract, hereinafter called the "Contract", between the United States of America, hereinafter called the "Government", and 1/ Coranda Corporation, a corporation

hereinafter called the "Operator"; and

WHEREAS, under certain provisions of said Contract which are set forth on the reverse side hereof, the Government will acquire certain rights and equities which do or may conflict with or be adverse to the interest of the undersigned in said property;

NOW THEREFORE, the undersigned, in consideration of said Contract and as an inducement to the Government and Operator to enter into same, undertakes and agrees as follows:

1. The Government's equity in and right to remove facilities, buildings, fixtures, and equipment, as provided in the Contract, shall prevail over and be prior and superior to any conflicting or adverse rights of the undersigned.

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3. The undersigned shall commit no act nor assert any claim that may contravene or conflict with the lien, claim, or rights of the Government under the provisions of the said Contract. This agreement shall be binding upon the heirs, executors, administrators, successors, and assigns of the undersigned.

Dated this _____ day of April, 1952.

Esther Rose

Tom Allen

1/ Insert the name of the Operator as it will appear in the Exploration Project Contract.

2/ Insert the maximum amount of the Government's contribution.

10919

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Dated this _____ day of April, 1968.

Esther Rea

Joe Malatesta

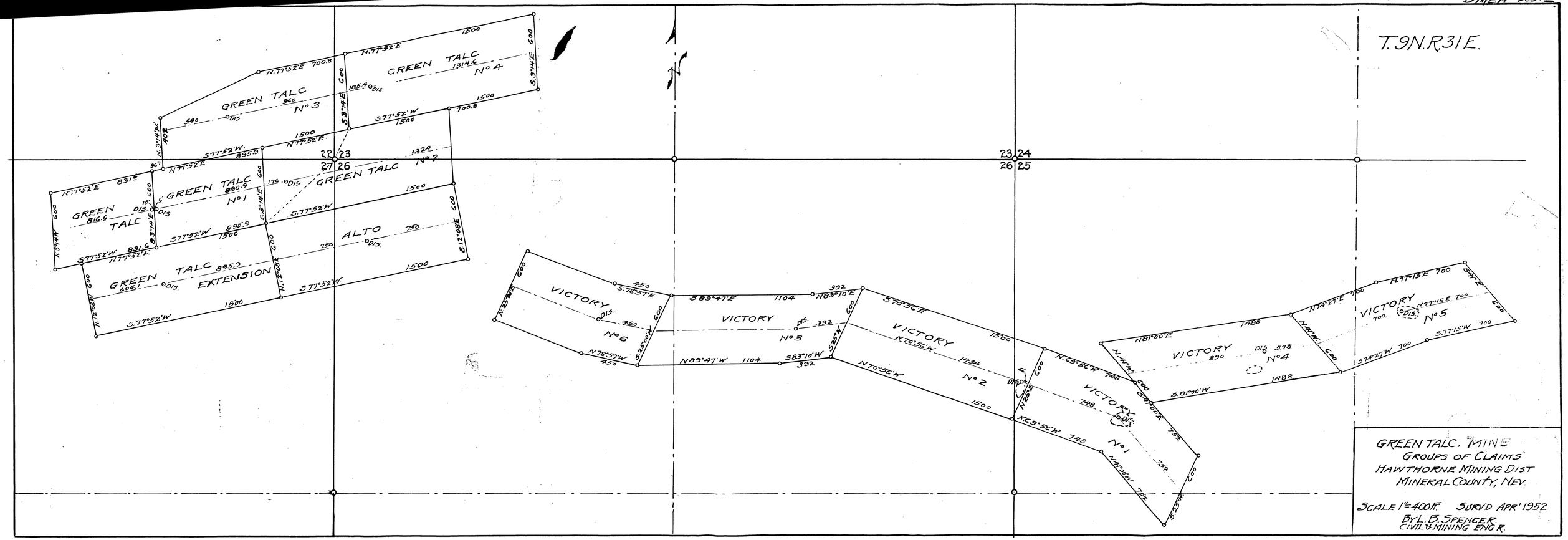
John Lucich

1/ Insert the name of the Operator as it will appear in the Exploration Project Contract.

2/ Insert the maximum amount of the Government's contribution.

10919

DMEA-2512


T.9N.R.31E.
GREEN TALC No 4
GREEN TALC No 3
GREEN TALC No 2
GREEN TALC No 1
GREEN TALC EXTENSION
ALTO
VICTORY No 6
VICTORY No 3
VICTORY No 2
VICTORY No 1
VICTORY No 4
VICTORY No 5
GREEN TALC. MINE
GROUPS OF CLAIMS
HAWTHORNE MINING DIST
MINERAL COUNTY, NEV.
SCALE 1"=400 FT. SURV'D APR' 1952
BY L. B. SPENCER
CIVIL & MINING ENG'R.

1 copy only for office or work file.

UNITED STATES
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS EXPLORATION ADMINISTRATION
WASHINGTON 25, D.C. 600

October 24, 1952

Notes of meeting with commodity specialists

Memorandum: Docket No. DMEA-2512 - Corundum
Coranda Corporation, Hawthorne, Nevada
"Bismark", "Deep", and "Green Talc" Mines.

Friday Morning 8:15 A.M. to 9:30 A.M. a meeting was held in the office of W. F. Dietrich, Room 3527, Interior, for the purpose of discussing an exploration project for the subject application.

In attendance were:

Lawrence G. Houk, Nonmetallic Minerals Divn., DMEA
Jasper T. Robertson, " " "
W. F. Dietrich, Bureau of Mines
Henry P. Chandler " "
Brooke L. Gunsallus " "
Ralph E. Van Alstine, U. S. Geological Survey

There was a discussion of the Field Team's report written by Holmes, Bodenlos and Sobel and a careful inspection was made of the maps and photographs showing outcrops of ore on the three mines. Considerable time was spent over details of sampling and drilling and particularly with respect to the "Bismark" Mine. The "Bismark" was agreed as first choice drilling and testing and the Green Talc Mine was second choice. The "Deep Mine" was not considered for a project mainly because it lay within the boundary of the Hawthorne Naval Ammunition Depot.

All agreed that a program of drilling the "Bismark" should be set up - tentatively estimated to cost about $20,000 to $22,000. Best method of sampling surface exposures was discussed. Testing and preparation of samples was discussed as were analysis and cone tests.

Marketing of product was briefly discussed.

The project was discussed from numerous angles and it was commonly agreed that exploration of extent and quality of Bismark ground by diamond drilling and surface sampling would be the best bet. An orebody 40 ft. wide by 140 ft. long could be indicated to a depth of probably 200 ft. Maybe 100,000 tons of material in one minable body.

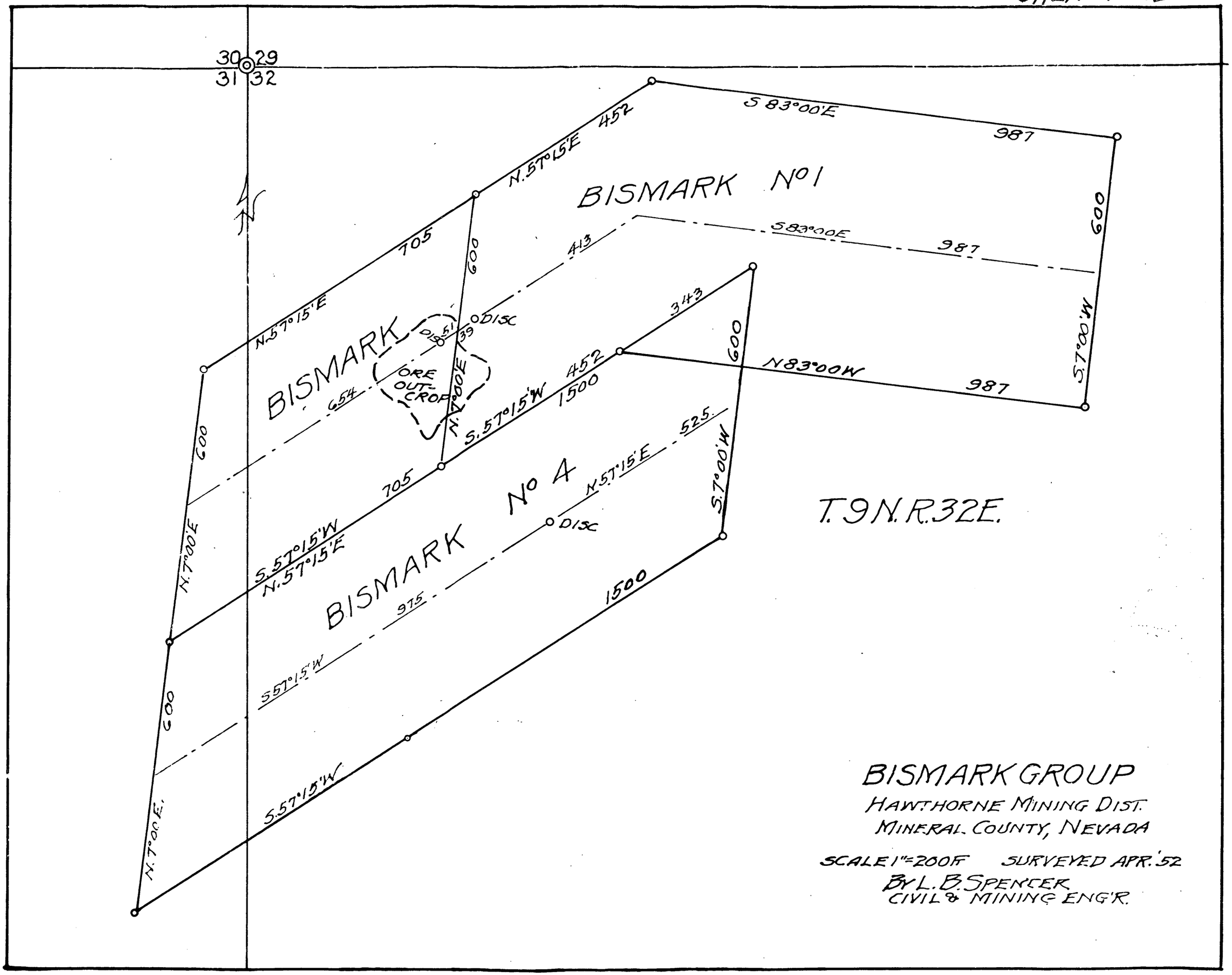
Unit cost of the work was discussed and the cost might be around $15.00 per foot. At least 1,000 ft. to 2,000 ft. of diamond drill hole would be required to test the Bismark.

Dietrich told of his recent talks with a Mr. Holt. He is the man who would most likely supervise the project for the company.

Jasper T. Robertson

Jasper T. Robertson
Nonmetallic Minerals Division

DMEA - 2512


30 29
31 32
N
BISMARK No 1
S 83°00'E
987
452
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705
600
413
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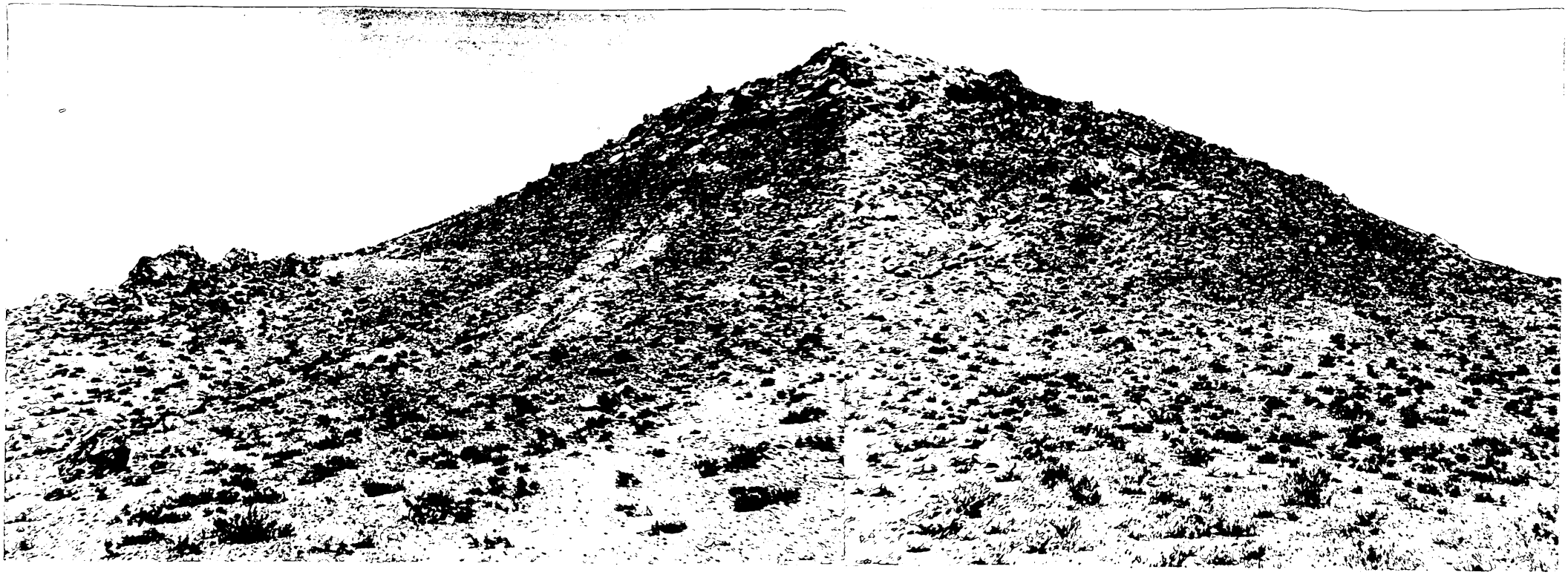
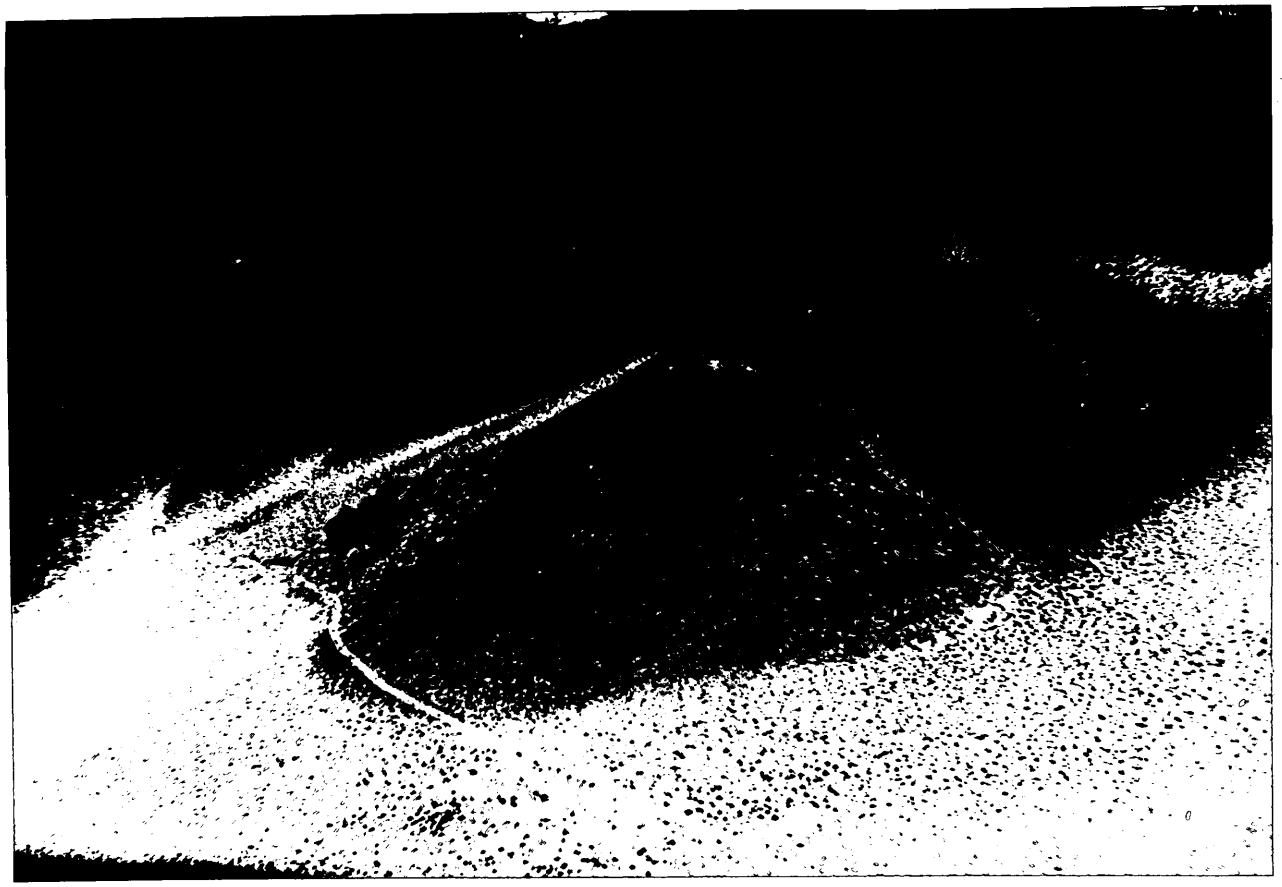
987
600
S.7°00'W
N83°00W
987
343
600
452
1500
S.57°15'W
N.7°00'E
BISMARK
ORE OUT-CROP
654
DISC
DISC
600
705
S.57°15'W
N.57°15'E
N.7°00'E
BISMARK No 4
N.57°15'E
525
S.7°00'W
DISC
975
1500
S.57°15'W
600
S.57°15'W
N.7°00'E
T.9N.R.32E.
BISMARK GROUP
HAWTHORNE MINING DIST.
MINERAL COUNTY, NEVADA
SCALE 1"=200FT
SURVEYED APR. '52
BY L. B. SPENCER
CIVIL & MINING ENG'R.



4. Panorama of Deep Mine outcrops looking North. Starting at the left working, the upper limit of the ore zone extends through the lower third of the vertical trench and rises to the upper right working and curves upward to the dark patch of rocks near the top right of the hill. It is reported that the ore zone extends beyond the lower limits of the picture.

2. Outcrop on Bismark Claim Group looking East along strike of structure.



1. Looking to North West on Bismark Claims. Outcrop in picture 2 shows at end of road to left of central hill. White spot on top of hill part of ore bearing structure strike extends left to right over hill.

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Dated this 24th day of April, 1962.

Walter Rea

E. Meredith

Joe Malatesta

John Vuich

1/ Insert the name of the Operator as it will appear in the Exploration Project Contract.

2/ Insert the maximum amount of the Government's contribution.

10919

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Dated this 24th day of April, 1952.

Esther Rose

John Tuich

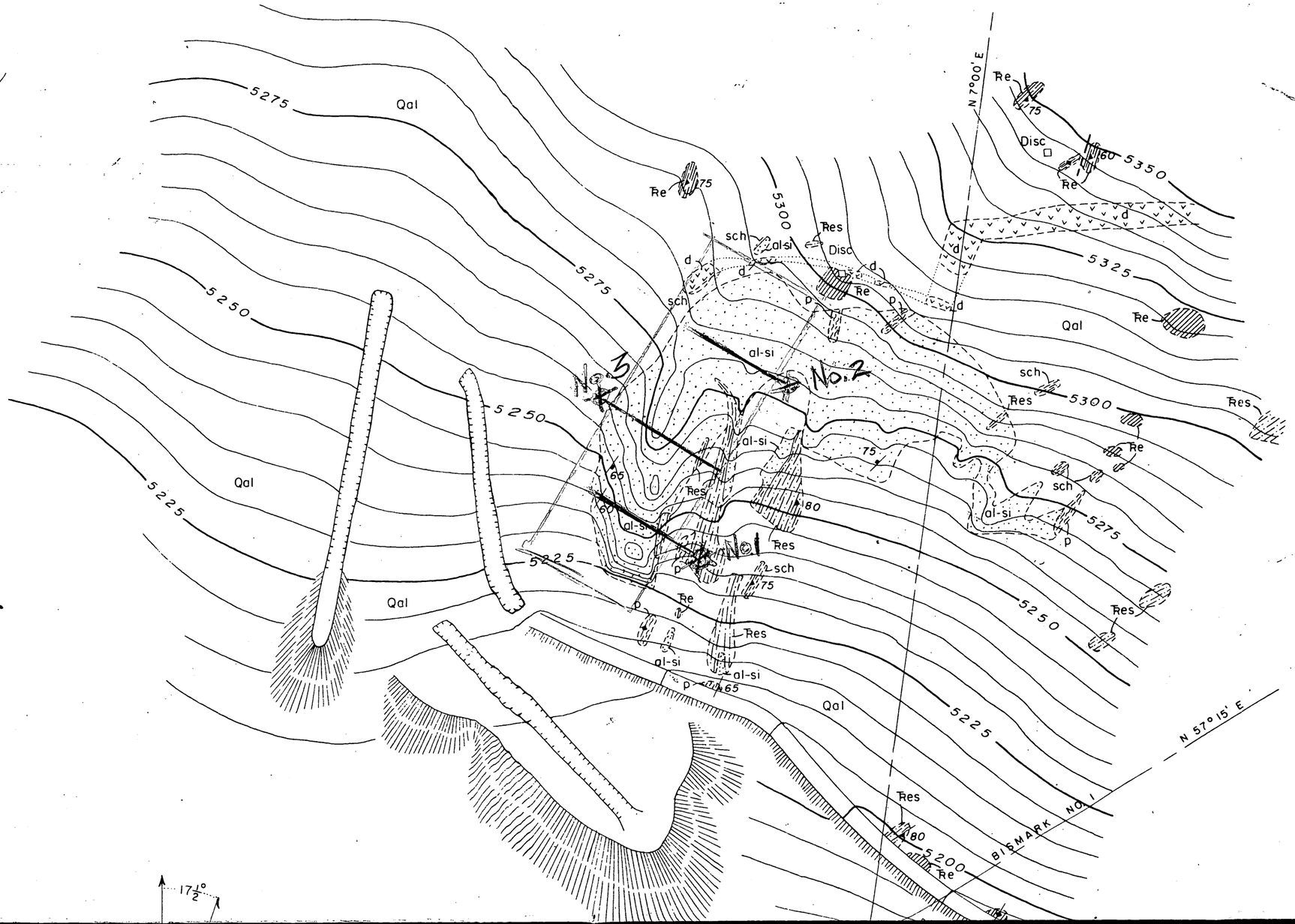
1/ Insert the name of the Operator as it will appear in the Exploration Project Contract.

2/ Insert the maximum amount of the Government's contribution.

10919

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

DMEA-2512



EXPLANATION

Qal
Sandy alluvium

Re
Metavolcanic rocks, principally meta-andesite

Res
Silicified metavolcanic rocks

sch
Schist

d
Diabase(?)

p
Green micas, possibly containing pyrophyllite

al-si
Fine-grained quartz, in part containing aluminum silicate minerals and corundum

Contact (Dashed where approximately located)

Concealed contact

Fault, approximately located

75
Strike and dip of foliation

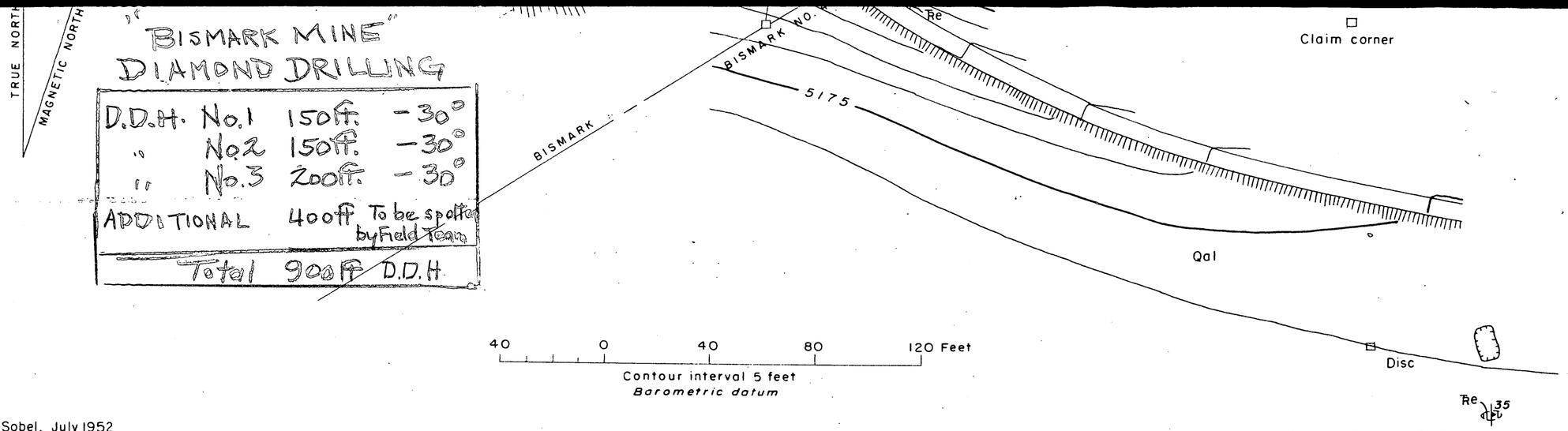
Strike of vertical foliation

60
Strike and dip of joints

Trench or open cut

Dump

□ Disc
Discovery monument



Topography by H. L. Sobel, July 1952

Geology by A. J. Bodenlos, July 1952

Figure 2

BISMARK ANALUSITE DEPOSIT, HAWTHORNE, MINERAL COUNTY, NEVADA

DOCKET NO. DMEA -2512

COMMODITY Corundum-Andalusite

UNITED STATES OF AMERICA
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS EXPLORATION ADMINISTRATION

EXPLORATION PROJECT CONTRACT[1]
(Short Form)

IT IS AGREED this _____ day of _____, 195__, between the United States of America, acting through the Department of the Interior, Defense Minerals Exploration Administration, hereinafter called the "Government," and[2] CORANDA CORPORATION (Organized under the laws of the State of Nevada), 386 Race Street, SAN JOSE, California

hereinafter called the "Operator," as follows:

ARTICLE 1. *Authority for contract.*—This agreement is entered into under the authority of the Defense Production Act of 1950, as amended, pursuant to DMEA Order 1 entitled "Government Aid in Defense Exploration Projects."

ARTICLE 2. *Operator's property rights.*—With respect to that certain land situated in the State of NEVADA, County of MINERAL, described ~~as follows:~~[3] The in Annex I property consists of two separate groups of mining locations, one a group of 7 mining location known as the Green Gale Group and the other a group of 3 contiguous mining locations known as the Bismark Mine, both located in the Hawthorne Mining District. Location and legal description more fully described in Annex I attached hereto.

the Operator represents and undertakes:[4]

(*a*) That the Operator is the owner, in possession and entitled to possession, and that the property is subject only to the following claims, liens, or encumbrances as to each of which the subordination agreement of the holder is attached: _____

(*b*) That the Operator is a lessee, in possession and entitled to possession, and the Owner's Consent to Lien is attached.

The Operator shall devote the land and all existing improvements, facilities, buildings, installations, and appurtenances to the purposes of the exploration project without any allowance for the use, rental value, depreciation, depletion, or other cost of acquiring, owning, or holding possession thereof.

ARTICLE 3. *Exploration project.*—The Operator, within ninety (90) days from the date of this contract shall commence work on a project of exploration for[5] Corundum and Andalusite in or upon the described land; and shall bring the project to completion within a period of nine (9) months from the date of this contract. The work to be performed is more fully described in Exhibit "A" attached hereto, which, with any maps or drawings thereto attached, are made a part of this contract. The Government will contribute to the cost of this work as hereafter provided. The work shall be performed by the Operator or by independent contractor or contractors efficiently, expertly, in a workmanlike manner, in accordance with good mining standards and State regulations for health and safety and for workmen's compensation and employers' liability insurance, with suitable and adequate equipment, materials, and labor, to bring the project to completion within the time fixed. The Government shall have the right to enter and observe and inspect the work at all reasonable times, and the Operator shall provide the Government with all available means for doing so. The Government may consult with and advise the Operator on all phases of the work.

ARTICLE 4. *Costs of the project.*—The agreed, estimated costs of performing the work, expressed in terms of units of work to be performed (per foot of drifting, per foot of drilling, per cubic yard of material to be moved, etc.) are set forth in Exhibit "A," attached hereto. The Government will pay ninety (90) percent of these agreed, estimated costs, as they accrue, for units of work actually performed that conform with the description or specifications for the work set forth in this contract, in an aggregate total amount not in excess of $32,400.00, which is 90 percent of $36,000.00, the agreed, estimated total cost of the project in which the Government will participate: *Provided,* That until the Operator's final report and final accounting have been rendered to the Government and any final check or auditing required by the Government has been made, and a final settlement of the contract has been made, the Government may withhold from the last voucher or vouchers such sums as it sees fit not in excess of ten (10) percent of the maximum total which the Government might have been called upon to pay under the terms of the contract. The Government may, as it sees fit, make payments direct to the Operator's independent contractors, if any, for the account of the Operator, rather than to the Operator.

ARTICLE 5. *Reports, accounts, audits.*—(*a*) *Progress reports.* The Operator shall provide the Government with monthly reports of units of work performed under the contract, in quintuplicate (five copies), upon forms provided by the Government. These progress reports shall be certified by the Operator, and shall constitute both the Operator's invoice of units of work performed on the project during the period covered by the report and his voucher for repayment by the Government, unless the Government requires the use of a standard voucher form with invoice attached. Progress reports shall include surface and/or underground engineering-geological maps or sketches showing the progress of the exploration, with assay-reports on samples taken concurrently with the advance in mineralized ground.

[1] If sufficient space is not provided in any blank, use an extra sheet of paper and refer to it in the blank.
[2] State name, address, and nature of organization if any.
[3] Give legal description or enough to identify the property, particularly excluding any land or interest therein to which the Government's lien is not to attach or the production from which is not to be subject to the Government's percentage royalty.
[4] Strike out the provision not applicable.
[5] Name of mineral or minerals.

(*b*) *Final report.*—Upon completion of the exploration work or termination of the contract the Operator shall pro Government with an adequate geological and engineering report, in quintuplicate (five copies), including an estimate reserves resulting from the exploration work.

(*c*) *Compliance with requirements.*—If, in the opinion of the Government, any of the Operator's reports are insuffici or incomplete, the Government may procure the making or completion of such reports and attachments as an expense of th exploration work; and the Government may withhold approval and payment of any vouchers depending upon insufficient or incomplete reports.

(*d*) *Accounts and audits.*—The Operator shall keep suitable records and accounts of the units of work performed, which the Government may inspect and audit at any time. The Government may at any time require a check of the work performed and an audit of the Operator's records and accounts, by a certified public accountant or otherwise, the cost thereof to be treated as a cost of the project. The Operator shall keep and preserve said records and accounts for at least 3 years after the completion of the project or the termination of this contract. Upon the completion of the project or termination of the contract the Operator shall render a final account and statement of work performed to accompany his final report.

ARTICLE 6. *Repayment by Operator.*—(*a*) If, at any time, the Government considers that a discovery or a development from which production may be made has resulted from the exploration work, the Government, at any time not later than 6 months after the Operator has rendered the required final report and final account, may so certify in writing to the Operator. The certification shall describe broadly or indicate the nature of the discovery or development. In the event of such certification, any minerals mined or produced from the land described in Article 2 within 10 years from the date of this contract, including any mined or produced before the certification, shall be subject to a percentage royalty which the Operator or his successor in interest shall pay to the Government, upon the net smelter returns, the net concentrator returns, or other net amounts realized from the sale or other disposition of any such production, in whatever form disposed of, including ore, concentrates, or metal, until the total amount contributed by the Government, without interest, is fully repaid, or said 10 years have elapsed, whichever occurs first, as follows:

(1) One and one-half (1½) percent of any such net amounts not in excess of eight dollars ($8.00) per ton.

(2) One and one-half (1½) percent of any such net amounts, plus one-half (½) percent of such net amounts for each additional full fifty cents ($0.50) by which such net amounts exceed eight dollars ($8.00) per ton, but not in excess of five (5) percent of such net amounts.

(For instance: The percentage royalty on a net amount of five dollars ($5.00) per ton, would be one and one-half (1½) percent; on a net amount of ten dollars ($10.00) per ton, three and one-half (3½) percent.)

(*b*) As here used, "net smelter returns," "net concentrator returns," and "other net amounts realized from the sale or other disposition," mean gross revenue from sales, or if not sold, the market value of the material after it is mined in the form in which and the place where it is held. In the case of integrated operations in which the material is not disposed of as such, these terms mean what is or would be the gross income from mining operations for percentage depletion purposes in income-tax determination.

(*c*) To secure the payment of its percentage royalty, the Government shall have and is hereby granted a lien upon the land described in Article 2 and upon any production of minerals therefrom, until the royalty claim is extinguished by lapse of time or is fully paid.

(*d*) This article is not to be construed as imposing any obligation on the Operator or the Operator's successor in interest to engage in any mining or production operations.

ARTICLE 7. *Assignment, transfer, or loss of Operator's interest.*—Without the written consent of the Government, the Operator shall not assign or otherwise transfer or hypothecate this contract or any rights thereunder. The Operator shall not make any voluntary nor permit any involuntary transfer or conveyance of the Operator's rights in the land described in Article 2, without making suitable provision for the preservation of the Government's right to a percentage royalty on production and lien for the payment thereof; *Provided,* that mere failure by the Operator to maintain the Operator's rights in the land, without any consideration running to the Operator other than relief from the cost of maintaining such rights (as by surrender of a leasehold, failure to perform assessment work, or failure to exercise an option), coupled with complete abandonment by the Operator of all interest in or operations on the land for a period of 10 years from the date of this contract, shall not constitute such a transfer or conveyance. Should the Operator make or permit any transfer or conveyance in violation of this provision, the Operator shall be and remain liable for payment to the Government of the same amounts, at the same times, as would have been paid under the terms of the percentage royalty on production. If for any reason the net smelter returns, net concentrator returns, or other net amounts realized from the sale or other disposition of such production are not available as a means of measuring the amount of the Operator's liability, the amount thereof shall be estimated as well as may be, and in the event of dispute as to such estimates, the determination thereof by the Administrator of Defense Minerals Exploration Administration or by his successor shall be final and binding upon the Operator.

ARTICLE 8. *Termination and completion.*—The Government may, at any time, by written notice to the Operator, terminate this contract: (*a*) If the Operator fails to provide his share of the money necessary to prosecute operations pursuant to the terms of the contract; (*b*) if the Operator, in the opinion of the Government, fails to prosecute operations pursuant to the terms of the contract; or (*c*) if, in the opinion of the Government, operations up to the time of the notice have not indicated the probability of making any worth while discovery and in the opinion of the Government further operations are not justified.

ARTICLE 9. *Changes and added provisions* .....

.....

.....

.....

.....

Executed in sextuplicate the day and year first above written.

THE UNITED STATES OF AMERICA

CORANDA CORPORATION

By ..... (Operator) President

By .....

By ..... Secretary

I, , certify that I am the secretary of the corporation named as Operator herein; that , who signed this contract on behalf of the Operator, was then of said corporation; that said contract was duly signed for and in behalf of said corporation by authority of its governing body, and is within the scope of its corporate powers.

.....

U. S. GOVERNMENT PRINTING OFFICE 16—66320

Redraft (HEADING)

EXHIBIT "A"

Description of the Wck

The project work will consist of exploring and testing to greater depth with diamond drill holes two outcrops of an aluminum silicate rock containing substantial amounts of the minerals, corundum and andalusite, in the Green Talc and Bismark Mines.

The Green Talc Mine Deposit: The larger of the two outcfops, known as the South Lens of the Green Talc Deposit, is approximately 200 feet wide by 400 feet long, and will be tested by six inclined diamond drill holes totaling 1600 feet.

The pattern or spacing of the ~~drxxx~~ individual holes is indicated on the map, Figure 3, attached hereto and made a part hereof and entitled "South Lens of the Green Talc Deppsit, Hawthorne, Mineral County, Nevada, DMEA-2512." The holes are listed as follows:

List of D.D. Holes for South Lens of Green Talc Deposit

(Copy table)

The Bismark Mine Deposit: The smaller of the two outcrops is known as the Bismark Mine. The west one-half of the Bismark Mine outcrop, an area about 50 feet wide by 150 feet long, is to be explored by 5 diamond drill holes totaling 900 feet.

The spacing of the 5 holes is as indicated on the map, Figure 2, attached hereto and made a part hereof and entitled "Bismark Analusite Deposit, Hawthorne, Mineral County, Nevada." The holes are listed as follows:

Copy table from draft

Deviation from the above pattern or spacing of holes for both the Green Talc and Bismark Mine Deposits may be made provided that the maximum allowable footage is not exceeded and provided that deviations are first approved by the Executive Officer, DMEA Field Team, Region III.

Preparations ~~for~~ of Cores and Samples for Tests: Cores are to be carefully tagged and boxed at the drill sites and holes mapped and logged. The boxed cores are to be shipped to the Bureau of Mines, Reno, Nevada, or such other convenient place for sample preparation as may be decided upon by the DMEA

Field Team in consultation with the Operator's project supervisor. The cores are then to be carefully tabulated, sorted, and prepared into the required number of samples for chemical determinations and for core test samples.

Approximately 250 samples are to be given Class #3 Analysis, and approximately 50 samples are to receive Pyrometric Equivalent Core Tests. Analyses and core tests are to be made by the Pittsburgh Testing Laboratory, or such other laboratory as may be approved by the DMEA Field Team Executive Officer, Region III.

Ø Careful supervision shall be maintained at the drill sites over the drill operations, and over the preparation of samples for distribution and testing. The Operator's supervisors must be approved by the aforenamed Executive Officer. It is estimated that after actual drill commences, about 6 months will be required to do the work.

agreed ~~Project Estimated Costs~~ ~~Estimated Costs of the Project~~

2500 feet diamond drill hole (Bx) @ $11.50 per foot 1/	$28,750.00	
250 - Class #3 Chemical Analyses @ $25.00 each 2/	6,250.00	
50 - Pyrometric Core Equivalent Tests @ $20.00 each 3/	1,000.00	
Total Estimated Cost of Project		$36,000.00
Government Participation @ 90%		$32,400.00

1/Ø This excludes the costs of Class #3 Chemical Analyses, and Pyrometric Core Equivalent Tests which are separately listed.

2/ the unit here is each analyses

3/ " " " " " test

(HEADING)

ANNEX I

The property referred to in Article 2 consists of two groups of unpatented lode mining claims known as the Bismark Mine Group and the Green Talc Mine Group, both groups located in the Gillis Range Mining District, Mineral County, Nevada. The notices of location hereinbelow noted are recorded in the Book of Mining Locations in the Office of the County Recorder of Mineral County, Hawthorne, Nevada.

Copy (X)

Copy (Y)

Esther Rea and John Vulich, as Owners of the Green Talc group of mining claims entered into an option and purchase agreement dated January 1, 1952 with Fred Fulkerson, Robert B. Holt, and J. J. H. Rodda, which authorized these individuals to go into possession of the Green Talc Group of claims for the purpose of preliminary development work, and Esther Rea, Joe Malatesta, Eugene Ferretti and John Vulich as Owners of the Bismark Group of mining claims entered into an option and purchase agreement dated January 1, 1952, with Fred Fulkerson, Robert B. Holt, and J. H. Rodda, which similarly authorized these individuals to go into possession of the Bismark Group of claims for the purpose of preliminary development work, and these individuals by an instrument dated April 9, 1952, duly assigned all their right, title and interest in and to the two aforesaid option and purchase agreements to Fred Fulkerson, Robert B. Holt, and J. H. Rodda, F. D. DiNapoli, Joseph P.

Perucci and JamesF. Boccardo, and these six individuals on April 28, 1952, entered into an operating agreement with the Operator granting the Operator for a term of 25 years the exclusive right to explore, develop, ~~operatre~~ operate, mine and remove concentrates and minerals from the Green Talc and Bismark groups of claims.

(HEADING)

EXHIBIT "A"

Description of the Work

The project work will consist of exploring and testing to greater depth with diamond drill holes two outcrops of an aluminum silicate rock containing substantial amounts of the minerals, corundum and andalusite, in the Green Talc & Bernardo Mines

The Green Talc Mine Deposit: The larger of the two outcrops, ~~is~~ known as the South Lens of the Green Talc Deposit, is approximately 200 feet wide by 400 feet long, and will be tested by six inclined diamond drill holes totaling 1600 feet.

The pattern or spacing of the individual holes is indicated on the map, Figure 3, attached hereto and made a part hereof and entitled "South Lens of the Green Talc Deposit, ~~Hawthorne~~ Hawthorne, Mineral County, Nevada, DMEA-2512". The holes are listed as follows:

List of D.D. Holes for South Lens of Green Talc Deposit

DD Hole	Size	Length	Inclination	Location
Green Talc #1	Bx	250 ft.	- 25°	See Fig. 3
" " #2	Bx	250 "	- 25°	~~See~~ Fig. 3
" " #3	Bx	200 "	- 20°	" Fig. 3
" " ~~$~~#4	Bx	200 "	- 20°	" Fig. 3
" " #5	Bx	350 "	To be determined by Field Team	
" " #6	Bx	350 "	To " " " " "	

The Bismark ~~[illegible]~~ Mine Deposit: The smaller of the two outcrops is known as the Bismark Mine. The west one-half ~~[illegible]~~ of the Bismark Mine outcrop, an area about 50 feet wide by 150 feet long, is to be explored by 5 diamond drill holes totaling 900 feet.

The spacing of the 5 holes is as indicated on the map, Figure 2, attached hereto and made a part hereof and entitled "Bismark Analusite Deposit, Hawthorne, Mineral County, Nevada." The holes are listed as follows:

Copy table from pencilled draft

~~Total footage Bismark Mine 900 ft.~~

Deviation from the above pattern or spacing of holes for both the Green Tale and Bismark Mine Deposits may be made provided that the maximum allowable footage is not exceeded and provided that deviations are first approved by the Executive Officer, DMEA Field Team, RegionIII.

Preparation of Cores and Samples for Tests: Cores are to be carefully tagged and boxed at the drill sites and holes mapped and logged. The ~~[illegible]~~ boxed cores are to be shipped to the Bureau of Mines, Reno, Nevada, or such other convenient place for sample preparation as may be decided upon by the DMEA Field Team in consultation with the Operator's project supervisor. The cores are then to be carefully tabulated, sorted and prepared into the required number of samples for chemical determinations and for some test samples.

Approximately 250 samples ~~of [illegible]~~ are to be given ~~analyzed for~~ Class #3 Analysis and approximately 50 samples are to receive and Pyrometric Equivalent Core Tests. Cone Analyses and tests are to be made by the Pittsburgh Testing Laboratory or such other

laboratory as may be approved by the DMEA Field Team Executive Officer, Region III.

Careful supervision shall be maintained at the drill sites over the drill operations, and over the preparation of samples for distribution and testing. The Operator's supervisors must be approved by the aforenamed Executive Officer. It is estimated that after actual drilling commences, about 6 months will be required to do the work.

Estimated Costs of the Project

2500 feet diamond drill hole(Bx) @ $11.50/ft. 1/	$28,750.00
250 - Class #3 Chemical Analyses @ $25 each	6,250.00
50 - Pyrometric Core Equivalent Tests @ $20 each	1,000.00
Total Estimated Cost of Project	$36,000.00
Government Participation @ 90%	$32,400.00

1/ This excludes the costs of ~~[illegible]~~ Class #3 Chemical Analyses, and ~~[illegible]~~ Pyrometric Core Equivalent Tests which are separately listed ~~[illegible]~~

Robertson (1)

DMEA-2512
Andalusite and Corundum

Exhibit "A"

Description of the Work

The project work will consist of exploring and testing to greater depth with diamond-drill holes two ~~widely separated~~ outcrops of an aluminum-silicate rock containing substantial amounts of the minerals corundum (Al_2O_3) and andalusite (Al_2SiO_5).

The Green Talc ~~Deposit~~ Mine Deposit:

The larger of the two outcrops ~~to be tested is called~~ the South Lens of the Green Talc Deposit. ~~This mineralized exposure~~ is approximately 200 ft. wide by 400 ft. long, will be tested by six inclined diamond drill holes totaling 1600 ft. ~~of drilling~~.

The pattern or spacing of the individual holes is indicated on the Figure 3 of the attached map. The holes are listed as follows:

List of D.D. Holes for South Lens of Green Talc Deposit

D.D. Hole	Size	Length	Inclination	Location
Green Talc #1	Bx	250 ft	-25°	See Fig. 3.
" " #2	Bx	250 "	-25°	" " 3
" " #3	Bx	200 "	-20°	" " 3
" " #4	Bx	200 "	-20°	" " 3
" " #5	Bx	350	To be determined by Field Team	
" " #6	Bx	350	" "	" "
Total footage Green Talc Mine		1600 ft.	~~(maximum allowable)~~	

Deviations from the above pattern or spacing of holes may be made ~~without exceeding~~ provided that the maximum allowable footage is not exceeded, and such changes are first approved by the Executive Officer, Field Team, Region III.

The Bismark Andalusite Mine Deposit:

The smaller of the two outcrops ~~to be tested is~~ known as the Bismark Mine ~~situated about 4 miles southeast from the larger deposit~~ approx. 2 mi. Mine

The west one-half of the Bismark Mine outcrop, an area about 50 ft wide by 150 ft. long, is to be explored by 5 diamond drill holes totaling 900 ft. ~~of diamond drilling~~.

The spacing of the five holes is as indicated on Figure 2 ~~of maps~~ attached hereto. The holes are listed as follows:-

List of D.D. Holes for Bismark Andalusite Deposit

D.D Hole	Size	Length	Inclination	Location
Bismark #1	Bx	150 ft	-30°	See Fig. 2
Bismark #2	Bx	150 ft	-30°	" Fig. 2.
Bismark #3	Bx	200 ft	-30°	" Fig. 2.
Bismark #4	Bx	200 ft	To be determined by Field Team	
Bismark #5	Bx	200 ft.	To be determined By Field Team	

Total footage Bismark Mine 900 ft.

Deviation from the above pattern or spacing of holes may be made provide that the maximum allowable footage is not exceeded, and provided that ~~changes or~~ deviations are first approved by the Executive Officer, Field Team, Region III

Preparation of Cores and Samples for Tests

Cores are to be carefully tagged and boxed at the drill sites and holes mapped and logged. The boxed cores are to be shipped to the Bureau of Mines, Reno, Nevada or such other convenient place for sample preparation as may be decided upon by the Field Team in consultation with the Operator's project supervisor.

The cores are then to be carefully tabulated, sorted and prepared into the required number of samples, which are to be approximately 250 in number, which are to be analyzed ~~by~~ Class #3 Determinations and ~~also~~ some 40 or 50 Pyrometric Equivalent Cone Tests for analyses and tests are to be made by the Pittsburgh

Testing Laboratory or such other laboratory as may be approved by the Field Team Executive Officer.

Carefully supervision shall be maintained at the drill sites ~~and at the~~ over the operations and over the preparation of samples ~~are prepared~~ for distribution and testing.

The ~~selection of proper~~ Operator's supervisors ~~should~~ must be approved by the ~~Executive Regional~~ Field Executive Officer.

It is estimated that about 6 months will be required to do the work after actual drilling ~~gets~~ commences.

Estimated Cost of Exploration Project

(* Items followed by an asterisk are allowable maintenance).

2500 ft. Diamond-drill hole (Bx) @ $11.50/ft.	$ 28,750.*
250 - Class #3 Chemical Analyses @ $25.00/ea.	6,250.*
50 - Pyrometric Cone Equivalent Tests @ $20.00/ea.	1,000.*
Total estimated cost of exploration project	$36,000.*
Governments share @ 90%	$32,400.*

UNITED STATES DEPARTMENT OF THE INTERIOR
Harold L. Ickes, Secretary

BUREAU OF MINES
R. R. Sayers, Director

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War Minerals Report 388

PRELIMINARY PILOT-PLANT CONCENTRATION OF ANDALUSITE-CORUNDUM ORE FROM THE VICINITY OF HAWTHORNE, NEV.

WASHINGTON: 1945

This report is intended for limited distribution among officials of the United States Government. The information contained therein should not be made available to unauthorized persons.

The War Minerals Reports of the Bureau of Mines are issued by the United States Department of the Interior to give official expression to the conclusions reached on various investigations relating to domestic minerals. These reports are based upon the field work of the Bureau of Mines and upon data made available to the Department from other sources. The primary purpose of these reports is to provide essential information to the war agencies of the United States Government and to assist owners and operators of mining properties in the production of minerals vital to the prosecution of the war.

PRELIMINARY PILOT-PLANT CONCENTRATION OF ANDALUSITE-CORUNDUM ORE FROM THE VICINITY OF HAWTHORNE, NEV.[1]

SUMMARY

The far-western area of the United States has relatively few developed deposits of minerals containing enough alumina to be used for the manufacture of high-alumina furnace refractories. The andalusite ore in the Hawthorne deposit is not sufficiently uniform to meet market specifications for refractory purposes, but it is possible that the ore may be beneficiated so as to produce a satisfactory concentrate. Preliminary tests have indicated that gravity concentration would produce the highest-grade product and would represent the simplest method of treatment.

Pilot-plant tabling tests were made on about 50 tons of ore that analyzed 42.5 percent Al_2O_3 and 54.2 percent SiO_2. Three flow sheets were used, each varying slightly in grinding and sizing procedure; 15 different concentrates were produced, which varied in grade from 52.1 to 72.4 percent Al_2O_3 and 44.9 to 25.2 percent SiO_2, the composited average being 62.3 percent Al_2O_3 and 35.1 percent SiO_2; the over-all ratio of concentration was 4.2 to 1. One special corundum concentrate containing 91.5 percent Al_2O_3 was made in addition.

The final value of the concentrates to the refractory industry will be determined by further large-scale tests conducted cooperatively by Pacific-coast refractory producers who will mix the concentrate with clay in an attempt to produce a super-duty fire brick.

INTRODUCTION

Modern industry steadily is increasing its demands for furnace refractories that possess a combination of high mechanical strength, low porosity and shrinkage, and resistance to abrasion at high temperatures. In many instances these demands have been fulfilled best by high-alumina refractories composed predominantly of the artificial mineral compound mullite, $3Al_2O_3 \cdot 2SiO_2$. Mullite is a product formed by the interaction of

1 By C. T. Baroch, ass't. supervising engineer; H. D. Snedden and V. E. Homme, associate metallurgists; and E. T. Schrenk, assistant mineralogist, Bureau of Mines.

silica and alumina in correct proportions at relatively high firing temperatures or may be obtained as a transition product of the decomposition of minerals of the kyanite group (andalusite, kyanite, and sillimanite) at high temperatures.

High-alumina refractories are neutral, and they flux or form slags with difficulty; consequently, they are used widely in lead and glass furnaces, clinker-zone linings in Portland cement kilns, in boiler-furnace settings used for high-ash coals, and in blast-furnace regenerators. A list of pyrometric cone equivalent values and chemical analyses of various grades of typical high-alumina brick are given in table 1.[2]

TABLE 1. - Typical analyses of high-alumina refractories

High alumina, class	Analysis, percent			
	50	60	70	80
Al_2O_3	51.5	60.8	70.6	79.4
SiO_2	41.9	33.3	22.8	15.8
TiO_2	2.7	3.0	3.7	2.1
Fe_2O_3	1.8	1.7	1.8	1.7
CaO	.1	.2	.2	.2
MgO	.5	.3	.3	.3
Alkalies	1.2	1.1	1.0	1.0
P.C.E., cone number	34-35	36-37	38	39
Temperature equivalent, °C.	1,773	1,815	1,835	1,865

Specifications for marketable andalusite require a product containing 60 to 65 percent Al_2O_3; it is sold frequently on the basis of a specific gravity ranging between 3.05 and 3.15. The Hawthorne deposits are not directly marketable as an andalusite of refractory grade, because most of the ore contains only 40 to 50 percent Al_2O_3.

Preliminary concentration tests made at the ore-testing laboratories of the Bureau of Mines, Salt Lake City, Utah, early in 1943 included gravity separation by "sink-float;" jigging and tabling methods on minus 1/2-inch, 3-mesh, and 35-mesh ore; electrostatic and electromagnetic separation on gravity separation products; and flotation with fatty acids, cationic reagents, and alcohols at high, intermediate, and low pH values.

Conclusions reached by the laboratory work showed that Hawthorne andalusite ore could be beneficiated as follows:

1. By table concentration of ore ground to minus 48-mesh and sized; 66.0 percent of the alumina was recovered in a product containing 63.2 percent Al_2O_3 and 35.8 percent SiO_2.

2. By cationic flotation of silica from ore ground to minus 100-mesh; 71.3 percent of the alumina was recovered in a product containing 60.0 percent Al_2O_3 and 39.4 percent SiO_2.

3. By fatty-acid flotation of ore ground to minus 100-mesh; 54.7 percent of the alumina was recovered in a product containing 60.7 percent Al_2O_3 and 37.8 percent SiO_2.

2 Rochow, W. R., Properties and Applications of Modern Refractories: Chem. and Met. Eng., vol. 42, 1935, p. 76.

Gravity concentration gave the highest-grade product and represents the simplest method of treatment; therefore, it appears to be the preferable method.

The value of clays and other minerals for refractory purposes can not be determined solely by chemical analyses, as many physical attributes of the materials and variations of processing techniques enter into the quality of a refractory. Consequently, it became apparent early in the investigation that the ultimate use-value of Hawthorne concentrates could be determined only by trial firings. This meant that a sizable quantity of concentrates would be required; therefore, 59 tons of the ore was shipped to the Boulder City, Nev., pilot plant. This ore was treated by table concentration, and concentrates were made in small lots of different grades and particle sizes for subsequent use in refractory firing tests. The refractory test work probably will be performed partly under cooperative agreements with Pacific-coast refractory manufacturers and partly by Bureau of Mines specialists in nonmetallic minerals.

DESCRIPTION OF THE ORE

The ore deposits are in the southern foothills of the Gillis Range about 10 miles northeast of Hawthorne, Mineral County, Nev. The Federal Geological Survey reports five groups of claims in the district. They are the Green Talc, Dover, Bismarck, Victory, and Deep Mines. The Bureau of Mines has made ore-dressing tests on samples from two of the groups - the Green Talc, controlled by William Rae and John Buich, and the Dover, controlled by B. H. Donnelly and associates. The original (Eriksen) sample tested by the Bureau of Mines is reported by Donnelly to be from his property. The sample treated in the Boulder City pilot mill was taken from the Green Talc group of claims.

Reserves

Little developing has been done, and no mineral reserve has been technically blocked in any of the deposits. Tonnage estimates of inferred mineral are based upon surface outcrops assumed to extend to a depth of 100 feet.

Green Talc group. - The main outcrop is approximately 800 by 200 feet in surface area. If assumed to extend to 100 feet in depth and to be of milling grade, 1,300,000 tons of inferred material is indicated.

Dover group. - No tonnage estimates can be made of mineral in this group because of surface overburden and insufficient development.

Deep Mines group. - Andalusite and associated aluminum silicate minerals outcrop over an area 300 by 300 feet. If mineralization is assumed to extend for a depth of 100 feet, 750,000 tons of milling-grade material may exist.

Victory group. - No mineral other than float has been found on this group. It was located recently and no work has yet been done.

Bismarck group. - Aluminum silicate minerals outcrop over an area 50 by 150 feet. If this deposit is assumed to extend to a depth of 100 feet, 62,500 tons of milling-grade minerals might be produced.

Estimated inferred mineral

	Tons
Green Talc group	1,300,000
Deep Mines group	750,000
Bismarck group	62,500
	2,112,500
Less 40 percent estimated for inclusions of dikes, quartzite, and submarginal material	845,000
Net	1,267,500

Submarginal mineral is that having a specific gravity less than 2.9.

The 59 tons of ore received for the test arrived in two truck-and-trailer shipments. The ore of the first truckload was characterized by large, conspicuous masses and veins of green sericite; the ore in the second shipment carried green sericite in small veins only. In general, the material is fine-grained, dense, and quite hard; it is gray to grayish-blue in color except in the zones or veins, in which the pale-green sericite predominates.

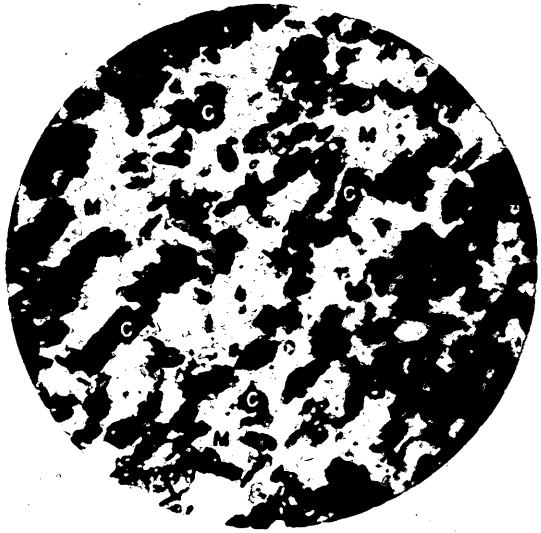
The rock appears to have been formed by contact metamorphism brought about by an igneous intrusion into argillaceous country rock and subsequently altered by hydrothermal action.

The principal minerals identified in thin sections include:

1. Andalusite. - Al_2SiO_5; specific gravity 3.16; hardness 7.5; usually breaks into prisms showing cleavage in one or two directions and an uneven fracture; changes to mullite at about 1,350° C. The andalusite in this ore is pale cream to milky white in color. It occurs chiefly as small crystals and remnants of crystals disseminated throughout the rock or occasionally as coarse crystals concentrated in short, thick, lenslike masses. In addition, all of the pale-green sericite veinlets examined contain small crystals of andalusite, typically shown in figure 1. Inclusions of sericite are common within individual andalusite crystals, and it appears that much of the original andalusite has been altered to sericite.

2. Corundum. - Al_2O_3; specific gravity 3.95-4.10; hardness 9; usually breaks into grains having irregular cleavage and uneven to conchoidal fracture; melting point, 2,050° C. Most of the corundum in this ore is deep blue in color, but some varies to almost white. It is disseminated throughout the ore, but areas of concentrated granular corundum are not uncommon. The crystals are very small, show inclusions of mica or mica-like minerals, and occur singly or in small clusters typically as shown in figure 2.

1



2

A - andalusite
C - corundum
Q - quartz
M - mica

Scale

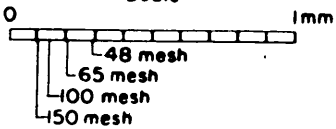


FIGURE 1.- Green sericite veinlet adjacent to andalusite crystals. Polarized light.
FIGURE 2.- Average gray-blue mottled ore. Corundum crystals in a groundmass of sericite. Plane light.

3. Mica. - Variable in composition but essentially acid salts of orthosilicic acid or acid aluminosilicate; specific gravity 2.7; hardness 2-2.25. Muscovite (potassium micas), sericite (fine-grained muscovite), and perhaps some paragonite (sodium mica) are present in the Hawthorne ore. Small books of muscovite were noted, but these are not abundant. However, sericite is abundant and occurs intimately mixed with the andalusite and corundum or independently in pale-green veinlets. Chemical analyses of selected material indicate that if the soda mica, paragonite, $H_2NaAl_3(SiO_4)_3$, is present, it is minor as compared to sericite, and that the sericite is low in potash, as shown in table 2.

TABLE 2. - Chemical analysis of pale-green sericite

	Percent		Percent
Al_2O_3	38.40	MgO	0.65
SiO_2	47.19	CaO	.28
Fe_2O_3	.32	TiO_2	.10
K_2O	8.18	B.[illegible]	.08
Na_2O	.76	L.O.I.	4.32

4. Quartz. - SiO_2; specific gravity, 2.5; hardness, 7. Quartz is present throughout all of this material as very small anhedral crystals or else as small, rounded grains up to 0.2 mm. in diameter. It is most abundant as small anhedral grains associated with the sericite.

5. Pyrophyllite. - $H_2Al_2(SiO_3)_4$; specific gravity, 2.8-9; hardness, 1-2. One mica-like constituent of the ore was identified by X-ray and chemical analyses as pyrophyllite. The chemical and physical similarities of this mineral and mica prevent quantitative determination of either when both are present in an ore.

Several accessory minerals, including titanite, magnetite, and hematite, were noted in the thin sections, but their percentage is small. A chemical analysis of the ore is given in table 3.

TABLE 3. - Chemical analysis of ore

	Percent		Percent
Al_2O_3	42.50	Fe_2O_3	0.42
SiO_2	54.20	TiO_2	.77
K_2O	.73	Fe*	.12
Na_2O	.29	L.O.I., 800° C.	2.13

*Metallic iron from grinding.

Mineralogical analyses were made by using two different techniques on representative portions of the ore, the first at the Boulder City station and the second at the Salt Lake station.

The first mineralogical analysis was made by using a combination of heavy-liquid separation and interpretation of chemical analysis. To assure accuracy, several tests were made and each product was examined under

the petrographic microscope. Assuming that quartz, combined silica (mica), corundum, and andalusite are the variables in this ore, the percentage of minerals can be calculated from the chemical analysis if the percentage of corundum is known. Corundum was determined by separation with the heavy liquid methylene iodide, specific gravity 3.325, using a sample ground to pass a 150-mesh screen. The quantity of mica was calculated from the K_2O and Na_2O determined by chemical analysis, but insufficient alkali was present to account for the percentage of micas actually observed with the microscope. It is possible that pyrophyllite, $Al_2O_3 \cdot 4SiO_2 \cdot H_2O$, may be present and that it has been mistaken for sericite, because the optical properties of these two minerals are very similar.[3] If pyrophyllite is present in large amounts correct interpretation of chemical analyses is impossible, because andalusite and pyrophyllite are so closely related chemically and because heavy-liquid separation of pyrophyllite from sericite is not practical. Furthermore, if pyrophyllite is present, the percentage of andalusite and quartz must be reduced. The results of this analysis is given in table 4, column I.

The second mineralogical analysis was made by microscopic grain count on closely sized and carefully split fractions of the ore, using oils of varying refractive indices to distinguish the various minerals. Corundum was the only mineral identified above the index of refraction of 1.7400. The micaceous minerals and quartz were all found to be below the index of refraction of 1.6031, and all the material above this index was considered to be either andalusite or corundum. A microscopic count was then made on the same fractions, using an oil with an index of refraction of 1.7400, and all the material having a higher index was assumed to be corundum. The sample, ground to minus 100-mesh, was sized into eight products by screening and elutriation, and each fraction was weighed. A statistical count of each mineral type was taken on 500 grains in each fraction. The weighted average of the microscopic counts, which represents the volume of the different minerals, was transposed to weight percentage by assuming the gangue to have a specific gravity of 2.8, the andalusite 3.1, and the corundum 3.8. The results are given in table 4, column II.

TABLE 4. - Estimated mineral analysis of heads, specific gravity 2.95

	Weight, percent	
	I	II
Andalusite	30-35	20
Corundum	15-20	20
Mica	20-30	-
Quartz	20-30	-
Titanite	1-2	-
Miscellaneous	5-10	-
Gangue	-	60

3 Rogers and Kerr, Optical Mineralogy, 2d ed.: McGraw-Hill Book Co., Inc., New York, 1942, p. 351.

The two methods of mineralogical analyses check well regarding the amount of corundum present, but the values for andalusite are controversial. The difference in the latter could be accounted for by the presence of pyrophyllite, which has been reported by others as being present in some samples from the Hawthorne deposits. If it was present in the test sample under consideration, it was evidently too fine-grained to be positively identified with the microscope. Other factors affecting the accuracy of any mineralogical analysis include (1) difficulty of identifying submicroscopic particles produced by grinding to obtain liberation, (2) difficulty of identifying various intermediate decomposition products that occur in the ore, (3) difficulty of obtaining a small sample for microscopic analysis that is wholly representative of the ore.

TEST PROCEDURE AND RESULTS

The original laboratory tests indicated that the valuable minerals were free only at sizes finer than 35-mesh; even finer grinding appears to be necessary to free completely the mineral particles in the ore received for the pilot-plant work. The mineral-dressing tests also showed that the determination of the point at which to make cuts on the table between concentrate, middling, and tailing is difficult because there is little difference in the appearance of these products. Some preliminary tests were made on a small laboratory table using ultraviolet light, with and without filters, and various colored and fluorescent lights, but of these, only white fluorescent light intensified the bluish color of the corundum slightly. A pale wine-colored andalusite, sized to the table feed, was added to the feed in one test to determine whether or not this would act as a guide to give a suitable indication where a separating cut might be made; the method is satisfactory, but a large amount of the colored mineral is required.

The ultimate control method adopted consisted of specific-gravity determinations and frequent vanner plaque tests on samples of the table products. The bluish corundum could be distinguished readily on the vanner; its presence could be determined in the tailings and middlings, and the operators soon learned how to appraise the approximate grade of concentrate by the relative amount of the contained blue mineral.

The difference in specific gravity between andalusite, 3.16, and the quartz-mica gangue, 2.6-2.7, is not large, and their gravity separation by tabling requires careful adjustment of feed rate and close sizing of table feed. In the pilot-plant runs, ground ore was hydraulically classified or screen sized, the coarsest fraction tabled directly, and the finer sizes stored in tanks and tabled later. The same table was used for all the classified products. Three flow sheets were used, each varying in the method of preparing and sizing table feed.

the entire concentrate end of the table, reducing the table capacity to 200 or 250 pounds of dry feed per hour. Tilting the table more would wash the concentrates over the tailing side. Most of the slime and coarse mica washed off the head end of the table, regardless of the feed size.

Approximately 33 tons of minus 1/2-inch ore was milled in accordance with flow sheet 2, producing concentrates 3 to 9, inclusive. Inasmuch as 50 percent of the ore was ground to minus 200-mesh in this circuit, it was decided to attempt a lighter grind and a coarser table feed with additional classification before tabling.

Third Flow Sheet

The third flow sheet is outlined in figure 4. The 2,100 pounds of 4-inch balls in the mill were removed and replaced with an equal weight of 1-1/2-inch balls in an effort to reduce over-grinding. The 48-mesh screen receiving the ball mill classifier overflow product was replaced by a 20-mesh screen, and the undersize from this passed to another rake classifier 24 inches wide by 15 feet long. Classifier sand product passed to the Fahrenwald sizer, where two pockets were used to produce two underflow sized products instead of one as in the previous flow sheets. The coarsest sizer product flowed directly to the table, the intermediate product was stored temporarily in a 7-foot tank, and the sizer overflow was combined with the classifier overflow to be stored in the 14-foot tank.

The change in the ball load did not noticeably affect operation of the ball mill; the maximum feed rate remained at 3,630 pounds per hour. Screen analyses of the classifier sand discharge and the three table feed products are shown in table 9.

TABLE 9. - Screen analyses of classifier and Fahrenwald sizer table feed products, flow sheet 3

Mesh	Weight, percent			
	Classifier 2 sand discharge	Fahrenwald sizer products		Classifier and Fahrenwald overflow products
		Coarse	Intermediate	
-20+28	6.67	16.74	-	-
-28+35	8.05	17.61	1.60	-
-35+48	12.76	22.61	6.91	-
-48+65	16.88	17.39	14.63	-
-65+100	21.10	11.96	29.26	-
-100+200	21.49	10.87	43.09	16.87
-200	13.05	2.82	4.51	83.13

Approximately 8 tons of ore was treated by the process shown in the third flow sheet and produced concentrates 10 and 11, the former from the coarse and intermediate sizer products and the latter from the classifier and sizer overflows. The middling from this run was stored separately from the middling products made previously and was tabled again later to produce concentrate 14.

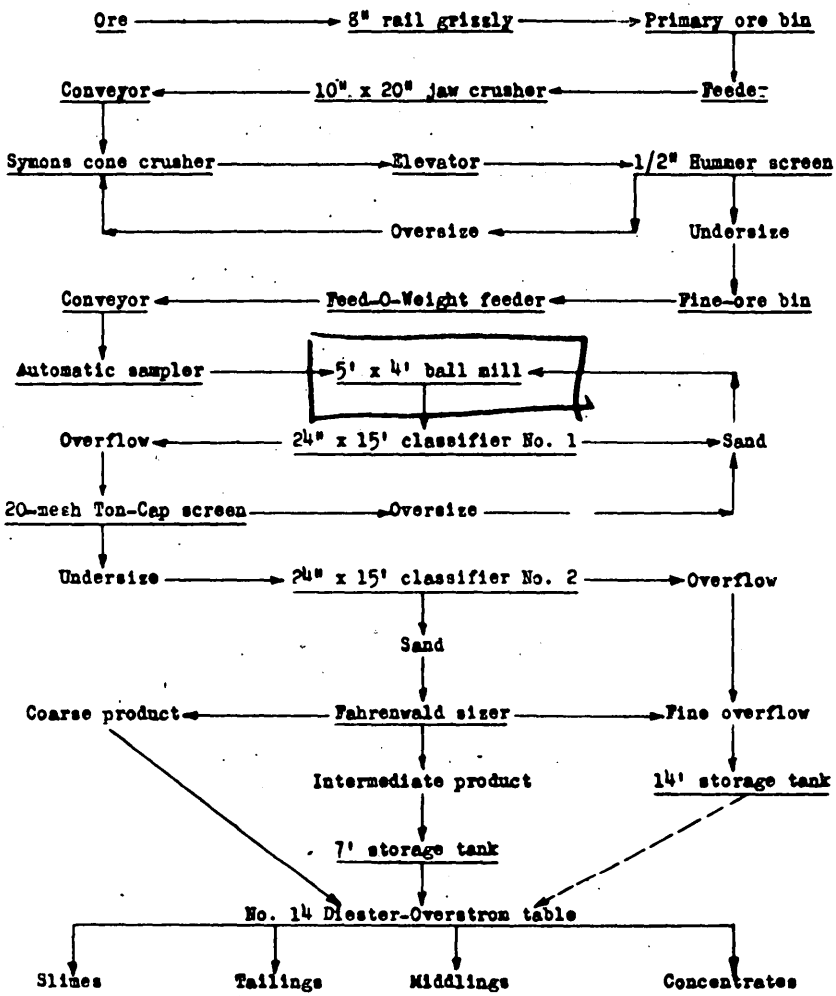


Figure 4. - Third flow sheet

Re-treatment of Middlings

A total of 8.94 tons of various middlings, dry weight, was produced from the 47.5 tons of ore used in the three flow-sheet processes. The middlings contained some free corundum and a fair amount of andalusite, which were recoverable by tabling without regrinding. Partial analyses of the middlings products are given in table 10.

The middlings from the first and second flow-sheet processes were passed over a 100-mesh Hummer screen and separated into a coarse and fine product, each of which was tabled separately to make concentrates 12 and 13, respectively. Middling from the third flow-sheet process was treated separately to produce concentrate 14. The rejected portion of the

middling has been called coarse and fine middling tailing in the summarized data.

TABLE 10. - Analyses of middlings

Number	Percent			
	Al_2O_3	SiO_2	Fe_2O_3	TiO_2
1	44.6	46.5	0.99	0.82
2	44.8	49.0	.43	.92
3	41.3	51.2	.49	.61
4	48.9	45.9	.28	.66
5	51.4	42.1	.28	.77
6	47.7	42.6	.35	.92
7	45.2	46.8	.31	1.17
8	47.9	46.3	.35	.92
9	44.4	49.4	.42	.82
Weighted average	45.3	47.4		

Concentrates and Recovery Data

Weights, particle size, specific gravity, and chemical analyses of all the concentrates are listed in table 11, and the pyrometric cone equivalents for each concentrate are listed in table 12.

The concentrates show a wide range in grade which, excluding the small amount of high-grade corundum recovered as concentrate 16, varied between 52.1 to 72.4 percent Al_2O_3 and 25.2 to 44.9 percent SiO_2. This range of concentrate grade may prove to be valuable, as the main objective of this work was to produce enough high-alumina material so that refractory tests could be made to determine the value of the products.

TABLE 12. - Pyrometric cone equivalents,* andalusite-corundum concentrates

Concentrate	Assay, percent		P. C. E.* No.	Temperature, °C.
	Al_2O_3	SiO_2		
1	62.6	34.5	37+	1,820+
2	60.4	37.6	37+	1,820+
3	60.3	35.9	38-	1,835-
4	67.6	29.3	38	1,835
5	69.2	28.7	39	1,865
6	67.1	28.7	40	1,885
7	66.3	29.5	38+	1,835+
8	72.4	25.2	38	1,835
9	68.0	30.2	40+	1,885+
10	65.4	33.6	38	1,835
11	65.8	32.3	39+	1,865+
12	52.1	44.9	35+	1,785+
13	62.2	35.7	38+	1,835+
14	52.3	44.1	35-	1,835-
15	59.0	39.6	37.5	1,827
16	91.5	5.7	41-	1,970-
Composite	62.3	35.1	38	1,835

*As determined by Northwest Experiment Station, Bureau of Mines, Seattle, Wash.

A large proportion of each concentrate has been shipped to Gladding, McBean & Co. at Pittsburg, Calif., for testing their value as a refractory. Other proportionate parts of the concentrates have been distributed within the Bureau of Mines for refractory and other test work.

TABLE 11. - Andalusite-corundum concentrates

Flow sheet	Concentrate	Weight pounds	Particle size*	Specific gravity	Chemical analyses, percent						
					Al_2O_3	SiO_2	Fe_2O_3	TiO_2	K_2O	Na_2O	MnO_2**
1	1	440	Fine	3.37	62.6	34.5	0.89	0.71	0.27	0.11	0.75
1	2	640	do.	3.28	60.4	37.6	.98	.71	.29	.03	.13
1-2	3	1,587	Coarse	3.20	60.3	35.9	.63	.87	.36	.05	.10
2	4	588	Fine	3.31	67.6	29.3	.42	.77	.25	.02	.05
2	5	550	do.	3.36	69.2	28.7	.56	.87	.34	.02	.05
2	6	555	do.	3.36	67.1	28.7	.56	.77	.31	.07	.09
2	7	1,873	Coarse	3.33	66.3	29.5	.49	.77	.34	.07	.03
2	8	1,171	do.	3.40	72.4	25.2	.78	.82	.25	.06	.04
2	9	3,323	Fine	3.33	68.0	30.2	.42	.77	.17	.07	.10
3	10	752	Coarse	3.27	65.4	33.6	.54	.87	.35	.13	-
3	11	1,923	Fine	3.28	65.8	32.3	.58	.66	.29	.17	.10
Middling.	12	5,214	Coarse	3.08	52.1	44.9	.49	.77	.48	.25	.05
Do.	13	3,030	Fine	3.24	62.2	35.7	.42	.66	.26	.17	.12
Do.	14	221	Coarse	3.10	52.3	44.1	1.09	.77	.53	.19	.08
Clean-up.	15	556	Fine	3.22	59.0	39.6	.41	.77	.38	.07	.70
Hi-grade.	16	182	do.	3.76	91.5	5.7	.70	.77	.08	Tr.	.40
Composite		22,605		3.25	62.3	35.1	.53	.76	.32	0.15	-

*The fine size is approximately minus 65-mesh. The coarse size is approximately minus 20-mesh with some minus 100-mesh.
**MnO_2 is an extraneous impurity resulting from contact of the ore with launders, pipe lines, and other equipment that had previously been used for manganese milling tests.

Andalusite is marketed on a specification of 60 to 65 percent Al_2O_3 content and a specific gravity of 3.05 to 3.15. Many buyers also specify that 25 to 50 percent of the product should be minus 4- and plus 10-mesh. This latter specification was not met by any of the test products. Furthermore, it does not appear possible that such a specification can be met on the type of ore received, because of the intimate mineralogical association as shown by microscopic examination and in photomicrographs (figs. 1 and 2).

A weighted composite of all the concentrates produced analyzes 62.03 percent Al_2O_3, which would place this material in a class equivalent to a marketable grade of andalusite, provided that mineralogical character and refractoriness prove satisfactory. Material between 50 and 70 percent Al_2O_3 can be composited from the various lots for the refractory tests.

The distribution by weight, the chemical analyses, and specific gravities of the heads, tailings, and concentrates, are given in table 13.

Table 13. - Distribution and analyses of mill test products

Material	Weight, pounds	Chemical analyses, percent						Sp.g.	P.C.E.*
		Al_2O_3	SiO_2	Fe_2O_3	TiO_2	K_2O	Na_2O		
Concentrate	22,605	62.3	35.1	0.53	0.76	0.32	0.15	3.25	38
Coarse middling tailing	6,718	37.3	61.4	.19	.87	.66	.17	2.92	31.5
Fine middling tailing	2,706	35.4	62.9	.14	.87	.52	.16	2.90	31^+
Tailing	18,454	36.4	60.8	.19	.77	.61	.19	2.89	32.5^-
Slime	44,600	35.6	61.4	.32	.92	1.14	.17	2.87	31^-
Calculated heading	95,083	42.2	55.1	.42	.85	.79	.17	2.97	-
Heading by analysis	-	42.5	54.2	.33	.77	.73	.29	2.95	32

*Pyrometric cone equivalent.

From the table, the ratio of concentration was 4.2 to 1. A lower-grade product containing between 50 and 55 percent Al_2O_3 may prove to be suitable for certain refractory purposes. A product made by combining the concentrates and the middlings as produced in this test operation would contain about 52.5 percent Al_2O_3; such a product would total 32,030 pounds, representing a ratio of concentration of 3.0 to 1.

CONCLUSIONS

1. Over 11 tons of table concentrates, in lots containing 50 to 70 percent Al_2O_3, were made from Hawthorne, Nev., ore. These are to be used for ceramic and refractory tests to determine their value in compounding high-alumina refractories.

2. If a certain standard quality of the concentrates analyzing between 50 and 65 percent Al_2O_3 proves to be of commercial value, such a product can be produced by table concentration. A commercial plant designed to provide well-classified and steady feed rates to tables undoubtedly could produce a fairly uniform product or a series of products varying in grade.

3. Specific-gravity determinations can be made quickly; they are reliable evidence of the product grade and may be used as a method of control in tabling operations.

4. The large proportion of minus 200-mesh fines produced by grinding suggests the possibility that additional recovery might be made by flotation on this material, provided such a product would have value. The formation of excessive amounts of fines in grinding is apparently an inherent characteristic of the ore, which is a mixture of hard and soft minerals, most of them extremely fine-grained.

5. Economic evaluation of a process for producing concentrates from Hawthorne ore by table concentration will depend upon the outcome of ceramic and refractory tests. Before such an appraisal can be made, the value and grade of a standard concentrate, as well as the use-value of any substandard byproduct, must be determined.

oOo

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

DMEA-2512

Topography by H L. Sobel, July 1952

Geology by A. J Bodenlos, July 1952

Figure 3

SOUTH LENS OF THE GREEN TALC DEPOSIT, HAWTHORNE, MINERAL COUNTY, NEVADA

40 0 40 80 120 Feet

Contour interval 5 feet
Barometric datum

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

DMEA-2512

Topography by A. J Bodenlos, July 1952

Geology by H. L Sobel, July 1952

EXPLANATION

Qal — Sandy alluvium

Re — Metamorphosed andesites and tuffs

Res — Silicified metavolcanic rocks

Req — Fine-grained quartz

d — Diabase(?)

p — Green micas, possibly containing pyrophyllite; some aluminum-bearing minerals (Pattern shows strike)

al-si — Fine-grained quartz, in part containing aluminum silicate minerals and corundum

q — Quartz vein

c — Copper staining

Contact (Dashed where gradational or approximate)

62 — Shear zone, showing dip

86 — Strike and dip of foliation

Strike of vertical foliation

Trench or open cut

Dump

Disc — Discovery monument

Claim corner

DEEP MINES ANDALUSITE DEPOSIT, HAWTHORNE, MINERAL COUNTY, NEVADA

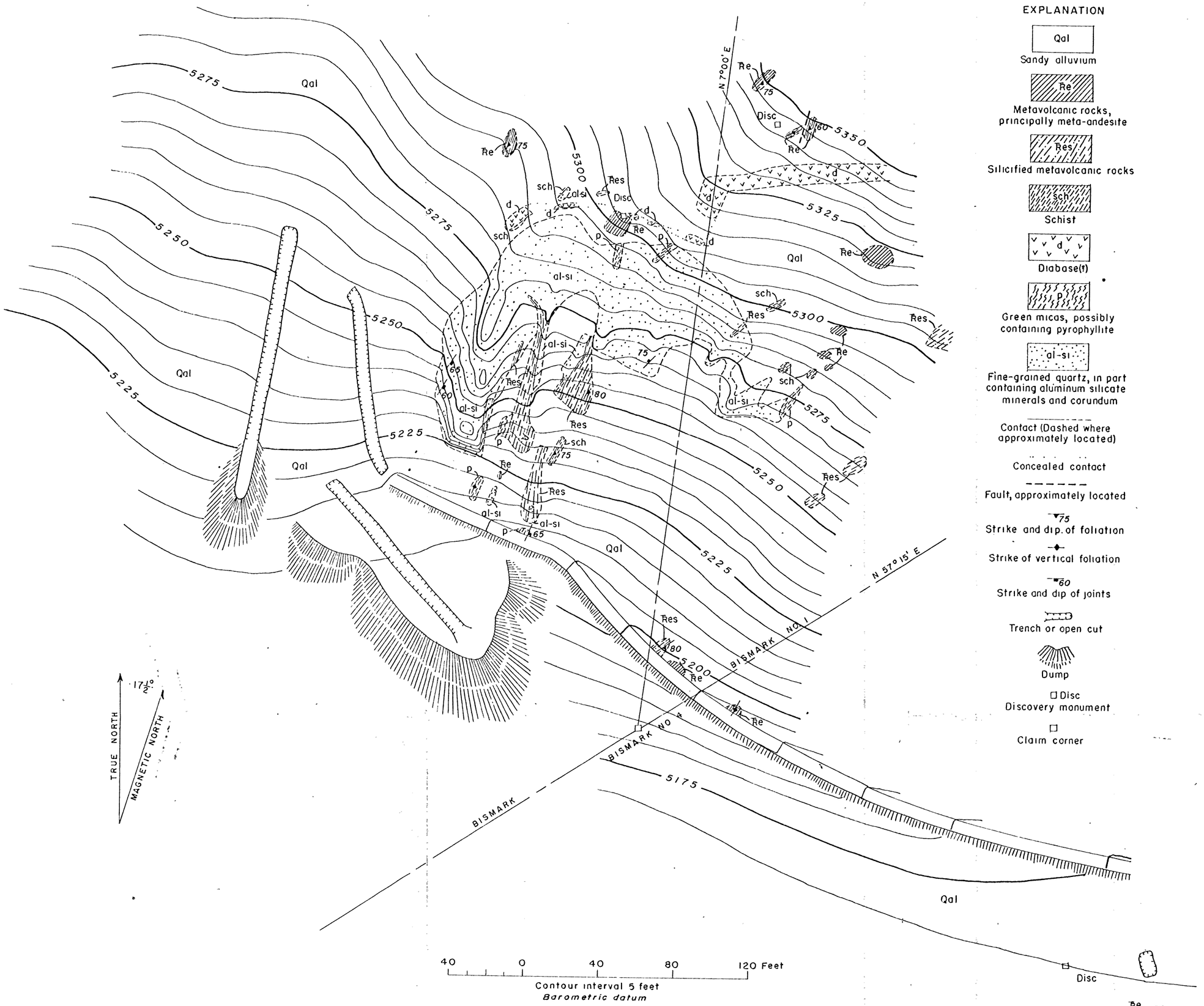
Figure 1

40 0 40 80 120 Feet

Contour interval 5 feet
Barometric datum

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

DMEA-2512



Topography by H L Sobel, July 1952

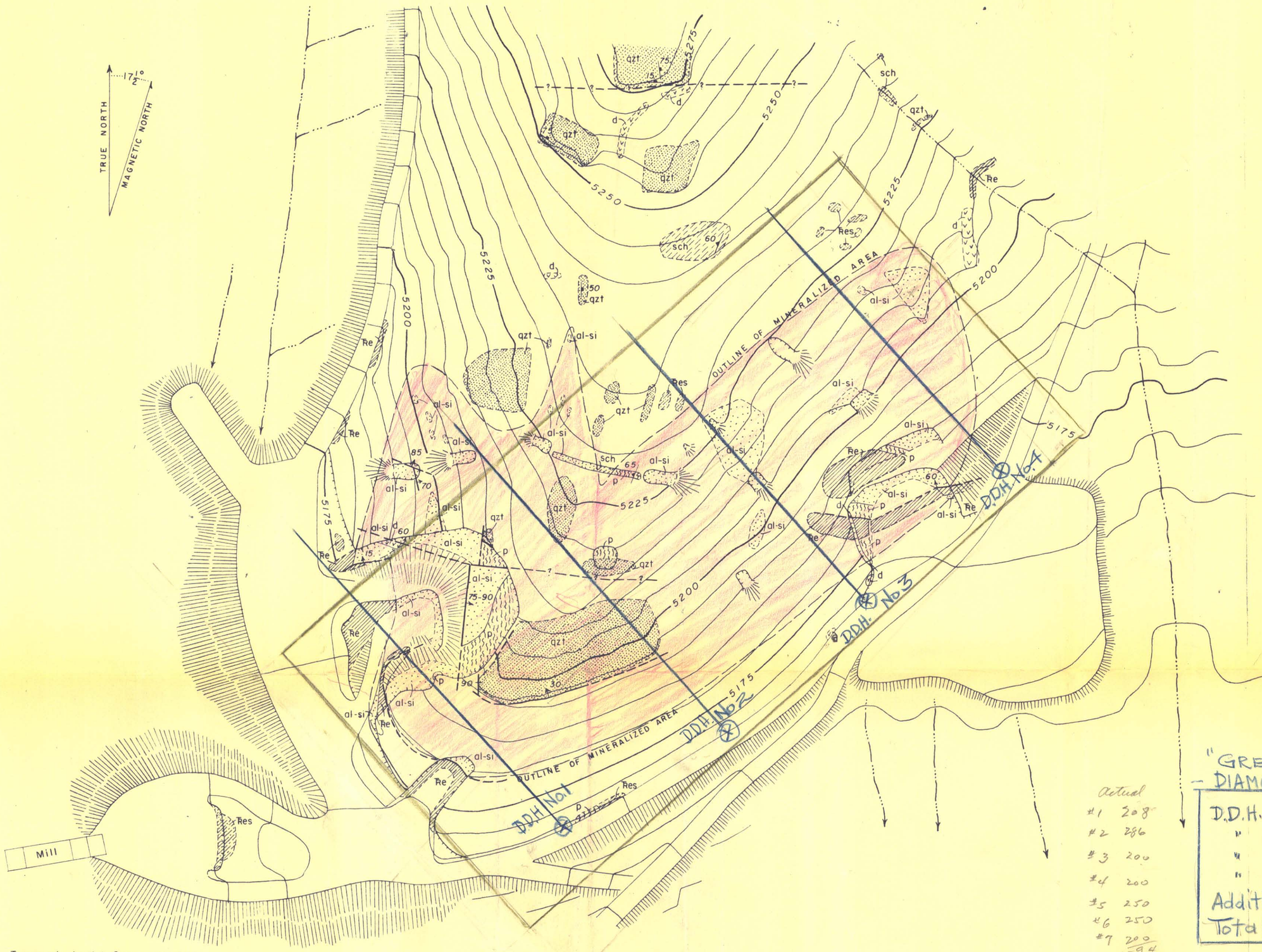
Geology by A J. Bodenlos, July 1952

Figure 2

BISMARK ANALUSITE DEPOSIT, HAWTHORNE, MINERAL COUNTY, NEVADA

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

DMEA-2512



Topography by H. L. Sobel, July 1952

Geology by A. J. Bodenlos, July 1952

EXPLANATION

- Cover
- qzt — Quartzite
- Re — Metavolcanic rocks, principally meta-andesite
- Res — Silicified metavolcanic rocks
- sch — Schist
- d — Diabase(?)
- p — Green micas, possibly containing pyrophyllite
- al-si — Fine-grained quartz, in part containing aluminum silicate minerals and corundum
- Contact (Dashed where approximately located)
- 60 — Fault, showing dip (Dashed where inferred)
- 90 — Vertical fault
- ? — Probable fault
- 60 — Strike and dip of foliation
- 50 — Strike and dip of joints
- Trench or open cut
- Dump

"GREEN TALC MINE"
– DIAMOND DRILLING –

D.D.H. No.1	250 ft.	-25°
" No.2	250 "	-25°
" No.3	200 "	-20°
" No.4	200 "	-20
Additional	700 "	{To be spotted by Field Team
Total.....	1600 ft.	D.D.H.

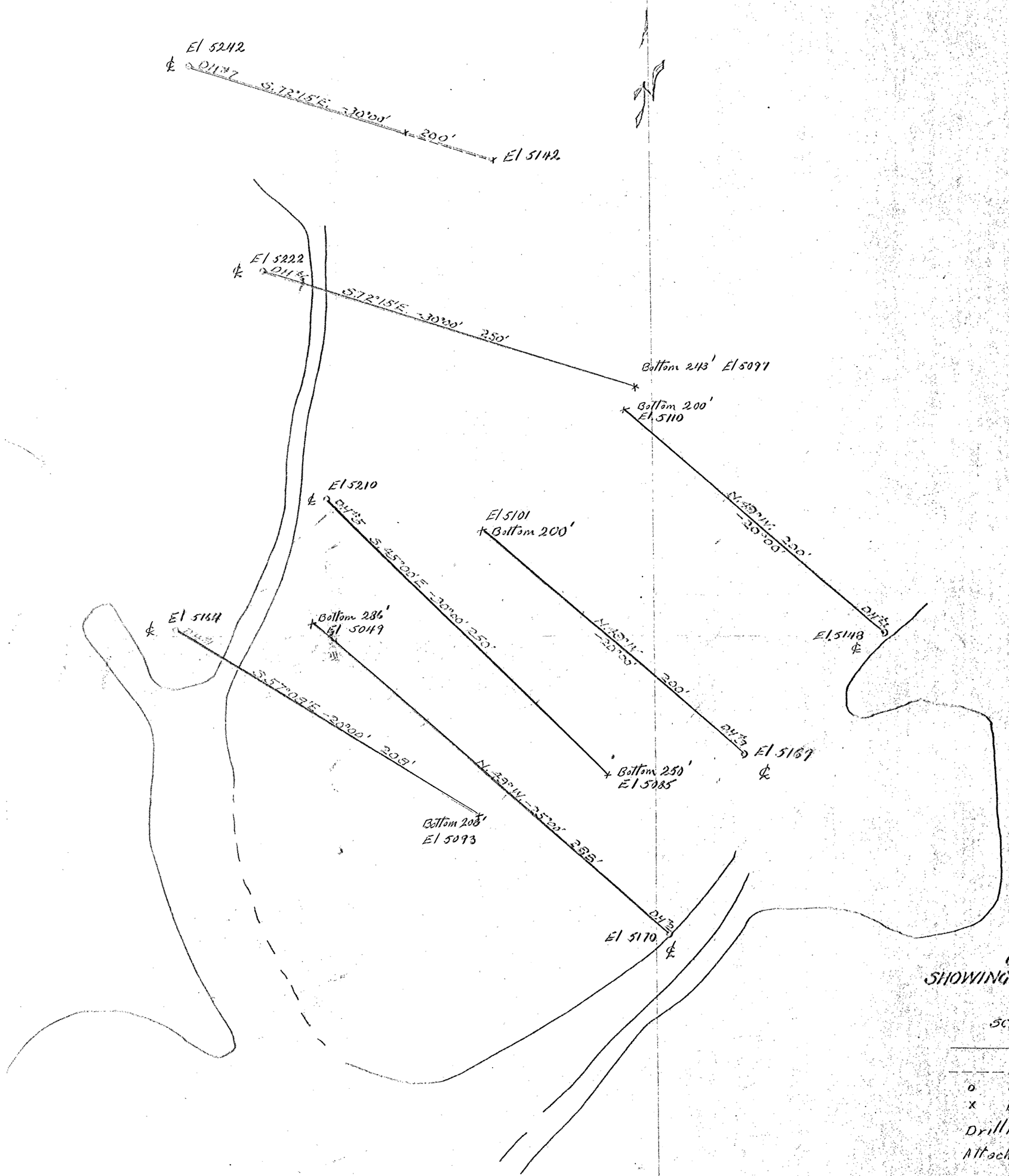
Actual
#1 208
#2 286
#3 200
#4 200
#5 250
#6 250
#7 200
1594

Figure 3

SOUTH LENS OF THE GREEN TALC DEPOSIT, HAWTHORNE, MINERAL COUNTY, NEVADA

40 0 40 80 120 Feet

Contour interval 5 feet
Barometric datum



GREEN TALC MINE
SHOWING D.D. HOLES LOCATIONS

SUR. BY L.B.S.

SCALE 1" = 40 ft

——— Drilled Hole

– – – – Footage Not Drilled

o Collar Elevation

x Bottom Elevation

Drilling Progress Map

Attachment to Monthly Progress Report 104 + 104A

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

DMEA-2512

Area No1. Approx. 40' x 80' = 3200 □ ft 3 samples Sample drilling of outcrop 178 holes 5' ea. 640' "Deep mine"
Trench " 10' x 80' = 800 □ ft. 3 samples 32 holes 5' ea. 160'
3 pits 6 holes in each 3 samples 18 holes 5' ea. 90'
178 holes 5' ea. 890'
890 ft @ 1.25 = $1112.50

Recommended by field report: –
9 samples from outcrop
2 diamond drill holes plus 300' additional after first 2 drilled

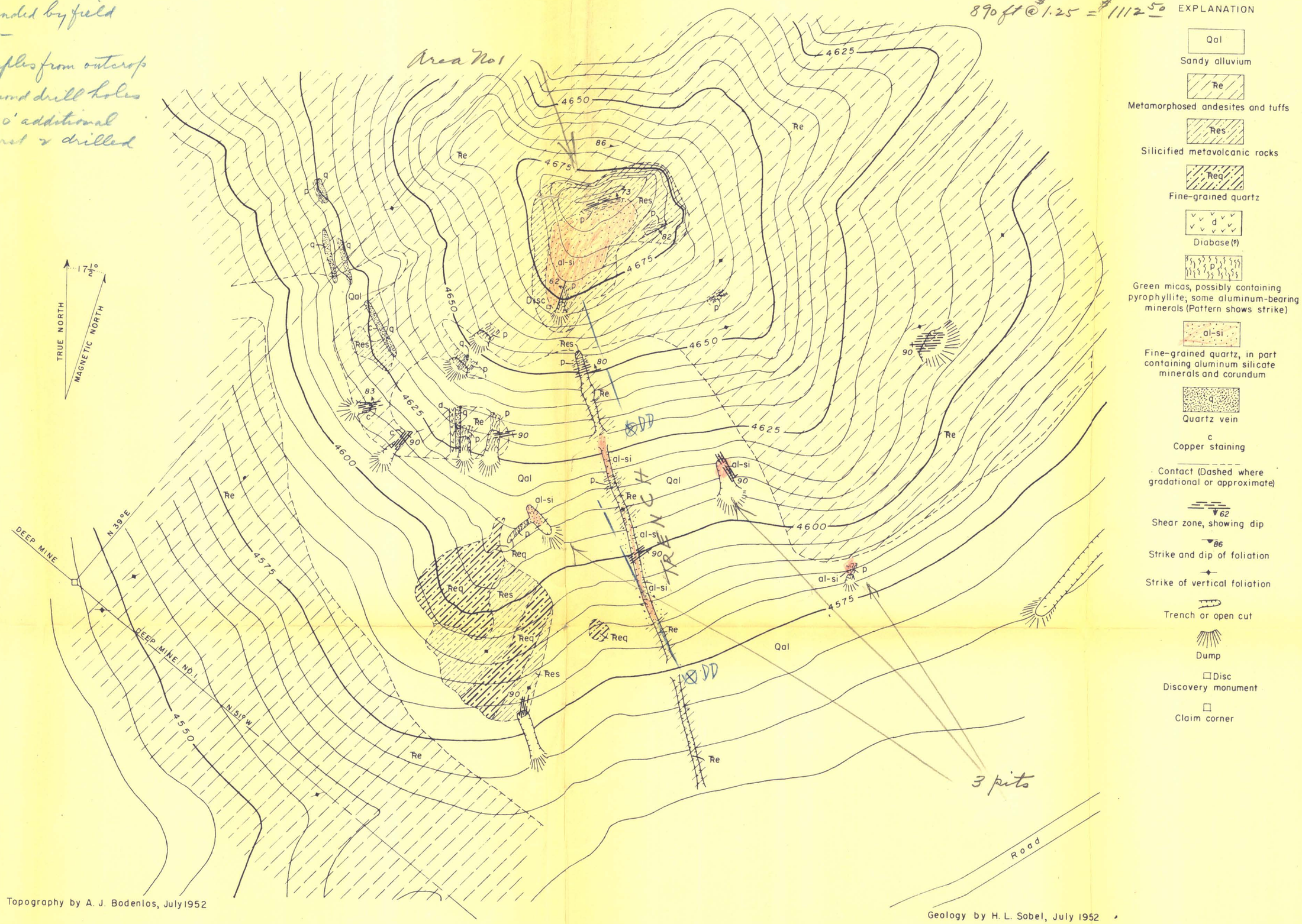


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Figure 1

DEEP MINES ANDALUSITE DEPOSIT, HAWTHORNE, MINERAL COUNTY, NEVADA

40 0 40 80 120 Feet

Contour interval 5 feet
Barometric datum