UNITED STATES
DEPARTMENT OF THE INTERIOR
Defense Minerals Exploration Administration

OFFICIAL DOCKET FILE

~~Terminated~~ (or cancelled) without certification. DMEA No. 1258

This is the official contract file containing all official records of the project. Duplicate material has been removed. The records contained in the files are checked and are arranged in this manner:

Left Side

Certificate of Audit (Final).

Interim Audit(s).

Report of Review.

Termination Notice or Agreement.

✓ Recision Notice.

Assignment of Contract.

Contract Amendments (latest on top).

✓ Contract with all exhibits and annexes.

Owner's Consent to Lien.

Subordination Agreement.

Leases and assignments of leases.

✓ Application and attachments.

Schedule of Collections.

Operator's monthly reports and all attachments (latest on top).

Right Side

Project summary.

✓ Work completed analysis.

✓ All other material is filed in chronological order with correspondence including the following reports as checked:

Final Field Team Report. (Tab)

Operator's Final Report.

Interim Reports.

✓ On-site Exam Report(s). (Tab)

Settlement Sheets.

If additional folders are required because of volume of records, show folder numbers and contents below:

Maps in folder number _____

Operator's Monthly Reports in folder number _____

IZM
Reviewer's Initials

7973

RESCISSION OF
EXPLORATION PROJECT CONTRACT IDM-E91

It is mutually agreed this 12th day of April, 1952, by and between the parties hereto that the Exploration Project Contract Idm-E91 (Docket DMA-1258X) dated July 31, 1951, between the parties shall be and is rescinded, revoked and cancelled as of July 31, 1951, the date of the contract.

R. E. Frowenfeld, President of the Altoona Quicksilver Mining Company, the undersigned Operator, releases and agrees to save harmless the United States of America from all claims and demands under or arising out of said Exploration Project Contract.

Witness the following signatures the day and year first above written.

DEPARTMENT OF THE INTERIOR
Defense Minerals Administration
RECEIVED
APR 14 1952

UNITED STATES OF AMERICA

By C O Mittendorf
Acting Administrator, Defense
Minerals Exploration Administration

R E Frowenfeld
Operator, President, Altoona
Quicksilver Mining Company

MF-200
(April 1951)

Indexed
New Card
Card
Reviewed

Docket No. DMA 1258X
Commodity Mercury
Idm-E91

UNITED STATES OF AMERICA
DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION

EXPLORATION PROJECT CONTRACT[1]

AUG 8 1951

It is agreed this 31st day of July, 1951, between the United States of America, acting through the Department of the Interior, Defense Minerals Administration, hereinafter called the "Government," and[2] Altoona Quicksilver Mining Co., 124 Presidio Ave., San Francisco 15, California hereinafter called the "Operator," as follows:

1. *Authority for contract.* This agreement is entered into under the authority of the Defense Production Act of 1950, pursuant to Mineral Order 5, entitled "Regulations Governing Government Aid in Defense Exploration Projects."

2. *Operator's property rights.* The exploration project shall be conducted on that certain property situated in the State of California, County of Trinity described as follows:[3] The Altoona Quicksilver Mine, lots 41-42 (patented) and lot 45 (patent being applied for) Section 22, Township 38 North, Range 6 West, MDB&M. with respect to which the Operator represents and undertakes:[4]

(*a*) That he is the sole 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: None

(*b*) ~~That he is the sole owner, in possession and entitled to possession, and the subordination agreement of the holder is attached~~

3. *Exploration project.* The Operator, within thirty (30) days from the date of this contract shall commence work on a project of exploration for[5] Mercury ore; shall prosecute the work efficiently, expertly, in a workmanlike manner, in accordance with good mining standards, with suitable and adequate equipment, materials, and labor, all properly designed to bring the project to completion within a period of[6] twelve (12) months from the date of this contract. The exploration project and the work to be performed are more fully described on Exhibit "A" attached hereto, which, with any maps or drawings thereto attached, is made a part of this contract.

4. *Performance of the work.* The work shall be performed by the Operator, under his sole direction and control: *Provided,* That with the consent of the Government and its written approval of the contract or contracts, all or any part of the work may be performed by the Operator through contract or contracts with independent contractors. 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.

5. *Fixtures and improvements.* 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. Attached hereto, marked "Exhibit 'B'," is a detailed list of additional facilities, buildings, and fixtures, to be purchased, installed, or erected by the Operator, with the estimated cost of each, to which the Government will contribute its agreed pro-rata share of the cost. The difference between the cost of such additional facilities, buildings, or fixtures, and the salvage value thereof at the conclusion of the work, shall be charged as a cost of the project to which the Government has contributed its pro-rata share.

6. *Operating equipment.* Attached hereto, marked "Exhibit 'C'," is a detailed list of operating equipment divided into categories of items to be rented, purchased, or furnished by the Operator, with the allowable rental, purchase price, or rental value, as the case may be, annexed to each. As to equipment purchased for the project, the Government will contribute its agreed pro-rata share of the cost thereof, and the difference between the cost and the salvage value at the conclusion of the work shall be charged as a cost of the project to which the Government has contributed its pro-rata share.

[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.
[4] Strike out the provision not applicable.
[5] Name of mineral.
[6] Not in excess of 2 years.

7. *Title to and disposition of property.* All facilities, buildings, fixtures, equipment, or other items costing more than $50 each, paid for or purchased with funds contributed jointly by the Operator and the Government, shall belong to the Operator and the Government jointly, in proportion to their respective contributions, and upon the termination of the contract, if they have any salvage value, shall be disposed of for their joint account unless the Government, in writing, waives its interest in any such items. The Government may require the dismantling, severance from land, and removal of any such items in order to realize its interest in the salvage value thereof, and the cost of any such removal and of the disposal of the items shall be for the joint account of the parties in proportion to their respective interests.

8. *Labor and supervision.* Attached hereto, marked "Exhibit 'D'," is an itemized schedule of labor, by numbers and classes (miners, muckers, millmen, etc.), and of supervisors, by numbers and positions, with the maximum wages or salaries that may be paid to each as an allowable cost of the project.

9. *Rehabilitation and repairs.* Attached hereto, marked "Exhibit 'E'," is a detailed schedule of existing facilities, buildings, installations, and fixtures, with a statement of the cost of any necessary rehabilitation or repairs to put into useful and operable condition, which cost shall be allowed as a cost of the project.

10. *Allowable costs of the project.* The allowable costs of the project in which the Government will participate are limited to the necessary, reasonable, direct costs of performing the exploration work, including the costs of materials, supplies, engineering, power, water, and utilities, including items of equipment costing less than $50 each; and the costs referred to in Articles 5, 6, 8, and 9, and the exhibits annexed to and referred to in the contract. Although the Government may pay part of the cost of new or additional facilities, structures, buildings, and equipment, only the depreciation on such items, computed as indicated in Articles 5 and 6, will be charged as a cost of the project. No items of general overhead, corporate management, interest, or any other indirect costs not expressly allowed by these regulations, or work performed or costs incurred before the date of this contract, shall be allowed as costs of the project in which the Government will participate.

11. *Participation by the Government.* At the end of the first full calendar month after the Operator has commenced work under the project, and at the end of each succeeding calendar month, the Operator shall submit to the Government a voucher for payment with a detailed statement of work done and allowable costs (as defined in Article 10 of this agreement) incurred, in a form and with supporting data acceptable to the Government. After approving the voucher, the Government shall pay to the Operator 75 percent of the sum of such costs incurred; *Provided,* That the aggregate total of all sums paid by the Government under this agreement shall not exceed $67,839, which is 75 percent of the agreed estimated total cost of this project, $90,452.

12. *Accounts and audits.* The Operator shall keep suitable records and accounts of operations, which the Government may inspect and audit at any time. The Government may at any time require an audit of the Operator's records and accounts by a certified public accountant, 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.

13. *Progress reports.* The Operator shall provide the Government with monthly reports of progress in form and content satisfactory to the Government, and upon the completion of the project or termination of the contract shall provide the Government with a comprehensive geologic and engineering report, including an estimate of ore reserves, to the best of his ability. Four copies of all reports shall be furnished to the Government.

14. *Repayment by Operator.* If, upon the completion of the exploration project or termination of the contract, the Government considers that a discovery or development has resulted from the work from which commercial production of ore may be made, the Government, within 6 months thereafter shall so certify to the Operator, particularly describing and delimiting its estimate of the discovery or the development. Thereafter, if and as ore is produced as a result of such discovery or development, the Operator and his successor in interest shall be and become obligated to pay to the Government a percentage royalty on the net smelter returns or other net proceeds realized from such ore, concentrates, or metal produced within ten (10) years from the date of this contract, until the total amount contributed by the Government, without interest, is fully repaid or said 10 years have elapsed, whichever occurs first, as follows:

Of net smelter returns or other net proceeds not in excess of eight dollars ($8.00) per ton of ore: One and one-half (1½) percent.

Of net smelter returns or other net proceeds in excess of eight dollars ($8.00) per ton of ore: One and one-half (1½) percent, plus one-half (½) percent additional for each full fifty cents ($0.50) in excess of eight dollars ($8.00) per ton of ore, but not in excess of a maximum of five (5) percent.

This obligation to repay from net returns or proceeds shall be and remain a claim and lien upon the property which is the subject of the exploration project and upon any production resulting from such discovery or development, in favor of the Government, until fully paid, or until said 10-year period has elapsed; and this claim and lien and the Government's right to repayment shall survive any termination of the contract, whether by completion of the exploration project or otherwise. This article is not to be construed as imposing any obligation on the Operator or his successor in interest to produce ore from any such discovery or development.

15. *No assignment of contract.* Without the written consent of the Government, the Operator shall not assign or otherwise transfer or hypothecate this contract or any rights thereunder.

16. *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 worthwhile discovery and in the opinion of the Government further operations are not justified. Upon the completion of the project or any termination of the contract the Operator shall render to the Government a full and final accounting of his operations under the contract and his expenditures of money; shall dispose of any unused materials, supplies, and equipment for the joint account of the Operator and the Government in the proportion of their respective interests; and shall pay to the Government its pro-rata share of any money remaining.

Executed in ~~triplicate~~ sextuplet the day and year first above written.

Altoona Quicksilver Mining Co.
(Operator)

By [signature]
President

THE UNITED STATES OF AMERICA

By [signature]
C. O. Mittendorf, Director
Production Expansion Division

U. S. GOVERNMENT PRINTING OFFICE 16—64066-1

ALTOONA QUICKSILVER MINING COMPANY

DMA DOCKET NO. 1258X

EXHIBIT "A"

MAP ATTACHED:- SECTION THROUGH MINE.

AT PRESENT THE MINE IS CLOSED DOWN, THE COLLAR OF THE SHAFT HAS CAVED, THE MINE IS FULL OF WATER, AND ALL MACHINERY USED IN FORMER OPERATIONS HAS BEEN REMOVED FROM THE PROPERTY.

IN ORDER TO EXPLORE AND DEVELOP THIS MINE, IT WILL BE NECESSARY TO REHABILITATE THE CAMP. THERE ARE FOUR HOUSES LEFT ON THE PROPERTY, ONE OF WHICH IS THE COOK HOUSE. THESE ARE IN NEED OF REPAIR. A NEW WATER LINE TO THE CAMP, ROUGHLY ONE MILE LONG, WILL HAVE TO BE INSTALLED. A CREW OF 10 MEN WILL BE NEEDED TO OPEN THE MINE AND DO THE NECESSARY EXPLORATION WORK. THE ORDER IN WHICH THIS WORK SHOULD BE DONE IS AS FOLLOWS:-

1 - REHABILITATE THE CAMP, HOUSES, WATER LINE, POWER CONNECTION, & INSTALL BLACKSMITH SHOP.

2 - REPAIR COLLAR OF SHAFT. ERECT HEADFRAME. INSTALL HOIST.

3 - UNWATER THE SHAFT AND REPAIR SHAFT TO THE 450 FOOT LEVEL.

4 - OPEN & RETIMBER WHERE NECESSARY THE 450 FT. LEVEL TO THE WINZE.

5 - UNWATER THE WINZE AND REPAIR TIMBERING TO THE 600 FOOT LEVEL.

6 - OPEN AND RETIMBER WHERE NECESSARY THE 600 FOOT LEVEL.

7 - DIAMOND DRILLING FROM THE 500 FT. AND 600 FT. LEVELS, AND DRIFTING AND CROSSCUTTING ON THE 600 FT. LEVEL AS WILL SUGGEST ITSELF AFTER EXAMINATION OF THE LOWER LEVEL.

ESTIMATED COSTS:-

1 - REHABILITATE THE CAMP & HOUSES		$ 3,000.
WATER LINE - 7000 FT. 2" STD. BLACK PIPE, NEW $34.27/100'		2,399.
POWER CONNECTION		3,500.
BLACKSMITH SHOP (Tools etc.)		300.
FOR LABOR COSTS (PER EXHIBIT "D" ATTACHED) ON:-		
ITEMS 1, 2, 3, 4, 5, & 6 (ABOVE)	25,100	
ITEM 7 (ABOVE):-		
1160 FT. OF DRIFTS, CROSSCUT & RAISE @ $15/FT	17,400	
1000 " " DIAMOND DRILLING @ $ 5/FT.	5,000	47,500
(NOTE:- SCHEDULE DRIFTING, CROSSCUTTING, RAISING & DIAMOND DRILLING ATTACHED.)		
OPERATING EQUIPMENT, PER EXHIBIT "C" ATTACHED		33,486
		$ 90,185.*

* NOTE: To this figure add $267 for contingencies which brings the total to the contract amount of $90,452. This is necessitated by attached additional information of July 16, 1951.

ALTOONA QUICKSILVER MINING COMPANY

DMA DOCKET NO. 1258X

EXHIBIT "A"

DRIFTING, CROSSCUTTING, RAISING, AND DIAMOND DRILLING:

500 FT. LEVEL:- 100 FT. OF CROSSCUT, ~~A~~ S 45° E. FROM WINZE TO CUT #1 & #2 VEINS.
200 FT. OF DRIFTING ON #1 AND #2 VEINS.
100 FT. OF DRIFTING ON #4 VEIN.
240 FT. OF DIAMOND DRILLING FROM WINZE STATION TO TEST DOWNWARD EXTENSION OF #1 AND #2 VEINS.
150 FT. OF DIAMOND DRILLING FROM 500 FT. LEVEL DOWNWARD TO TEST DOWNWARD EXTENSION OF #3 AND #4 VEINS.

600 FT. LEVEL:- 60 FT. OF CROSSCUT, S 45° E. FROM WINZE TO CUT #1 VEIN.
200 FT. OF DRIFTING ON #1 VEIN.
200 FT. " " " #3 "
100 FT. " " " #2 "
100 FT. " " " #5 "
80 FT. OF DIAMOND DRILLING FROM NEAR WINZE STATION TO TEST DOWNWARD EXTENSION OF #1 VEIN.
330 FT. OF DIAMOND DRILLING FROM A POINT ON THE 600 LEVEL BETWEEN #2 AND #3 VEINS TO TEST DOWNWARD EXTENSION OF #2, #3, and #5 VEINS.
200 FT. OF DIAMOND DRILLING FROM THE END OF THE 200 FT. DRIFT ON #3 VEIN TO TEST DOWNWARD EXTENSION OF VEIN AT THIS POINT.

RAISE FROM 600 TO 500 LEVEL FOR VENTILATION AND TO BE RUN IN #3 VEIN FOR EXPLORATION - 100 FEET.

ALTOONA QUICKSILVER MINING COMPANY

DMA DOCKET NO. 1258X

EXHIBIT "B"

ADDITIONAL FACILITIES, BUILDINGS, AND FIXTURES, TO BE PURCHASED, INSTALLED, OR ERECTED BY THE OPERATOR, WITH THE ESTIMATED COST OF EACH:-

1 - DEPOSIT ON POWER CONNECTION - - - - - - - - - (NOTE:- $2,500 OF THIS DEPOSIT RETURNABLE. COST OF POWER PER MONTH SHOWN IN EXHIBIT "D".)	$ 3,500.
2 - BLACKSMITH SHOP, TOOLS, ETC. - - - - - - - -	300.
3 - WATER LINE - 7000 Ft. 2" STD. BLACK PIPE, NEW. $34.28/100' - - - - - - - - -	2,399.
	$ 6,199

ALTOONA QUICKSILVER MINING COMPANY

DMA DOCKET NO. 1258X

EXHIBIT "C"

TO BE PURCHASED

OPERATING EQUIPMENT:

1 - TRUCK	$ 2,500.
10 - TONS 16# RAIL, WITH PLATES, BOLTS & SPIKES	$ 2,000.
1000 - FEET 10" #22 GAUGE, GALV. AIR PIPE @ $87.10	871.
1 - 10" AMERICAN BLOWER, WITH 5-HP MOTOR & STARTER	410.
1 - 50-HP SINGLE DRUM MINE HOIST, CAPACITY 4000# AT A ROPE SPEED OF 400-FEET PER MINUTE, COMPLETE WITH DRUM CONTROLLER, SHEAVE WHEEL AND CABLE, ALL RECONDITIONED	1,750.
1 - 440-FT. INGERSOLL-RAND TYPE XB-2 COMPRESSOR, SIZE 15 - 9 x 12, COMPLETE WITH 75-HP MOTOR, STARTER, AIR RECEIVER AND NECESSARY PIPING, ALL RECONDITIONED	2,250.
1 - 1250# INGERSOLL-RAND TYPE EUA SINGLE DRUM AIR HOIST, WITH 300 FT. 1/4" CABLE, ALL RECONDITIONED	400
3 - SULLIVAN JACKHAMMERS, 55# LATE MACHINES (365)	1,095.
2 - " " MOUNTINGS (180)	360.
2 - SULLIVAN SETS COLUMN BARS, 3" WITH ARM, SADDLE (150)	300.
3 - PCS. 50' LENGHTS 3/4" AIR HOSE CPLD. (32)	96.
3 - " " " 1/2" WATER " " (23)	69.
5 - SETS 1" QO. DRILL STEEL, THREADED AND SHANKED: 2' @ 4.75; 42" @ $6.20¢ 60" @ $7.60¢ 72" @ $8.50 - TOTAL $27.00	135.
500 - TIMKIN BITS, THREE GAUGES @ 44¢	220.
1 - SULLIVAN DIAMOND DRILL, MODEL HS-15, AIR. OUTFIT COMPLETE (300')	2,100.
8 - MINE CARS, 16-FT. 18" GA. ROLLER BEARING (200)	1,600.
1 - "LAYNE & BOWLER" DEEP WELL TURBINE PUMP #A-C-20 HEAD 450-FT. 8" COLUMN, 450-FT. 1-11/16" RODS, #10 - 14- STAGE BOWLS, WITH 75-HP MOTOR, 1750-R.P.M. WITH STARTER, DELIVERED REDDING, CALIF. THIS PUMP GOOD FOR 500/GALS/MIN. FOR 450' HEAD	8,325.
1 - "LAYNE & BOWLER" DEEP WELL PUMP, TURBINE, #A-C*20 HEAD, (6" COLUMN, 200-FT.) 200-FT. 1-3/16" RODS. #10 - 7-STAGE BOWLS, WITH 40-HP MOTOR, 1750-RPM. CAPACITY: 500-GALLONS MINUTE, FOR 200-FT. HEAD. PRICE, DELIVERED CARS, REDDING, CALIFORNIA	3,255.
1000 - FT. ELECTRIC CABLE @ $1.25/FT/	1,250.
TIMBER AND LUMBER COST, ABOUT	2,500.
MISCELLANEOUS TOOLS & SUPPLIES	2,000
	$ 33,486.

ALTOONA QUICKSILVER MINING COMPANY

DMA DOCKET NO. 1258X

EXHIBIT "D"

LABOR:

ENGINEERING, SURVEYING, CONSULTANTS, ETC. - - - - - - - $ 1,900.

CREW OF 10 MEN ABOUT AS FOLLOWS:

1 - SUPERINTENDENT - -	$ 500.	MO.	
1 - COOK - - - - - - - -	300.	"	
1 - HOISTMAN - - - - -	350.	"	
1 - PUMP MAN & MECHANIC	350.	"	
2 - MINERS ($300. EA)	600.	"	
2 - MUCKERS " "	600.	"	
2 - TIMBERMEN " "	600.	"	
	3,300.	"	
ELECTRIC POWER - - - - - - -	500.	"	
	3,800	"	- - PER YEAR 45,600
			47,500

ALTOONA QUICKSILVER MINING COMPANY

DMA DOCKET NO. 1258X

EXHIBIT "E"

REHABILITATION & REPAIRS

BUILDINGS:- THE FOUR HOUSES ON THE PROPERTY WILL REQUIRE REPAIR AND REHABILITATION - - - - - - - - - - - - $ 3,000.

JULY 16, 1951

ALTOONA QUICKSILVER MINING COMPANY

DMA DOCKET NO. 1258X

ADDITIONAL INFORMATION REQUESTED BY MR. WESTON BOURRET IN WIRE OF JULY 3 ON EXHIBIT 'A' ITEMS 1 - 7:

ITEM #1 - REHABILITATE THE CAMP, HOUSES, WATER LINE, POWER CONNECTION, AND INSTALL BLACKSMITH SHOP.

(a) - - THERE ARE FOUR HOUSES WITHIN AN AREA OF 125 FT. OF THE SHAFT. THREE ARE BUNKHOUSES AND ONE IS A COMBINED COOKHOUSE-DINING ROOM. WE BELIEVE THEY WILL BE SUFFICIENT FOR THE CREW FOR THE DEVELOPMENT WORK. NEEDED ARE:

SHINGLES
WINDOWS, DOORS, SCREENS & HARDWARE
BATH FIXTURES
HEATING STOVES
BEDS & BEDDING
CHAIRS & SMALL TABLES
REFRIGERATOR
COOK STOVE
SINK
SILVER, CHINA, COOKING UTENCILS & CUTLERY
CHAIR TABLES
PIPE & FITTING FOR PLUMBING

(b) - - WATER LINE

THE WATER LINE RUNS ABOUT 1-1/4 MILES UPGRADE FROM THE CAMP. AS WE DO NOT THINK FREEZING CONDITIONS WILL AFFECT IT, WE DO NOT PLAN TO BURY IT EXCEPT WHERE IT WILL RUN UNDER THE ROAD. THERE IS PLENTY OF WATER FOR A YEAR-AROUND SUPPLY. WE FIGURE 20 SHIFTS @ $15/SHIFT FOR THIS WORK, WHICH IS INCLUDED IN THE $1,500 BELOW.

(c) - - POWER CONNECTION

THE $3,500 SHOWN IN EXHIBIT 'A' COVERS THE CHARGE OF THE CALIFORNIA-OREGON POWER COMPANY FOR DEPOSIT, MATERIAL & INSTALLATION.

(d)- - BLACKSMITH SHOP

THIS IS SHOWN IN EXHIBIT 'A' AND INCLUDES A ROUGH SHACK, PLUS THE VARIOUS TOOLS NEEDED.

ESTIMATED COSTS OF ITEMS a, b, c, and d, IN ITEM 1:

100 MAN SHIFTS -		$ 1,500.00	
EQUIPMENT & MATERIALS - - - - - - - - - - - - - - - - - -		1,500.00	
PLUS ITEMS LISTED IN EXHIBIT 'B':-			
WATER LINE - 7000 FT. 2" BLK. PIPE -	$2,399.		
POWER CONNECTION - - - - - - - - - - -	3,500.		
BLACKSMITH SHOP - - - - - - - - - - -	300.	6,199.00	
**POWER EST. @ $500 MO. FOR 12 MONTHS - - - - - - - - -		6,000.00	$15,199.00

** MR.MILLER IN SAN FRANCISCO SUGGESTED THIS CHARGE BE TRANSFERRED FROM ~~ITEM~~ 'D'.

EXHIBIT

JUNE 18, 1968

ARIZONA QUICKSILVER MINING COMPANY

INA DOCKET NO. 1880

ADDITIONAL INFORMATION REQUESTED BY MR. HERTEN DURING TIME OF JULY 8 ON MEMORANDUM "A" ITEMS 1 - 7:

ITEM #1 - REHABILITATE THE CAMP, HOUSES, WATER LINE, POWER CONNECTION, AND INITIAL BLACKSMITH SHOP.

(a) -- THERE ARE FOUR HOUSES WITHIN AN AREA OF 1SE 1T. OF THE SMALT. THESE ARE BUNKHOUSES AND ONE IS A COMBINED COOKHOUSE-DINING ROOM. WE BELIEVE THEY WILL BE SUFFICIENT FOR THE CREW FOR THE DEVELOPMENT WORK. NEEDED ARE:

SLEEPERS
WINDOWS, DOORS, SCREENS & HARDWARE
BATH FIXTURES
HEATING STOVES
BEDS & BEDDING
CHAIRS & SMALL TABLES
REFRIGERATOR
COOK STOVE
SINK
SILVER, CHINA, COOKING UTENSILS & UTENSILS
CHAIR PADS
PIPE & FITTING FOR PLUMBING

(b) -- WATER LINE

THE WATER LINE RUNS ABOUT 1-1/4 MILES UPCANYON FROM THE CAMP. AS IT DO NOT THINK FREEZING CONDITIONS WILL AFFECT IT, WE DO NOT FEEL TO BURY IT EXCEPT WHERE IT WILL RUN UNDER THE ROAD. THERE IS PLENTY OF WATER FOR A YEAR-ROUND SUPPLY. WE FIGURE 20 SHEETS 3 MLS/SHEET FOR THIS LINE, WHICH IS INCLUDED IN THE $1,500 ESTIM.

(c) -- POWER CONNECTION

THE $5,500 SHOWN IN EXHIBIT 'A' COVERS THE CHARGE OF THE CALIFORNIA-OREGON POWER COMPANY FOR DEPOSIT, MATERIAL & INSTALLATION.

(d) -- BLACKSMITH SHOP

THIS IS SHOWN IN EXHIBIT 'A' AND INCLUDES A ROUGH SHACK, PLUS THE VARIOUS TOOLS NEEDED.

ESTIMATED COSTS OF ITEMS a, b, c, and d, IN ITEM 1:

100 NEW SHEETS -	$1,500.00	
EQUIPMENT & MATERIALS -	1,500.00	
OTHER ITEMS LISTED IN EXHIBIT 'B':-		
WATER LINE - 7000 FT. 2" BLK. PIPE - $2,229.		
POWER CONNECTION -	5,500.	
BLACKSMITH SHOP -	6,150.00	
**POWER EST. @ $500 MO. FOR 12 MONTHS - - - - - - - - - - - - - - -	6,000.00	$28,179.00

** MR. MILLER IN SAN FRANCISCO SUGGESTED THIS CHARGE BE TRANSFERRED FROM ~~ITEM~~ 'D'.

EXHIBIT

JULY 16, 1951

ALTOONA QUICKSILVER MINING COMPANY

DMA DOCKET NO. 1258X

FORWARD - $ 15,199.00

ITEM #2 - REPAIR COLLAR OF SHAFT. ERECT HEADFRAME. INSTALL HOIST.

(a) - - HOIST HOUSE

2000 BD.FT. LUMBER @ $50/M - - - - - - - - - -	$ 100.00	
1000 LBS. CORRUGATED IRON - - - - - - - - - -	100.00	
25 SACKS CEMENT - - - - - - - - - - - - - -	37.50	
3 YDS. SAND - - - - - - - - - - - - - - - -	4.50	
5 YDS. ROCK - - - - - - - - - - - - - - - -	7.50	249.50

(b) - - HOIST & COMPRESSOR FOUNDATION:

200 SACKS CEMENT - - - - - - - - - - - - - -	300.00	
17 YDS. SAND - - - - - - - - - - - - - - - -	25.50	
30 YDS. ROCK - - - - - - - - - - - - - - - -	45.00	
WIRING, SWITCHES & ELECTRICAL MISCEL. - - -	200.00	
LABOR, 60 MAN SHIFTS INC. HOIST HOUSE - - -	900.00	1,470.50

(c) - - HEADFRAME

8000 BD. FT. LUMBER @ $50/M - - - - - - - - -	400.00	
700 LBS. CORRUGATED IRON - - - - - - - - - -	70.00	
25 SACKS CEMENT- - - - - - - - - - - - - - -	37.50	
3 YDS. SAND - - - - - - - - - - - - - - - -	4.50	
5 YDS. ROCK - - - - - - - - - - - - - - - -	7.50	
1200 LBS. STEEL PLATE - - - - - - - - - - - -	120.00	
BOLTS, NUTS, WASHERS, ETC. - - - - - - - - -	400.00	
MISCELLANEOUS - - - - - - - - - - - - - - -	100.00	
LABOR - 100 MAN SHIFTS - - - - - - - - - - -	1,500.00	2,639.50

(d) - - CONCRETE SHAFT 2 SETS DOWN FROM COLLAR:

1000 BD. FT. LUMBER @ $50/M - - - - - - - -	50.00		
1000 LBS. REINFORCING IRON - - - - - - - -	100.00		
40 SACKS CEMENT - - - - - - - - - - - - - -	60.00		
10 YDS. SAND - - - - - - - - - - - - - - - -	15.00		
15 YDS. ROCK - - - - - - - - - - - - - - - -	22.50		
LABOR - 24 MAN SHIFTS - - - - - - - - - - -	360.00	607.50	4,967.00

FORWARD - - 20,166.00

ALTOONA QUICKSILVER MINING COMPANY

DMA DOCKET NO. 1258X

FORWARD -		$ 20,166.00

ITEM 3 - UNWATER THE SHAFT & REPAIR SHAFT TO THE 450' LEVEL:

THE SHAFT TO THE 450' LEVEL HAS ABOUT 55,000 BD. FT. OF WALL PLATES, END PLATES, POSTS & DIVIDERS & LAGGING. SAY 1/4 NEEDS REPLACING - THIS WOULD BE:

14,000 BD. FT. LUMBER @ $50/M - - - - - - - - - - - -	$ 700.00	
LABOR - 90 MAN SHIFTS - - - - - - - - - - - - - - - - -	1,350.00	
LADDERS, GUIDES, PIPE SUPPORT, & MISCELLANEOUS - -	300.00	2,350.00

ITEM 4 - OPEN & RETIMBER WHERE NECESSARY THE 450' LEVEL TO THE WINZE:

OPEN AND RE-TIMBER THE 450' LEVEL FROM SHAFT TO WINZE, A DISTANCE OF SOME 280 FT. AT 200 BD. FT. PER SET & 56 SETS TO GO WE HAVE -

11,200 BD. FT. LUMBER @ $50/M - - - - - - - - - - - -	560.00	
LABOR - AT 4'/SHIFT, 140 MAN SHIFTS - - - - - - - - -	2,100.00	2,660.00

ITEM 5 - UNWATER THE WINZE & REPAIR TIMBERING TO THE 600' LEVEL:

UNWATER WINZE; RETIMBER WINZE & STATIONS; INSTALL HOISE.

20000 BD. FT. LUMBER @ $50/M - - - - - - - - - - - -	1,000.00	
(FOR 450 STATION & WINZE)		
LABOR - 6 MEN 30 DAYS - 180 MAN SHIFTS - - - - - -	2,700.00	
WEDGES, HANGING RODS, GUIDES, LADDERS, & MISC. - -	600.00	
TIMBER & LAG 600 LEVEL STATION:		
2000 BD. FT. LUMBER @ $50/M - - - - - - - - - - - -	100.00	
LABOR - 16 MAN SHIFTS - - - - - - - - - - - - - - - -	240.00	4,640.00

ITEM 6 - OPEN & RETIMBER WHERE NECESSARY THE 600' LEVEL:

500 FT. OF LEVEL NEEDS 100 SETS & AT 200 BD. FT. PER SET IS:

20,000 BD. FT. LUMBER @ $50/M - - - - - - - - - -	1,000.00	
LABOR - 250 MAN SHIFTS - - - - - - - - - - - - - - -	3,750.00	4,750.00

ITEM 7 - DIAMOND DRILLING FROM THE 500' & 600' LEVELS, & DRIFTING & CROSSCUTTING ON THE 600' LEVEL AS WILL SUGGEST ITSELF AFTER EXAMINATION OF THE LOWER LEVEL.

1,160' OF DRIFTS, CROSSCUT & RAISE @ $15/FT. - -	17,400.00	
1,000' OF DIAMOND DRILLING @ 5/FT. - -	5,000.00	22,400.00
		56,966.00
OPERATING EQUIPMENT PER EXHIBIT 'C' SENT IN JUNE 11 - - - - - - -		33,486.00
		$ 90,452.00

JULY 16, 1951

ARIZONA QUICKSILVER MINING COMPANY

DMA DOCKET NO. 1850X

MOVANT -

ITEM 5 - DEEPEN THE SHAFT & REPAIR SHAFT TO THE 450' LEVEL:

THE SHAFT TO THE 450' LEVEL HAS ABOUT 15,000 FT. OF WOOD PLATES, TWO FLOORS, PORTS & DRIPPINGS & LEGEND.
PAY 1/4 HOURS REPAIRING - THIS COUNT 25:

14,000 EF. FT. LUMBER @ $50/M - - - - - - - - - - - - - -	$ 700.00
LABOR - 30 MAN SHIFTS - - - - - - - - - - - - - - - - - -	1,680.00
MATERIALS, GUIDES, FIRE EXTRCT, & MISCELLANEOUS - -	800.00
	3,180.00

ITEM 6 - OPEN & RETIMBER THREE NECESSARY THE 450' LEV. TO THE 1 LEVEL:

OPEN ALL RE-TIMBER THE 450' LEVEL FROM SHAFT TO LINE, A DISTANCE OF SOME 280 FT. AT 300 EF. FT. THE SET & 36 SETS TO GO WE HAVE -

12,600 BD. FT. LUMBER @ $50/M - - - - - - - - - - - -	630.00
LABOR - 17 4/SHIFT, 140 MAN SHIFTS - - - - - - - - - -	4,200.00
	2,830.00

ITEM 7 - TO RETOP THE LINE & REPAIR TIMBERING TO THE 800' LEVEL:

WEEKLY LINE; BETTERED WINZ & STATIONS; INSTALL MINE-
2000 EF. FT. LUMBER @ $50/M - - - - - - - - - - - - - - 1,000.00
(TOP. 450 STATION & WINZ)
LABOR - 3 MEN 30 DAYS - 180 MAN SHIFTS - - - - - - - 2,700.00
MATERIALS, HANDLE FOTE, GUIDES, SAFETYS, & MISC. - - 800.00
TIMBER @ LAG 800 LEVEL STATION:
2000 EF. FT. LUMBER @ $50/M - - - - - - - - - - - - - 100.00
LABOR - 16 MEN SHIFTS - - - - - - - - - - - - - - - - 240.00
| 4,340.00

ITEM 8 - OPEN & TIMBER WHERE NECESSARY THE 800' LEVEL:

800 FT. OF NEWER MINES 100 SETS @ AT 800 BD. FT. PER SET 18:
30,000 EF. FT. LUMBER @ $50/M - - - - - - - - - - - - 1,500.00
LABOR - 350 MAN SHIFTS - - - - - - - - - - - - - - - - 2,750.00
| 4,250.00

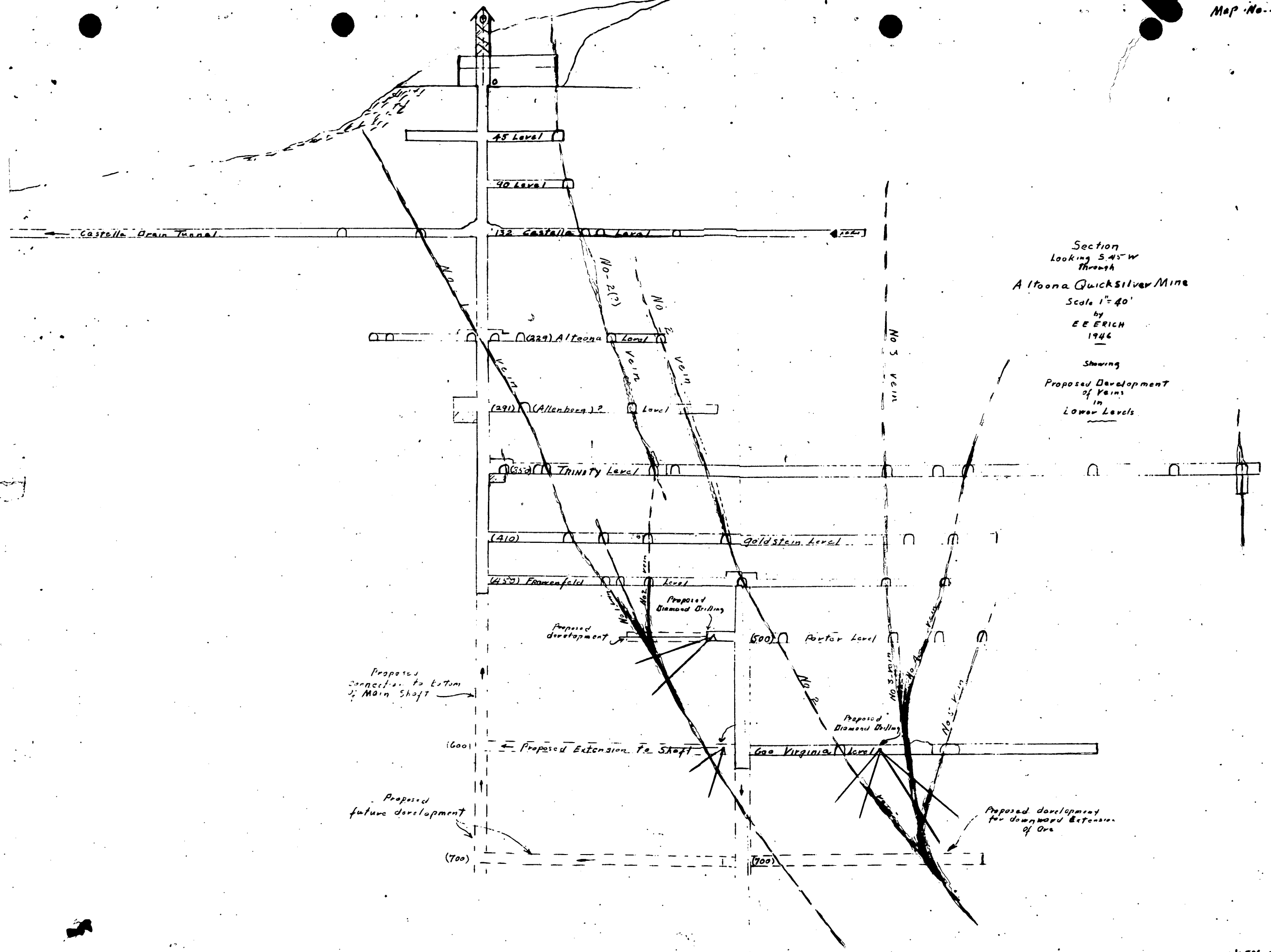
ITEM 7 - DRAWOFF PRIMING FROM THE 500' & 800' LEVELS, & MAKING & CROSSCUTTING ON THE 800' LEVEL AS WELL SUCCOUT ITEM AFTER EXAMINATION OF THE LOWER LEVEL.
1,100' OF DRIFTS, CROSSCUT & RAISE @ $15/FT. - - 17,400.00
1,000' OF DIAMOND DRILLING @ $5/FT. - - 5,000.00
| 22,400.00

22,400.00

SUBSTITUTED MOVEMENT PER EXHIBIT 'C' SENT IN JUNE 11 - - - - - - - 22,400.00

$ 80,440.00

Map No. 4.



Map No 4

July 31, 1951

AIR MAIL

Altoona Mid-Silver Mining Co.
124 Presidio Ave.
San Francisco 15, Calif.

Attention: Mr. [illegible] Greenfield
Re: Docket No. [illegible] - 12533

Gentlemen:

Enclosed find executed exploration project contract No. [illegible]-91 dated July 31, 1951, with attached exhibits "A" "B" "C" "D" and sketch map; also a set of monthly progress reports ([illegible]). This report is to be submitted monthly in quadruplicate to the DMEA field representative in your area where additional copies may be obtained.

Any questions appertaining to this project should be referred to Mr. H. [illegible] Miller, Executive Officer, DMEA Field Team, Region III, 1445 Appraisers Building, San Francisco, California. Please notify Mr. Miller when you begin work on this project.

A press release dated May 14, 1951 on "Questions and Answers on the Minerals Exploration Program" is also enclosed for your information.

Sincerely yours,

C. O. Mittendorf

C. O. Mittendorf, Director
Production Expansion Division

Enclosures-7

[illegible]lis/jem
cc to: Messrs. Mittendorf-Hand
Reports & Records
Docket
Lyon
Courret
Ellis
Miller, Region III
Contract Service Sec. [illegible]
Field Finance Sec.
Miss Terry

Form MF-103
(April 1951)

U. S. DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION

Budget Bureau No. 42-R1035.
Approval expires 6-30-51.

APPLICATION FOR AID FOR AN EXPLORATION PROJECT PURSUANT TO MINERAL ORDER 5, UNDER DEFENSE PRODUCTION ACT OF 1950

DO NOT FILL IN THIS BLOCK

Docket No. dma 12 58 X

Date received 5-25-51

Participation

ALTOONA QUICKSILVER MINING COMPANY
124 PRESIDIO AVENUE
SAN FRANCISCO 15, CALIFORNIA

Name and address of applicant

Date MAY 21, 1951

FILL IN THIS BLOCK

Date of application MAY 21, 1951

Estimated cost $91,000.00

Mineral or metal QUICKSILVER

Percentage of Government participation 75%

Location of mine CINNABAR MINING DIST
TRINITY COUNTY
CALIFORNIA

Date of filing MF-100 MAY 21, 1951

DMA Docket Number, if available dma 12 58 X

INSTRUCTIONS

Read Mineral Order 5, Regulations Governing Government Aid in Defense Projects, before completing this application. Submit four signed copies of the application to Defense Minerals Administration, Department of the Interior, Washington 25, D. C., or to the nearest field executive officer thereof, with your name and address on each sheet of the application and all accompanying papers. If any question is inapplicable, or if you cannot answer it, so state on the form. Where the space provided for answer is insufficient, answer on a separate sheet, annex it to the application form, and refer to it in space for answer. If the application is approved, you will be presented with an exploration project contract on Form MF-200, for your signature.

THE APPLICANT

*1. Is applicant an individual, partnership, or corporation? CORPORATION

*2. If a partnership, state names and addresses of partners.

*3. If a corporation, state names and addresses of officers, directors, and five largest stockholders. SEE FORM MF-100 ATTACHED

*4. Describe the mining and general business experience of (*a*) the applicant, and (*b*) the person or persons who will manage the project. INCORP.1875. PRESIDENT ASSOCIATED WITH PROPERTY 25 YEARS. REPUTABLE MINING ENGR. TO BE EMPLOYED.

*5. Are you the owner or the lessee of the property? OWNER

6. If owner, state what claims, liens, or encumbrances, if any, are against the property. NONE

7. If lessee, attach a copy of the lease and state if it is in good standing.

NOTE.—It will be necessary to procure and attach to the exploration project contract agreements of claimants, lienors, encumbrances and lessors subordinating their interests in the property to the interest of the Government under the contract.

8. Furnish current financial statement, showing assets and liabilities, and a profit and loss statement. INACTIVE

9. How much money is applicant prepared to invest in proposed project? Is it sufficient to pay your part of the cost of the project as detailed in question 23 of this application form, in accordance with the regulations on Government participation (Section 9 of Mineral Order 5)? YES

*If you have already answered these questions on MF-100, you are not required to answer the questions for this application.

16—64067-1

THE PROPERTY

10. (*a*) Give a description of the real property that will be in any way involved in the exploration project, including any existing mine or operating property. SEC.22, T.38 N. R. 6 W., M.D.B. LOTS 41-42-45

(*b*) Give the legal description of the exact parcel, plot, or area upon which the exploration is to be conducted.

NOTE.—If both areas are the same, so state. The only obligation to repay the Government is from the net earnings from any commercial discovery made in the area specified in (*b*) above in which the exploration is to be conducted, and the expenditure of funds which may be charged as costs of the project must be limited to that area or to work necessary to perform the exploration in that area.

*11. State the present and former names of the property, if any. ALTOONA QUICKSILVER MINING CO. SINCE 1875.

*12. State, in detail, the location of the property with reference to towns, railroads, roads, shipping points, including distances and directions and kinds and conditions of roads. 24 MILES TO CASTELLA - NEW ROAD.

*13. State source and quantity of water available for operations and its sufficiency at all seasons. - DOE CREEK/STATE PERMIT State amount of power to be used, rate per hour or other cost, and source. ORE.CALIF.POWER CO. 0.12 CU.FT.SEC

*14. Describe any existing useable facilities, equipment, buildings, or structure now on the property that will be devoted to the exploration work.

15. State in detail how the ore could be shipped and how and where milled. FURNACED AT MINE. CASTELLA SHIPPING POIN

*16. History: SEE REPORTS ATTACHED.

(*a*) Give a statement, as complete as possible, of previous exploration, development, operation, and production of property, with reasons for any past suspensions of operations.

(*b*) State briefly the known history and production of adjoining and neighboring properties.

(*c*) Furnish any available (private) reports that may apply to this application, including results of mine examinations, recommended exploration and development, and metallurgical investigations.

*17. Production:

(*a*) If mine is in production, furnish the following information:

	Tons per day	*Grade or analysis*	*Cost per ton*	*Net value per ton*
(1) Mining				
(2) Milling				
(3) Shipped or sold				

*18. Ore or mineral reserves: (If property is or has been operating.)

(*a*) Describe the ore or mineral deposits briefly. QUICKSILVER

(*b*) Submit available maps and assay data. ATTACHED

(*c*) Give estimated tonnage and grade of each class of ore reserves.

19. State any conditions or circumstances regarding the property not sufficiently brought out by the foregoing questions.

THE EXPLORATION

20. For what mineral or minerals and for what types of deposits and ores will the exploration be conducted? QUICKSILVER

21. Describe briefly, but concisely, the proposed work and the estimated time required to complete it. SEE ATTACHED FROM C.N.SCHUETTE, M.E.

NOTE.—The Government will not participate in a project that will require more than 2 years to complete.

22. Furnish statement of the geological basis of the project with particular emphasis on factors leading the operator to expect the finding of commercial ore bodies. This statement should be accompanied by supporting maps such as geological maps, maps of the proposed openings and assay maps, sample lists, and other pertinent data.

THE REQUIREMENTS AND COSTS

23. Tabulate in the form of an itemized statement with a sum for each item the estimated requirements and costs of the project so that the total will give the estimated cost of the project in which the Government will participate, as follows:

(*a*) Labor, by numbers and classes (miners, muckers, millmen, etc.), with wages of each.

(*b*) Supervisors, by numbers and positions, with salaries of each.

(*c*) Cost of necessary repairs to existing facilities, structures, and buildings.

(*d*) Cost of necessary installation or construction of additional facilities, structures, and buildings.

(*e*) Cost of items of equipment, not now owned by the applicant which must be purchased for operations at a cost of $50 or more each.

(*f*) Cost of rental for equipment which the operator proposes to rent.

(*g*) Rental value of items of equipment which the operator now owns and which will be devoted to the work.

(*h*) Cost of materials and supplies, including items of equipment costing less than $50 each.

(*i*) Cost of power, water, utilities, and any other items not provided for above.

24. Furnish a time schedule of the project, stated in terms of months after project is approved, showing progress expected to be accomplished and the money expected to be spent.

CERTIFICATION

The undersigned company, and the official executing this certification on its behalf, hereby certify that the information contained in this form and accompanying papers is correct and complete to the best of their knowledge and belief.

ALTOONA QUICKSILVER MINING COMPANY
(Name of company)

By [signature]
(Signature of authorized official)

MAY 21, 1951
(Date)

PRESIDENT
(Title)

Title 18, U. S. Code (Crimes), Section 1001, makes it a criminal offense to make a willfully false statement or representation to any department or agency of the United States as to any matter within its jurisdiction.

*Same as footnote on page 1.

16—64067-1 U. S. GOVERNMENT PRINTING OFFICE

Form MF-100
(March 1951)

U.S. DEPARTMENT OF THE INTERIOR
DEFENSE MINERALS ADMINISTRATION

Form approved.
Budget Bureau No. 42-R1026.

GENERAL TECHNICAL DATA FOR USE UNDER THE DEFENSE PRODUCTION ACT OF 1950

NOT TO BE FILLED IN BY APPLICANT

Docket No. dma 12158 X

Date received 5-25-51

ALTOONA QUICKSILVER MINING COMPANY
124 PRESIDIO AVENUE
SAN FRANCISCO 15, CALIFORNIA

Name and address of applicant

Date MAY 21, 1951

INSTRUCTIONS

This form is to be filed with Defense Minerals Administration, Department of the Interior, Washington 25, D. C. It should be accompanied by appropriate application form when a specific type of Government assistance is requested, in the form of (1) loan, (2) purchase contract, (3) Government guarantee of a private loan, (4) ~~necessity certificate pursuant to the provisions of Sec. 124-A (Amortization Deduction) of Internal Revenue Code, 1950, (5)~~ priorities or allocation of mining equipment, and maintenance, repair and operating supplies, and ~~(6)~~ 5 other forms of Government assistance that might arise under the Act. Submit four (4) signed copies of the form and accompanying papers. Name and address should be stamped or typed on each sheet of this form and all accompanying papers. *When a question is inapplicable it should be so stated on the form.* Additional sheets may be attached in answering any questions or in supplying additional information. (IF YOU CANNOT ANSWER A QUESTION, SO STATE.) If a question is answered elsewhere indicate where answered. It is not necessary to answer it again.

GENERAL TECHNICAL DATA

Supply the following information on separate sheets, arranged, numbered, and lettered as indicated:

1. Materials produced:
   (*a*) What are the chief mine, mill, or smelter products? QUICKSILVER
   (*b*) What are the byproducts, if any? NONE
2. Name(s) and type(s) of mine(s), mill(s), smelter(s), refinery(ies), pit(s), quarry (ies), drilling operation(s). Include old names of property, if any. Show extent of workings, including the following: SEE ATTACHED REPORTS.
   (*a*) Linear feet of shafts. 600 FEET
   (*b*) Linear feet of drifts and crosscuts. 10,000 FEET
   (*c*) Linear feet of tunnels or adits. 885 FEET
   (*d*) Linear feet of other mine openings (explain briefly) SEE ATTACHED MAPS & SECTIONS.
   Indicate whether mine is flooded or not. Describe any pumping problems. Give size or productive capacity. MINE IS FLOODED 500 GPM TO UNWATER; 200 GPM TO HOLD WATER
3. For each operation listed above supply the following:
   (*a*) Distance and direction from nearest town and shipping point. 24 MILES TO CASTELLA.
   (*b*) Mining district. CINNABAR MINING DISTRICT
   (*c*) Township, Section, Range. SEC.22, T.38 N. R. 6 W., M.D.B.
   (*d*) County, State. TRINITY COUNTY, CALIFORNIA
4. (*a*) State whether or not property is now in operation, and if in operation, by whom operated. NOT IN OPERATION.
   (*b*) Are you operating this property as:
   XXX Owner.
   ☐ Lessee.
   ☐ Contractor.
5. Number of years in production SEE HISTORY ATTACHED.
   If not in production or operation, estimated date when production will begin ONE YEAR AFTER WORK OF REHABILITATION IS RESUMED.
6. Experience of operators:
   Describe the mining and general business experience of (*a*) the applicant, and (*b*) the person or persons who manage the project. APPLICANT IDENTIFIED WITH PROPERTY 25 YEARS. REPUTABLE MINING ENGINEER WOULD BE IN CHARGE.
7. History:
   (*a*) Give a statement, as complete as possible, of previous exploration, development, operation, and production of property, with reasons for suspension of operation. SEE REPORTS ATTACHED.
   (*b*) State briefly the known history and production of adjoining and neighboring properties. 3 SMALL MINES.
   (*c*) Furnish any available (private) reports that may apply to this application, including results of mine examinations, recommended exploration and development, and metallurgical investigations.

8. Names and addresses of Officers, Directors, or Partners, and in addition thereto, the five largest stockholders if applicant is a corporation.

Name and Address (a)	Official Title (If officer is also director indicate by "D") (b)	Total of Annual Salary, Commissions, Bonuses, Etc., Received From Applicant and Affiliates During Last Fiscal Year (c)	Estimated Net Worth Outside of Interest in Applicant (d)	Number of Shares Held in Applicant Corporation: Common (e)	Number of Shares Held in Applicant Corporation: Preferred (f)	Life Insurance Carried for Benefit of Applicant: Amount (g)	Life Insurance Carried for Benefit of Applicant: Net Cash Surrender Value After Loans (h)
R. E. FROWENFELD	PRESIDENT-D			67,004			
" " "				25,086	(Trustee)		
" " "				92,090			
FRANK E. LEE 116 N. MONTGOMERY ST SAN FRANCISCO	SECY.TREAS.-D						
W.P.REAGOR 123 RICARDO, PIEDMONT,CAL	D						
	Total		x x x x x			x x x x x	x x x x x

If more lines are needed continue on separate sheet.

9. Capital Stock Issues:

For Corporate Applicants

Item	Authorized (a)	Outstanding (b)	Par Value (c)	Number of Shares Outstanding (d)	Dividend Rate Last Paid* (e)
Common stock	$	$	$	100,000 SH. ISSUED 98,734 OUTSTANDING	
Preferred stock	$	$	$		

*Indicate period covered.

10. Production:

Item	Kind of Product (a)	1948 Total (b)	1949 Total (c)	1950 Total (d)	Present Average Monthly (e)
1. Quantity of product mined or quarried (Short, long, metric tons; barrels; pounds; etc.)					
2. Quantity of product processed (specify unit of measure and type of process)					
3. Quantity and grade of product sold or shipped (specify units of measure)					

11. Do you contemplate a change in the present average monthly rate of production? If so, state estimated maximum monthly production and basis of change.

12. Ore or Mineral Reserves:

(a) Describe the ore or mineral deposit briefly. Accompany the application by any available report on the geology and ore reserves. SEE REPORTS ATTACHED.

(*b*) If deposit is other than placer:

(1). Submit assay plans and/or sections showing location and size of proved (measured) and probable (indicated) ore or mineral reserve.

(2) State the tonnage (indicate type of ton) and grade of each class of ore reserve, as above, and show how computed. Tabulated total ore reserve as follows:

TOTAL ORE OR MINERAL RESERVES

Ore or Mineral Reserve	Estimated Tons (a)	Metal or Mineral Content Per Ton (Grade) (b)	Gross Value Per Ton (c)	Recoverable Unit Value Per Ton (d)	Estimated Cost of Production Per Ton (e)
Measured (proved)					
Indicated (probable)					

(*c*) If placer:

(1) Give estimated total yardage and average marketable mineral content of each deposit.

(2) Submit map showing location of placer deposit and surrounding area, with all test holes or pits. Submit logs of each hole and test pit with depth and average value of each.

(3) Describe gravel, stating whether fine, medium or coarse; loose, tight, cemented, or frozen, and whether it contains stumps or boulders more than 1 foot in diameter; if so, how large, and in what proportion.

(4) Describe bedrock, giving type (granite, sandstone, shale, etc.) and state whether it is hard or soft, smooth, uneven or rough.

(5) Describe overburden, stating whether loose, tight, or cemented; fine or coarse textured; furnish estimate of average thickness and total amount.

(6) Tabulate the reserves using the form outlined above for ore or mineral reserves.

13. Access Roads:

Give road distances to shipping, supply and residence points, stating kind and condition of roads.
24 Miles to Castella. New road in excellent condition.

14. Water Supply:

State source and quantity of water available for operations and whether sufficient for all seasons of year. Sufficient for all seasons. Current permit 0.12 cu.ft. per second.

15. Power:

State amount of power used, rate per hour, and source thereof. Oregon-California Power Co.

16. Labor:

State number and classes (miners, muckers, millmen, etc.) of men employed during a recent representative payroll period.
20 to 30 men.

17. Equipment and Facilities:

Describe present equipment on the property, including buildings. (State condition.) List major pieces of equipment now owned or controlled and in serviceable condition available for this operation. 4 houses in need of repair.

18. Are there any particular conditions or circumstances affecting your operations that are not described above? If so, explain.

CERTIFICATION

The undersigned company, and the official executing this certification on its behalf, hereby certify that the information contained in this form and accompanying papers is correct and complete to the best of their knowledge and belief.

ALTOONA QUICKSILVER MINING COMPANY
(Name of company)

By [signature]
(Signature of authorized official)

MAY 21, 1951
(Date)

PRESIDENT
(Title)

Title 18, U. S. Code (Crimes), Section 1001, makes it a criminal offense to make a willfully false statement or representation to any department or agency of the United States as to any matter within its jurisdiction.

U. S. GOVERNMENT PRINTING OFFICE 16—63792-1

DEPARTMENT OF THE INTERIOR
Defense Minerals Administration
RECEIVED
MAY 25 1951
LANDON F. STROBEL
Executive Secretary

c
o
p
y

dma 12158X

C.N.SCHUETTE
CONSULTING MINING ENGINEER
6390 BARNETT VALLEY ROAD W.
SEBASTOPOL, CALIFORNIA

May 18, 1951

Mr. R. E. Frowenfeld
124 PRESIDIO AVENUE
San Francisco 15, California

Dear Mr. Frowenfeld:

In accordance with your request to me on April 30th, I have carefully gone over all the data that I have which relates to the Altoona Mine in order to aid you in obtaining government assistance for exploration of said mine thru Mineral Order 5 under the Defence Production Act of 1950 and especially to furnish you the answers to questions 23 and 24 of Form MF-103.

The Altoona Mine has a very good production record and ranks as the 12th largest quicksilver mine in California in point of total production. The greater part of the production was made before 1900. It was idle for many years due to its isolated location. In recent times, new roads, trucks and a power line to the property have largely removed the handicaps of isolation.

The mine was last in operation in 1943-44 when it was equipped with a 25ton per day reduction plant. This operation was handicapped by inadequate financing and partly by indifferent management. For the first 5 months of 1944 (151 days) of which I have a detailed record and during which time the mine operation was in competent hands, an average of 21.7 tons per day was treated in the plant, producing 739 flasks of quicksilver from ore that had an average content of 17.1 pounds of quicksilver per ton. This gives a fair idea of what the mine can do when properly operated and certainly suggests that it merits exploration and development.

At present the mine is closed down, the collar of the shaft has caved, the mine is full of water and all machinery used in former operations has been removed from the property.

In order to explore and develop the Altoona Mine it will be necessary to rehabilitate the camp. There are four houses left on the property, one of which is the cook house. These are in need of repair. A new water line to the camp, roughly one mile long, will have to be installed. I estimate that a total crew of ten men will be needed to open the mine and do the necessary exploration work.

The order in which this work should be done is as follows:

1. Rehabilitate the camp, houses, water line, power connection.

2. Repair collar of shaft. Erect headframe. Install hoist.

3. Unwater the shaft and repair shaft to the 450 foot level.

4. Open and retimber where necessary the 450 foot level to the winze. (This was last done in 1945.

5. Unwater the winze and repair timbering to the 600 foot level.

6. Open, and retimber where necessary the 600 foot level.

7. Diamond drilling from the 500 and 600 levels as suggested by E.E.Erich in his report of July 1946, and drifting and crosscutting on the 600 level as will suggest itself after examination of the lower level.

Equipment needed for the work of exploring the mine:

10-tons 16 lb. rail, with plates, bolts & spikes - - - - - - - - - - - -	$ 2,000.00
1000-ft. 10" #22 gauge, galv. air pipe, @ $87.10 - - - - - - - - - - - -	871.00
1 - 10" American Blower, with 5 HP motor and starter - - - - - - - - - -	410.00
1 - 50 HP Single Drum Mine Hoist, capacity 4000# at a rope speed of 400 ft. per minute, complete with drum controller, sheave wheel and cable, all reconditioned -	1,750.00
1 - 440-Ft. Ingersoll-Rand type XB-2 compressor, size 15 - 9 x 12, complete with 75-HP motor, starter, air receiver and necessary piping, all reconditioned -	2,250.00
1 - 1250# Ingersoll-Rand type EUA single drum air hoist, with 300 ft. 1/4" cable, all reconditioned -	400.00
3 - Sullivan Jackhammers, 55# late machines (365) - - - - - - - - - - - -	1,095.00
2 - Sullivan Jackhammer mountings (180) - - - - - - - - - - - - - - - - -	360.00
2 - Sullivan Sets Column Bars, 3" with arm, saddle (150) - - - - - - - -	300.00
3 - Pcs. 50' Lgths 3/4" Air Hose Cpld (32) - - - - - - - - - - - - - - - -	96.00
3 - Pcs. 50' Lgths. 1/2" Water Hose Cpld. (23) - - - - - - - - - - - - - -	69.00

5 - Sets 1" QO. Drill Steel, Threaded and Shanked:
2' @ 4.75; 42" @ $6.20; 60" @ $7.60; 72" @ $8.50;
Total $27.00 - 135.00

500 - Timkin Bits, three gauges @ 44¢ - - - - - - - - - - - - - - - - - - 220.00

1 - Sullivan Diamond Drill, Model HS-15, Air, outfit complete (300') - 2,100.00

1 - Blacksmith Shop outfit, tools, etc. etc. - - - - - - - - - - - - - - 300.00

7000 Ft. 2" Standard Black Pipe, NEW $34.27/100' - - - - - - - - - - - 2,399.00

8 - Mine cars, 16-Ft. 18" ga. roller bearing (200) - - - - - - - - - - 1,600.00

1 - "Layne & Bowler" Deep Well Turbine pump #A-C-20 Head
450-Ft. 8" Column, 450-Ft. 1-11/16" Rods, #10 -
14- Stage bowls, with 75-HP Motor, 1750-r.p.m. with
starter, delivered, Redding, California.
This pump good for 500/gals/min. for 450' Head. - - - - - - - - - - 8,325.00

1 - "Layne & Bowler" Deep Well Pump, Turbine, #A-C*20 Head,
(6" Column, 200-Ft.) 200 Ft. 1-3/16" Rods.
#10 - 7-Stage Bowls, with 40-HP Motor, 1750-rpm.
Capacity: 500-Gallons minute, for 200-Ft. Head.
Price, delivered cars, Redding, California - - - - - - - - - - - - 3,255.00

1000 - ft. electric cable @ $1.25/ft. - - - - - - - - - - - - - - - - - - 1,250.00

1 Truck - 2,500.00

Deposit on Power Connection - 3,500.00
($2,500.00 of this deposit returnable)

Total 35,185.00

NOTE:- I am quoting specific items of equipment on which I obtained prices. If other makes are preferred the price should be about the same.

Thus the total outlay for the necessary machinery would be about - 35,200.00
The rehabilitation of the camp would cost about - - - - - - - - - 3,000.00
Timber and lumber would cost about - - - - - - - - - - - - - - - - 2,500.00
Miscellaneous tools and supplies - - - - - - - - - - - - - - - - - 2,000.00
Engineering, surveying, consultants, etc. - - - - - - - - - - - - 1,900.00
A crew of 10 men would come about as follows:

1 - superintendent - - - -	$500/ month	
1 - cook - - - - - - - - - -	300	
1 - hoistman - - - - - - -	350	
1 - pump man & mechanic -	350	
2 - miners - - - - - - - -	600	
2 - muckers - - - - - - -	600	
2 - timbermen - - - - - -	600	
TOTAL	3,300/month	
POWER	500/ "	
	3,800/ " for 1 year - - - - - - -	45,600.00

Grand Total 90,200.00

The unwatering of the mine and the rehabilitation of the workings down to and including the 600 level should not take more than 6 months and an additional 6 months of diamond drilling and drifting and crosscutting should suffice to give a comprehensive picture of the ore expectation in the lower workings of the mine.

If the preliminary work of opening the mine can be accomplished in 3 or 4 months the extra time and money will be available for the search for ore, which should be an incentive to proceed as expeditiously as possible.

Thus an equitable exploration of the mine could be accomplished in about one year's time at an estimated cost of about $90,000. On its record, I conclude that the Altoona Mine merits the expenditure of such a sum for exploration.

Sincerely yours

C. N. SCHUETTE

DEPARTMENT OF THE INTERIOR
Defense Minerals Administration
RECEIVED
MAY 25 1951
LAMECH F. STROBEL
Executive Secretary

☐ Audited

☐ Certified

WORK ANALYSIS SHEET - DMEA PROJECT

Analysis as of 12-5-56
Incl. Voucher for _____

☑ Actual Cost

☑ Agreed Unit Costs

Name Altoona Quicksilver Mining Co.

Docket No. DMA 1258 X

State California

Commodity Mercury

Idm-E No. 91

OPERATION	AUTHORIZED Units	AUTHORIZED Cost	COMPLETED Units	COMPLETED Cost	NET COST
Drifting & Crosscutting	1,160	$ 17,400.00		—	—
Raising					
Shafts					
Winzes					
Drilling, Diamond (Specify)	1,000	5,000.00		—	—
Surface Excavation					
Underground Excavation					
Roads and Trails					
Operating Equipment Purchased		$ 33,486.00		—	—
Surface Rehabilitation & Repairs		13,558.50		—	—
Underground Rehabilitation		15,007.50		—	—
New Building, Improvements, etc.				—	—
Other (Specify) Power		6,000.00		—	
Totals		$ 90,452.00		—	—

Note: Recission of contract agreement executed 4/12/57.

Prepared by _____

71626

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

Office of
Executive Officer
DMEA Field Team
Region III

1012 Flood Building
870 Market Street
San Francisco 2, Calif.

Air Mail

April 15, 1952

Memorandum

To: Frank E. Johnson, Chairman, Operating Committee, Defense Minerals Exploration Administration, Washington, D. C.

From: Executive Officer, DMEA Field Team, Region III

Subject: Docket DMA-1258X, Contract Idm-E91 (Mercury), Altoona Quicksilver Mining Co., Trinity County, California.

Reference is made to your air mail memorandum dated April 3, concerning the captioned contract.

In line with your recommendation, I had Mr. R. E. Frowenfeld, President of Altoona Quicksilver Mining Company, sign the six copies of an agreement of rescission which previously had been signed for the Government by Mr. Mittendorf.

In returning the signed copies to me, Mr. Frowenfeld wrote in part:

> "I have signed and am enclosing the original and four copies in accordance with your request. When the legal difficulties with adjacent owners have been overcome, we shall file another application which we note will be accepted without prejudice.
>
> "This procedure is very much appreciated, as well as the cooperative understanding of our situation shown by Mr. Mittendorf and yourself."

The original and three copies of the signed agreement are attached herewith. Mr. Frowenfeld retained one copy, and another copy is being sent to our field engineers at Reno. We will expect the finance officer's copy from Washington shortly.

H. C. Miller
Executive Officer
DMEA Field Team, Region III

Attachment

Copy to E. H. Bailey, USGS
A. C. Johnson, Reno, Nev.

FILE COPY
SURNAME:

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

AIR MAIL

APR 8 1952

Mr. H. C. Miller, Executive Officer
Region III, Wst. Field Team
1012 Flood Building
70 Market Street
San Francisco 2, California

Re: Docket DMA-1258, Idm-91 (Mercury)
Altoona Quicksilver Mining Company
Trinity County, California

Dear Mr. Miller:

Acknowledgement is made of your memorandum of March 24, 1952, concerning the captioned contract.

We quite agree with you that this agency has been very lenient with Mr. M. M. Brownfield, President of the Altoona Quicksilver Mining Company, in allowing his company to procrastinate as to the date on which the work under the contract would be started.

We have learned indirectly that the Altoona Quicksilver Mining Company because of legal difficulties with adjacent owners will be unable to fulfill the terms of the contract as to the date on which the project should be commenced and terminated. We therefore recommend that the contract be rescinded. We believe that by doing this it will permit the company to arrange its affairs and then file another application without prejudice.

We are enclosing six copies of an agreement of rescission signed by the Acting Administrator. Please have the operator sign this agreement and then distribute the copies according to the distribution of the original contract.

Sincerely yours,

(signed) FRANK E. JOHNSON

Chairman, Operating Committee
Defense Minerals Exploration
Administration

Enclosures - 6

HFKeller/jem
3/31/52
cc to: Adm. Reading File
Docket
Messrs. L.T.McKnight, Rm. 4204GS
Ellis
Keller
Miss H.M.Meyer, Rm. 3623
Operating Committee
Field Team, Reg. III

APPROVED: J. H. Hedges
Member, Bureau of Mines

T. P. Thayer
Member, Geological Survey

FILE COPY
700 SURNAME:

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

March 28, 1952

MEMORANDUM

To: C. G. Wittendorf

From: H. F. Keller

Subject: Docket DMA-1258 (Mercury)
Contract Idm-191
Altoona Quicksilver Mining Co.
Trinity County, California

Reference is made to the attached letter from Mr. H. C. Miller, and our letter of this date to him on the captioned subject.

We discussed the question of this contract with Mr. Sam Williston, President of the Cordero Mining Company, who informed us that the contract covers not only the claims of the applicant, but also adjacent claims. At present the owner of those claims is not willing to enter into the contract by leasing his claims to the applicant or by entering as a party to the contract. It is therefore our opinion that this difference may be cleared up more quickly by rescinding the contract.

H. F. Keller

HFKeller/jem
cc to: Adm. Reading File
Docket
Ellis
Keller

3/26/52 gla

DEPARTMENT OF THE INTERIOR
Defense Minerals Administration
MAR 2 1952

UNITED STATES
DEPARTMENT OF THE INTERIOR

DEFENSE MINERALS ADMINISTRATION

WASHINGTON 25, D. C.

Office of
Executive Officer
DMEA Field Team
Region III

1012 Flood Building
870 Market Street
San Francisco 2, Calif.

Air Mail

March 24, 1952

Memorandum

To: Frank E. Johnson, Chairman, Operating Committee, Defense Minerals Exploration Administration, Washington, D. C.

From: Executive Officer, DMEA Field Team, Region III

Subject: Docket DMA-1258X (Mercury), Contract Idm-E91 -- Altoona Quicksilver Mining Company, Trinity County, California.

Reference is made to your subject letter dated March 20, 1952.

The subject contract has been one that has given me considerable concern. The contract was mailed to the applicant from Washington with a covering letter from Mr. Mittendorf dated July 31, 1951. On August 31, Mr. Frowenfeld, President, Altoona Quicksilver Mining Company, wrote Mr. Mittendorf that he "has been in continuous negotiation since receiving the above contract on August 6th and these negotiations have not been completed to date. Also taking into consideration the winter conditions, I feel that I must respectfully request that the contract be advanced to June 1, 1952."

My memorandum to Mr. Mittendorf dated September 18, 1951, subject: Docket DMA-1258X, Altoona Quicksilver Mining Company, gives information requested of Mr. Frowenfeld by Mr. Mittendorf in his letter to the company dated September 12,1951.

Nothing further was heard from Mr. Frowenfeld so I wrote him on September 12, calling his attention to the need for amending his contract if work is to be done under it, as the starting date expired. On December 20 Mr. Frowenfeld wrote that nothing definite had taken place at Altoona, but that the situation appeared more hopeful than at the last time he talked with me.

On January 30, 1952, I again wrote to Mr. Frowenfeld, asking what progress was being made toward commencing the exploration work at the Altoona Mine, and on February 4 he replied that "Progress in negotiations to carry out the above exploration program has been delayed by an extended trip of one of the principals. However, I

believe I shall be able to give you more definite information within a short time." Nothing further has been heard from Mr. Frowenfeld to date.

I have been lenient with Mr. Frowenfeld, realizing the jam he was in, but every time I talked with him it seemed he was just around the corner from getting straightened out. I understood, also, that Mr. Sam Williston, President, Cordero Mining Company, on one or more of his frequent trips to Washington, had discussed the Altoona matter with Mr. Mittendorf so I believe he (Mittendorf) is familiar with the reason work on the contract has not been started.

With Spring just around the corner and the possibility the work may soon be started at the property if no legal obstacles serve to prevent it, I believe that we should now demand that work be started within a certain specified time or the contract cancelled. I would welcome a letter from you to that effect so that I would have that additional support to my contention that action is imperative. I have not been too firm with the applicant mainly because I understood that Mr. Williston had discussed the matter with Mr. Mittendorf, and not having heard from Mr. Mittendorf I concluded it was his intention to wait awhile longer before definitely deciding the next course to take.

H. C. Miller
Executive Officer
DMEA Field Team, Region III

Copy to E. H. Bailey, USGS

FILE COPY
SURNAME

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

AIR MAIL

Miller
Ellis
Meyer
McKnight

Mr. H. L. Miller
Executive Officer, Region III
DMEA Field Team
1012 Flood Building
870 Market Street
San Francisco 2, California

Re: Docket No. [illegible]-1258 (Mercury)
Idm-491
Altoona Quicksilver Mining Co.
Trinity County, California

Dear Mr. Miller:

Contract number Idm-491 was signed on July 31, 1951, and the operator was supposed to have commenced work on the project within thirty days. As we have received no notification that this contract was canceled by either the operator or your agency, nor have we received any information concerning work done on this project, we would appreciate it if you would advise us of the present status of the subject contract.

Sincerely yours,

cc 3/20

(signed) FRANK E. JOHNSON
(HB)

Chairman, Operating Committee
Defense Minerals Exploration
Administration

APPROVED: J. H. [illegible] (HB)
Member, Bureau of Mines

T. P. Thayer (HB)
Member, Geological Survey

HFKeller/jem
3/13/52
cc to: Adm. Reading File
Docket
Messrs. McKnight, ET Rm. 4204 GS
Ellis
Keller
Johnson, F.E. Rm. 4624 (Op Com.)
Miss H. Meyer
Field Team, Region III

DEPARTMENT OF THE INTERIOR
MINERALS
ADMINISTRATION
D.C.
SEP 24 3 45 PM '51

UNITED STATES
DEPARTMENT OF THE INTERIOR
~~BUREAU OF MINES~~
~~REGION III~~
DEFENSE MINERALS ADMINISTRATION

OFFICE OF
~~REGIONAL DIRECTOR~~
Executive Officer
DMA Field Team
Region III

1012 FLOOD BUILDING
870 MARKET STREET
SAN FRANCISCO 2, CALIFORNIA

Sept. 18, 1951

Memorandum

To: C. O. Mittendorf, Director, Production Expansion Division, Defense Minerals Administration, Washington, D. C.

From: Executive Officer, DMA Field Team, Region III

Subject: Docket DMA-1258X
Altoona Quicksilver Mining Company

On September 12 you addressed a letter to Mr. R.E.Frowenfeld, President, Altoona Quicksilver Mining Company, in reply to his letter to you dated August 31, requesting that the date of his exploration project contract be advanced to June 1, 1952. Copies of both letters are acknowledged.

Mr. Frowenfeld called at the office yesterday to try to explain to me why he requested advancing the date of his contract. The story as I got it is not too clear, but this is the way it was told to me. Mr. Frowenfeld has been approached by the Cordero Mining Company to direct or take over the property. Cordero, however, has brought up the thought that inclusion of some adjoining property is essential to underground operation of the Altoona mine. The adjoining property owner, however, so far has signified that he will not cooperate, and it appears that apex rights may ultimately lead to a law suit if Altoona went ahead with its contemplated program.

Sam Williston is working on the deal whereby his company, the Altoona Quicksilver Mining Company, and the adjoining property holder may get together. It will take time, however, to clear old titles and consummate a satisfactory tri-party arrangement. Mr. Williston will not be back in San Francisco until about October 1, so my advice to Mr. Frowenfeld was to wait a while longer and see what happens. In the meantime, no work is being started on Contract Idm-E91.

H. C. Miller
Executive Officer, DMA Field Team
Region III

Copy to: E. H. Bailey, USGS

400

FILE COPY
SURNAME:

Mittendorf

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

AIR MAIL

SEP 12 1951

Altoona Quicksilver Mining Company
124 Presidio Avenue
San Francisco 15, California

Re: Docket No. DMA - 1258X

Dear Mr. Frowenfeld:

This is in reply to your letter dated August 31, 1951 by which you request that the subject exploration contract be revised so as to "advance the contract to June 1, 1952."

An examination of your file reveals that your contract was dated July 31, 1951 and provided for a period of twelve months within which to complete the approved exploration project. Consequently, under these provisions, the termination date of your contract as now written is July 31, 1952. It is not clear to this office whether you are seeking an extension, or possibly an increase in the period within which the work must be completed, or both. In the circumstances, and since the Regional Field Offices have recently been delegated authority to make certain revisions, it is my suggestion that you contact Mr. H. C. Miller, Executive Officer, DMA Field Team, Region III, 1012 Flood Building, 870 Market Street, San Francisco 2, California, in the matter.

Sincerely yours,

C. O. Mittendorf

BF 9/12

C. O. Mittendorf, Director
Production Expansion Division

COMittendorf/jem
9/11/51

cc to: Adm. Reading File
Reports & Records
Messrs. Mittendorf, Olund
Mr. Ellis
Mr. Bourret
Mr. McKnight
Field Team, Reg. III (2)
Docket

Dr. Ellis

San Francisco, California
August 31, 1951

DEPARTMENT OF THE INTERIOR
RECEIVED
SEP 5
Defense Minerals Administration,
Production Expansion Division

Mr. C. O. Mittendorf, Director
Production Expansion Division
U.S. Dept. of the Interior
Defense Minerals Administration
Washington 25, D. C.

RE: DOCKET NO. DMA - 1258X

Dear Mr. Mittendorf:

I have been in continuous negotiation since receiving the above contract on August 6th and these negotiations have not been completed to date. Also taking into consideration the winter conditions, I feel that I must respectfully request that the contract be advanced to June 1, 1952.

Yours very truly

ALTOONA QUICKSILVER MINING COMPANY

Frowenfeld

REF/g

R. E. FROWENFELD, PRESIDENT

124 PRESIDIO AVENUE
SAN FRANCISCO 15
CALIFORNIA

DEFENSE MINERALS
ADMINISTRATION
WASHINGTON, D.C.
SEP 4 2 11 PM '51

1900-12587

My dear Senator Knowland:

I am pleased to report to you that the Defense Minerals Administration of this Department has recently entered into a contract with the Altoona Quicksilver Mining Company, operating in your state for the exploration of possible sources of mercury ore.

The contract provides that the Government will participate in the expense of this work up to 75% of the cost thereof.

This type of assistance is provided for under Section 303 of the Defense Production Act.

The Defense Minerals Administration will be glad to furnish you any further details you may desire regarding the matter.

Sincerely yours,

Secretary of the Interior

EWEllis/jem
7-31-51

Hon. William F. Knowland
United States Senate
Washington 25, D.C.

Identical letter to: Hon. Richard M. Nixon
Mr. Clair Engle

cc to: Secy's Reading File
Adm. Reading File
Mr. Mittendorf-Olund
Mr. Ellis
Reports & Records
Docket Copy

FILE COPY
Surname:
140
Guthrie

UNITED STATES
DEPARTMENT OF THE INTERIOR
OFFICE OF THE SECRETARY
WASHINGTON 25, D. C.

July 31, 1951

Memorandum

To: Director, Production Expansion Division

From: General Counsel

Subject: Altoona Quicksilver Company--exploration contract--Docket No. 1258X

The contract in the captioned case is approved as to legal form and sufficiency subject to:

1. Correction of the figures shown in Exhibit "A" so that the total agrees with the total amount of the contract. Any necessary information contained in the additional information sheets of July 16, 1951, also attached, should be incorporated into the exhibits and the additional information sheets should be eliminated, or, if they must be kept, referenced in Exhibit "A".

2. A showing in Exhibit "C" of whether the items there listed are to be rented, supplied by the Operator, or purchased.

3. Dating as of the day of delivery to the prospective Operator.

Your file is returned herewith.

J. L. Hofflund
J. L. Hofflund
General Counsel

Attachment

RRGuthrie/em
Copy to: J. L. Hofflund
R. R. Guthrie
Files

FILE COPY
SURNAME:

Ellis
Olund
Mittendorf

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

July 31, 1951

AIR MAIL

Altoona Quicksilver Mining Co.
124 Presidio Ave.
San Francisco 15, Calif.

Attention: Mr. R. E. Frowenfeld
Re: Docket No. DMA - 1258X

Gentlemen:

Enclosed find executed Exploration Project Contract No. Idm-E91 dated July 31, 1951, with attached Exhibits "A" "B" "C" "D" "E" and sketch map; also a set of monthly Progress Reports (MF-104). This report is to be submitted monthly in quadruplicate to the DMA field representative in your area where additional copies may be obtained.

Any questions appertaining to this project should be referred to Mr. H. C. Miller, Executive Officer, DMA Field Team, Region III, 1415 Appraisers Building, San Francisco, California. Please notify Mr. Miller when you begin work on this project.

A press release dated May 14, 1951 on "Questions and Answers on the Minerals Exploration Program" is also enclosed for your information.

Sincerely yours,

C. O. Mittendorf

C. O. Mittendorf, Director
Production Expansion Division

Enclosures-7

EWEllis/jem
cc to: Messrs. Mittendorf-Olund
Reports & Records
Docket
Lyon
Bourret
Ellis
HCMiller, Region III
Contract Service Sec. GAO
Field Finance Sec.
Miss Terry

FILE COPY
SURNAME:

Ellis
Olund
Mittendorf

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

July 31, 1951

a.&.c.

Mr. Frank McAtee, Jr.
Contract Service Section
General Accounting Office
Washington 25, D.C.

Re: Docket DMA- 1258X
Exploration Project Contract
Idm-E91
Altoona Quicksilver Mining Co.
San Francisco 15, California

Dear Mr. McAtee:

Enclosed for recording in your office is the original, signed copy of an Exploration Project Contract executed between the operator named in the above reference and the Government of the United States.

Sincerely yours,

C. O. Mittendorf

C. O. Mittendorf, Director
Production Expansion Division

Enclosure-1

EWEllis/jem

cc to: Adm. Reading File
Mr. Mittendorf-Mr. Olund
Mr. Bourret
Mr. Hosted - AEC
Mr. Lyons
Mr. Ellis
Reports & Records
Docket

FILE COPY
SURNAME:
Ellis
Olund
Mittendorf

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

July 31, 1951

AIR MAIL

Mr. H. C. Miller
Executive Officer
DMA Field Team, Region III
1415 Appraisers Building
San Francisco, California

Re: Docket DMA- 1258X
Exploration Project Contract
Idm-E91
Altoona Quicksilver Mining Co.
San Francisco 15, California

Dear Mr. Miller:

Enclosed for the use of your office is a copy of the contract covering the subject exploration project, which has been signed for the Altoona Quicksilver Mining Company and for the Defense Minerals Administration.

A copy for the Regional Finance Officer will be forwarded directly by the Washington Finance Division, together with accounting instructions.

Sincerely yours,

C. O. Mittendorf 8/3

C. O. Mittendorf, Director
Production Expansion Division

Enclosure-1

EWEllis/jem
cc to: Adm. Reading File
Mr. Mittendorf-Olund
Mr. Lyon
Mr. Billings
Field Team - Region III
Mr. Ellis
Miss Terry - Wash. Finance Office
Reports & Records
Docket
Mr. McKnight

FILE COPY
SURNAME:
Ellis
Olund
Mittendorf

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

July 31, 1951

Memorandum

TO: Mr. Francis B. Speaker (Room 2465)
Requirements Division

FROM: C. O. Mittendorf, Director
Production Expansion Division

SUBJECT: Equipment requirements necessary for
Altoona Quicksilver Mining Co.
Docket DMA-1258X

Attached hereto is a list of the equipment necessary for subject contractor.

NAME AND ADDRESS:

Altoona Quicksilver Mining Co.
124 Presidio Avenue
San Francisco 15, California

MINE NAME:

Altoona Quicksilver Mine
Trinity County, California

COMMODITY: Mercury

COST OF PROJECT: $90,~~452~~ 185.00

C. O. Mittendorf
8/3/51
cc

EWEllis/jem

cc to: Adm. Reading File
Mittendorf-Olund
Reports & Records
Docket
Ellis

ALTOMA QUICKSILVER MINING COMPANY

JOB GALLET NO. 1258X

EXHIBIT "C"

A. BUILDING EQUIPMENT:	
1 - TRUCK -	$ 2,500.
10 - TONS 16# RAIL, WITH PLATES, BOLTS & SPIKES - - - - - - - - - - - - - -	$ 2,000.
1000 - FEET 10" #22 GAUGE, GALV. AIR PIPE @ $87.10 - - - - - - - - - - - -	871.
1 - 10" AMERICAN BLOWER, WITH 5-HP MOTOR & STARTER - - - - - - - - - - - -	410.
1 - 50-HP SINGLE DRUM MINE HOIST, CAPACITY 4000# AT A ROPE SPEED OF 400-FEET PER MINUTE, COMPLETE WITH DRUM CONTROLLER, DRIVE WHEEL AND CABLE, ALL RECONDITIONED -	1,750.
1 - 440-FT. INGERSOLL-RAND TYPE 18-2 COMPRESSOR, SIZE 15 - 9 x 12, COMPLETE WITH 75-HP MOTOR, STARTER, AIR RECEIVER AND NECESSARY PIPING, ALL RECONDITIONED -	2,250.
1 - 1250# INGERSOLL-RAND TYPE PCD SINGLE DRUM AIR HOIST, WITH 300 FT. 1/4" CABLE, ALL RECONDITIONED -	400.
3- SULLIVAN JACKHAMMER, 55# LATE MACHINES (365) - - - - - - - - - - - -	1,095.
2 - " " MAINTENANCE (180) - - - - - - - - - - - - - - - -	360.
2 - SULLIVAN SETS COLUMN MTS., 3" WITH AIR, SADDLE (150) - - - - - - -	300.
3 - PCS. 50' HOSES 3/4" AIR HOSE CPLD. (32) - - - - - - - - - - - - -	96.
3 - " " " 1/2" WATER " " (23) - - - - - - - - - - - - -	69.
5 - SETS 1" HEX. DRILL STEEL, TRAPEZOID AND SHANKS; 2' @ 4.75; 42" @ 6.20; 60" @ 7.60; 72" @ 8.50 - TOTAL 27.00 - -	135.
500 - TIMBER SETS, THREE MAJORS @ 44¢ -	220.
1 - SULLIVAN DIAMOND DRILL, MODEL HS-15, AIR. EQUIPT COMPLETE (300') -	2,100.
8 - MINE CARS, 16-FT. 18" GA. ROLLER BEARING (200)- - - - - - - - - - -	1,600.
1 - "LAYNE & BOWLER" DEEP WELL TURBINE PUMP #A-C-20 HEAD 450-FT. 8" COLUMN, 450-FT. 1-11/16" RODS, #10 - 14- STAGE BOWLS, WITH 75-HP MOTOR, 1750-R.P.M. WITH STARTER, DELIVERED REDDING, CALIF. THIS PUMP GIVES 500/GALS/MIN. FOR 450' HEAD- - - - - - - - - - -	8,325.
1 - "LAYNE & BOWLER" DEEP WELL PUMP, TURBINE, #A-C-20 HEAD, (6" COLUMN, 200-FT.) 200-FT. 1-3/16" RODS. #10 - 7-STAGE BOWLS, WITH 40-HP MOTOR, 1750-RPM. CAPACITY: 500-GALLONS MINUTE, FOR 200-FT. HEAD. PRICE, DELIVERED CARS, REDDING, CALIFORNIA - - -	3,255.
1000 - FT. ELECTRIC CABLE @ $1.25/FT/ -	1,250.
TIMBER AND LUMBER COST, ABOUT -	2,500.
MISCELLANEOUS TOOLS & SUPPLIES -	2,000.
	$ 33,[illegible]

FILE COPY
SURNAME:

Gordon
Bennett
McKnight

UNITED STATES
DEPARTMENT OF THE INTERIOR

DEFENSE MINERALS ADMINISTRATION
WASHINGTON 25, D. C.

July 25, 1951

MEMORANDUM

Commendation

To: Director, Production Expansion Division

From: Director, Supply Division

Subject: Altoona Quicksilver Mining Company
Trinity County, California
Mercury - DMA-1258X

Under date of May 25, 1951, the Altoona Quicksilver Mining Company submitted the subject application, DMA-1258X, requesting a project totaling $90,452.00 for a government participation of $67,839.00 (75%). Applicant will invest $22,613.00.

The following factors have been carefully considered and weighed in reviewing this application:

1. Criteria

(a) Additional sources of domestic mercury are desirable.

(b) E. T. McKnight, U.S.G.S. recommends the project, "as proposed, on basis of geologic probability." E. H. Bailey, U.S.G.S., states "The mine is believed to offer better than average possibilities for further exploration.", and "the request for government assistance to unwater the mine and do further exploration in the lower parts should be given careful consideration, ——".

(c,d,e,f) Sufficient manpower, equipment, supplies and water are available. A Good road leads to the property. Electric power is available from the Oregon-California Power Company.

(g) The company proposes to employ a reputable mining engineer to direct the work. He should be acceptable to the DMA field team.

2. The ground to be included in the contract consists of two patented and one unpatented lode claims, Altoona, Trinity and Blockade or Central, owned by Altoona Quicksilver Company.

Dmc-1258

They comprise lots 41-42-45 in Sec. 20, T. 38N. R.6W, M.D.M., Trinity County, California. There are no liens nor encumbrances against the property.

3. The project can be completed within one year following date of approval. Work will start within 30 days following approval. Estimated time schedule follows:
1st quarter - Rehabilitate camp, shaft collar, erect headframe, install hoist and pump, unwater and repair shaft.
2nd quarter - Reopen 450 feet level to winze, unwater winze and repair timbering, reopen 600 feet level.
3rd quarter - Diamond drill from 5th and 6th levels; start drifting and crosscutting on 5th and 6th levels, as indicated by study of reopened workings.
4th quarter - Complete diamond drilling program to total of 1000 feet of BX hole; complete drifting program to total of 1060 lineal feet of headings; drive 100 ft. raise from 6th to 5th level in #3 vein. Draw up detailed report with evaluation of results attained and present to DMA.

4. The project consists of equipping, dewatering and rehabilitating the mine shaft and necessary subsidiary workings to a dept of 600 feet to permit exploration by headings and diamond drilling on the two lower levels, i. e. 1,060 feet of crosscuts and drifts; 1,000 feet of BX hole; one 100 feet raise. Exact location of headings and diamond drill holes are to be cleared by DMA field team, as they can be laid out precisely only after mine is dewatered.

5. Estimated costs are as follows:

(a)	Power connection	$ 3,500.00
(b)	Camp rehabilitation (four buildings, blacksmith shop, and waterline)	5,699.00
(c)	Purchase of equipment	33,486.00
(d)	Electric power, 12 mos. @ $500	6,000.00
(e)	Hoist and headframe erection, shaft collar repairs	4,967.00
(f)	Mine rehabilitation	14,400.00
(g)	1,160 feet of drifts, crosscut and raise, @ $15/ft. (labor - supplies)	17,400.00

(h) 1,000 feet of AX diamond - drill hole @ $5/ft. $5,000.00

Total cost of project $90,452.00

Therefore, it is recommended that the Production Expansion Division negotiate a formal contract (ref-200) with Altoona Quicksilver Mining Company, which will permit the applicant to undertake the following specific exploration, along the lines described above:

(1) Rehabilitate camp, new tar paper rooms, station shaft, drift to winze and winze to bottom of stope workings.

(2) Drive 1,060 feet of crosscuts and drifts.

(3) Drive 100 foot raise.

(4) Drill 1,000 feet of AX diamond drill hole.

(5) Draw up report evaluating results obtained, with maps, assay - data and drill logs and submit promptly to DMA.

Tom Lyon, Director
Supply Division

EGordon:ez

Copy to: Administrator's Reading File
Reports and Records Branch
Mr. Lyon
Mr. H. Meyer
E.T. McKnight
Field Team III
P. Bourret
Files

San Francisco, Calif
July 16, 1951

Mr. Weston Bourret
Chief Miner & Rare Metals
U. S. DEPT. of the Interior
Washington 25, D. C.

DEPARTMENT OF THE INTERIOR
Defense Minerals Administration
RECEIVED
JUL 18 1951
LANDON F. STROBEL
Executive Secretary

RE: ALTOONA QUICKSILVER MINE
DMA DOCKET NO. 1258X

Dear Mr. Bourret:

As I was uncertain of just what information was desired in the breakdown requested in your telegram of July 3, I consulted with Mr. H. C. Miller in your San Francisco office. He, in turn, consulted with Washington and Mr. Ernest R. Gordon (Supply Division) has suggested that this be sent as is attached.

Repeating my statement in Exhibit 'A' - at present the mine is closed down, the shaft is caved, and the mine is full of water. Therefore the amount of re-timbering and the lower workings is very difficult to estimate in detail. After consultation with Mr. C. N. Schuette (Mining Engineer who estimated the original amount submitted), the attached is his further estimate of the breakdown in detail - with this footnote added by Mr. Schuette: "Since the shaft and levels cannot at present be inspected, their present condition is an unknown factor; and these estimates are based on experience with similar jobs of reopening old mines."

Thanking you for the attention you have given us, we are

Yours very truly

ALTOONA QUICKSILVER MINING COMPANY

R. E. FROWENFELD, PRESIDENT

REF/g

ENCL.

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

Office of
Executive Officer
DMA Field Team
Region III

1012 Flood Bldg.
870 Market Street
San Francisco 2, Calif.

July 16, 1951

Air Mail

Memorandum

To: Tom Lyon, Director, Supply Division, DMA, Washington, D. C.

From: Executive Officer, DMA Field Team, Region III

Subject: Altoona Quicksilver Mine--Docket DMA-1258X

Reference is to a telephone conversation I had with Mr. Ernest R. Gordon last week regarding subject exploration project loan application. In accordance with instructions given me by Mr. Gordon, I got in touch with Mr. R. E. Frowenfeld, President, Altoona Quicksilver Mining Company, and obtained from him a more detailed breakdown of his estimated costs than had previously been submitted with his application.

Having satisfied myself that Mr. Frowenfeld's exhibits were in satisfactory shape, I drew up, as suggested by Mr. Gordon, a set of exploration project contract forms, MF-200, and had Mr. Frowenfeld sign them.

Attached are six copies of the contract form, together with Exhibits A to E inclusive. The date of the contract has been left blank. Attached also is the original of a letter from Mr. Frowenfeld to Mr. Weston Bourret, dated July 16.

H. C. Miller
Executive Officer, DMA Field Team
Region III

DEPARTMENT OF THE INTERIOR
Defense Minerals Administration
RECEIVED
JUL 18 1951
[illegible]
Executive Secretary

Attachments

Copy to: Edgar H. Bailey, Geological Survey

San Francisco, Calif
June 11, 1951

DEPARTMENT OF THE INTERIOR
Defense Minerals Administration
RECEIVED
JUN 12 1951
LANDON F. STROBEL
Executive Secretary

Mr. Tom Lyon, Director
Supply Division, D.M.A.,
U.S. Dept. of the Interior
Washington 25, D. C.

Re: Altoona Quicksilver Mine
DMA Docket No. 1258X

Dear Mr. Lyon:

In accordance with your air mail letter of June 4, I am enclosing Exhibits "A" to "E", inclusive.

Thank you for sending me contract form MF-200, which I have given careful study, and for suggesting that I discuss this with Mr. H. C. Miller in your San Francisco field office. I have found him to be most cooperative and very helpful in the preparation of these exhibits.

The delay in sending this data to you has been caused by the necessity of getting additional photostats of the map. The four sets mailed with application forms MF-100 and MF-103 were the only copies in our file.

Please accept my appreciation for the attention you have given this application.

Yours very truly

ALTOONA QUICKSILVER MINE

R.E.Frowenfeld

REF/g

R.E.FROWENFELD, PRESIDENT

Enclosures

Minor and Rare Metals Branch

Supply Division, DMA

Gentlemen
Bourret
Lyon

July 3, 1951

Mr. F. W. Frowenfeld
Altoona Quicksilver Mining Company
128 Presidio Avenue
San Francisco, California

REFERENCE DMA-1255X WE REQUIRE ESTIMATE OF DETAILED LABOR AND MATERIAL COSTS COVERING EACH OF THE SEVEN POINTS FOR EXHIBIT A PAGE ONE. THESE DETAILS BE ACCURATE ENOUGH BEFORE WE CAN DRAFT A PRELIMINARY STATEMENT FOR THE PROPOSED CONTRACT.

Weston Bourret, Chief
Minor and Rare Metals Branch

WBourret/bf
cc: Adm. Reading File
Records & Reports
Lyon
McKnight
Meyer
Field Team III
Bourret
Files

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

FILE COPY
SURNAME:

FILE COPY
SURNAME:

Bourret

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

June 4, 1951

Mr. R. E. Frowenfeld, President
Altoona Quicksilver Mining Company
124 Presidio Avenue
San Francisco 15, California

Re: Altoona Quicksilver Mine
DMA Docket No. 1258X

Dear Mr. Frowenfeld:

Your exploration application, DMA Docket No. 1258X, dated May 21, 1951, for a $91,000 exploration project has been received by the Minor and Rare Metals Branch of the Supply Division.

Before a final decision can be reached on your request it will be necessary to obtain additional information. I am attaching hereto contract form (MF-200) which I suggest you review carefully at this time. In the event your project is approved the next step is to draw up a contract; unless the exhibits referred to (Exhibits A to E inclusive) are completed in detail, including maps, unnecessary delays will result. I would suggest therefore that you prepare this material immediately and forward to this office, in quadruplicate. Please contact our San Francisco field office, Mr. H. C. Miller, in the event you are in doubt regarding any of the points mentioned in the contract.

Very truly yours,

Tom Lyon

Tom Lyon, Director
Supply Division

Enclosure
WBourret/GMcC
cc: Files
Adm. Reading File
Mr. Strobel
Mr. Mittendorf
Mr. Lyon
Mr. McKnight, USGS
Mr. Bourret (2) (Application, etc. retained by Mr. Bourret)
Field Team, Region III

DMA 1258

FILE COPY
SURNAME:

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

May 29, 1951

Mr. R. E. Frowenfeld
President
Altoona Quicksilver Mining Company
124 Presidio Avenue
San Francisco 15, California

Subject: DMA-1258X
Re: Exploration Loan
Altoona Quicksilver Mine

My dear Mr. Frowenfeld:

Receipt is acknowledged of your application and attachments of May 21, 1951 for an exploration loan under the Defense Production Act of 1950.

The application was assigned Docket Number DMA-1258X and was referred to Mr. Weston G. Bourret, Acting Chief, Minor and Rare Metals Branch on May 28, 1951.

In any future correspondence relating to your application, kindly refer to DMA-1258X.

Sincerely yours,

LANDON F. STROBEL
jhs

Landon F. Strobel
Executive Secretary

LFSTROBEL:jhs
cc: Strobel-2
Files
Bourret
Lyon

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
102 Old Mint Building
San Francisco 3, California

May 17, 1951

Mr. E. T. McKnight
Mineral Deposits Branch
U. S. Geological Survey
Washington 25, D. C.

Dear Mac:

This letter concerns a DMA exploration docket to be submitted shortly by Mr. R. E. Frowenfeld, principal stockholder of the Altoona mine, Trinity County, California. I have conferred with Mr. Frowenfeld several times regarding his plans to request Government financial aid in reopening and exploring the Altoona mine, but because of circumstances explained below I feel the docket he intends to submit may still appear not entirely satisfactory.

The Altoona quicksilver mine is 13th in rank in the United States in terms of recorded production and may well have had other unrecorded production. The major production was obtained in the period 1895-1901, although the mine was first developed at a much earlier date. During World War II the upper 140 feet of the mine was unwatered and worked, and late in the period it was pumped out to the 350-foot level. The upper parts of the mine were mapped for the Survey by Swinney and Fix during this period (see California Journal of Mines and Geology, vol. 46, no. 3, pp. 395-404, 1950). The deeper workings, extending to a depth of 600 feet, have been flooded since about 1900, and no accurate planimetric or geologic maps are available.

The workings are now flooded and the shaft caved around the collar. Mr. Frowenfeld proposes to establish a small camp, pump out the mine, repair the shaft, and do some drifting and diamond drilling in the lower part of the mine. According to my understanding, there may be some doubt as to whether all of this can be financed on an exploration basis, even though all the preliminary work has to be done before the actual exploration can be done. Further, the exploration proposed is couched in quite general terms; in fact, so general that I suspect the docket would normally be returned for a more specific proposal. The main purpose of this letter is to point out that owing to the absence of

of any good planimetric or geologic maps of the lower levels, it is impossible to plan exploration in advance of dewatering and mapping the mine. To return the docket for a more specific proposal is, therefore, useless.

The owner is apparently honest and sincerely trying to get the mine back in production. He is neither a promoter nor a mining man by training. He expects to employ Mr. C. N. Schuette, a well-known quicksilver operator, to run the mine if the exploration is successful.

The mine is believed to have considerable stope fill in the lower levels. Swinney estimates the ore mined to have averaged 25 pounds to the ton and the stope fill to contain 10 pounds to the ton. The figures are probably reliable, as much of the ore treated during the World War II period was old stope fill. Swinney also suggests five places in the mine which should be further explored for new ore. In addition, fairly reliable reports indicate the early day work was not continued downward because of the problem of handling the water, even though some ore was known to extend below the lowest stopes.

In summary, although geologic information is too scant to pinpoint targets for exploration, the mine is believed to offer better than average possibilities for further exploration. In addition, it is reliably reported to contain old stope fill of good enough grade to be profitably treated in a moderate size furnace. In my opinion, the request for Government assistance to unwater the mine and do further exploration in the lower parts should be given careful consideration, even though available information is too scant to make any prediction as to how much quicksilver is likely to result.

Sincerely yours,

Edgar

Edgar H. Bailey

6/5/51

Defense Minerals Administration

Review of Application for Exploration Assistance

Docket No. 1258

Commodity Quicksilver

Total Amount $90,185

Govt. Participation 75%

1. Name and Address of Applicant Altoona Quicksilver Mining Co., 124 Presidio Ave, San Francisco 15, Cal

2. Location of Property East Fork of Trinity River, Trinity Co., Cal; sec. 22, T 38N., R 26W

3. Mineral or metal Quicksilver Is it listed in Section 9 of MO-5? yes

If not, application will be rejected.

4. Geologic probability of discovery—based on data in application (question #16, 17, 18, 20 and 22)*

Mines or Survey reports, etc., do you rate chances:

a) Good X See attached note

b) Poor

c) None

d) Don't know—needs field examination

e) Is there an alternative and favorable project? No
(If so, attach an explanation)

5. Is the applicant's right to the property clearly stated? yes-owner
(question 5, 6, 7)*

6. If applicant is a lessee, is a copy of the lease attached?

Does the lease have sufficient time to run to cover a future

productive period?

*question numbers are those of MF-103

4. (a) The Altoona mine has produced, chiefly between 1875 and 1901, 33,820 flasks of quicksilver. The ore occurs in diorite on faults striking NE and dipping from 53° NW to vertical. The ore shoots average about 5 ft. in thickness and locally attain a length and depth (down the dip) greater than 200 ft. Typical virgin ore runs 20 to 30 lbs. of quicksilver per ton.

Mine was originally opened to a depth of 600 feet. Below this level, the early miners had pumping troubles with equipment available at that time, and after the mine was abandoned in 1901, the lower 150 feet have never been unwatered. Statement of the mine manager as of 1901 is to the effect that ore was good to the bottom of the mine. One of the main veins was not explored in the lower levels. Furthermore, projected intersections of veins near the 600 level are promising for ore occurrence, although there will be uncertainty as to just where these intersections will fall until the mine is pumped out and the veins mapped on the lower levels. For this reason, the exact details of exploration on the 500 and 600 levels, proposed by applicant which is based on one interpretation of vein projections from upper levels, may have to be modified by what is revealed, but the amount of drifting, crosscutting and diamond drilling proposed by applicant is of a reasonable order of magnitude. The ore at depth was rich enough so that in the early days, a plan was made to drive a long drainage tunnel, but this plan was abandoned because of failure to secure a right-of-way.

7. Are subordination agreements necessary? No

a) MF-201? _____

b) MF-202 _____

8. From the data presented, does the proposed project appear feasible from the point of view of:

a) Available manpower _____

b) Equipment and supplies _____
(Question 14 plus general knowledge of availability)*

c) Accessibility (question 12)* _____

d) Water (question 13)* _____

e) Power (question 13)* _____

Is a field check needed on any of these points? _____

9. Does the experience of the applicant appear to be adequate to assure that he can properly conduct the proposed project? (question 4)* _____

_____

Is a field check needed on this point? _____

10. Exhibit A. (questions 21 and 22)*

a) Is the project adequately described? yes - in exhibit A

If not, are there sufficient data given so that you can describe the project? _____ If so, attach a draft.

b) Is there an adequate map or sketch of the proposed work? In part; shown in cross-section. Map is adequate for known geology.

c) Is the proposed work "exploration" under the definition of Section 8, MO-5? yes

If not, what part of it is? _____

_____

_____

_____

Is this part a worthwhile exploration project?_____

d) Are the cost estimates detailed?_____

Can they be summarized, as on page 2 of Procedural Instruction 5-A, from the available data?_____ If so, attach a draft.

e) Are the cost estimates reasonable?_____

f) Should more information be requested from applicant? No

g) Is a field examination necessary to complete Exhibit A? No

11. Exhibit B (question 23-d)*

a) Is it applicable?_____

b) If so, are sufficient data furnished?_____ If so, attach a draft.

c) Is a field check needed?_____

12. Exhibit C (question 23-e, f and g)*

a) Is it applicable?_____

b) Sufficient data?_____ If so, attach a draft.

c) Are rents and charges reasonable?_____

d) Is a field check needed?_____ _____

13. Exhibit D (question 23-a, b)*

a) Are there sufficient data?_____

b) Is the schedule adequate for the work proposed?_____

c) Is the schedule excessive for the work proposed?_____

d) Are the proposed wages and salaries reasonable?_____

e) Is a field check needed?_____

14. Exhibit E (question 23-c)*

a) Is it applicable? _____

b) Sufficient data? _____

c) Reasonable? _____

d) Field check needed? _____

15. In your judgment, can the proposed work be done in the proposed time? _____

(All exploration must be completed within two years)

16. If field examination is not needed, attach your recommendation. Recommended as proposed, on basis of geologic probability. E.T.M.

17. If field examination is needed, do you have any special instructions for the field team not indicated by your answers to the foregoing question? _____

Reviewed by: E.T. McKnight

Date June 28, 1951

INT.-DUP. SEC., WASH., D.C. 99009

dma 12558X

STANFORD UNIVERSITY

SCHOOL OF MINERAL SCIENCES

STANFORD UNIVERSITY
CALIFORNIA
JUNE 20, 1949

Mr. R. E. Frowenfeld
124 Presidio Avenue
San Francisco, Calif.

Dear Mr. Frowenfeld:

I am sending you, somewhat belated, a letter containing a few ideas regarding the Altoona Quicksilver mine.

I feel that the Altoona is a promising and important mine as far as quicksilver mines in the United States are concerned. It has yielded a total of about 34,000 flasks of mercury which puts it in a class with the above average mercury mines of the country with the exception, of course, of the few really large ones such as the New Almaden, the New Idria, the Oat Hill, etc.

In an early report written during the war, a future production of over 2,000 flasks was estimated. This was a very cautious and conservative estimate, since at that time it was better to error on the low side rather than over estimate. Actually, I believe the mine capable of producing much more, possibly 12,000 or more flasks. In the report that I recently wrote for the Geological Survey, I suggested a production of 200 flasks per month over a period of several years if the price of quicksilver could be maintained at a fairly high level ($125.00/flask). My reasons for thinking this are several. First, the early workers did not mine ore running below 10 pounds of mercury per ton. Material of this sort was even used as backfill in the stopes and was mined by the Marsman Company during the war. However, they did not unwater the mine and it seems likely that much ore of this grade remains in the old stopes. Second, if the company maps are to be believed, there is still considerable ground that has not been prospected. The possibility especially of an intersection of Vein No. 4 with Veins No. 1, 2, and 3. Third, the old company map indicates low grade ore on the Virginia level. This is probably at least 10 pound ($\frac{1}{2}$%) ore. Fourth, the almost right angle bend made by the Virginia level ore body suggests an intersection of two veins. Such intersections elsewhere in the mine would be likely areas for ore deposition.

I do not think it wise to go to any greater depth unless a good vein can be directly followed. Most quicksilver mines are shallow and 600 feet is quite deep. Even some of the larger mines, as the New Almaden, had their greatest ore production above the 800-foot level.

I'm sorry I do not have more factual information available, but much of the interpretations have been made from the old company maps and just how faithfully they picture the underground workings below the Altoona level is not known.

Sincerely yours

C. M. SWINNEY

c
o
p
y

dma 1258X

C.N.SCHUETTE
CONSULTING MINING ENGINEER
6390 BARNETT VALLEY ROAD W.
SEBASTOPOL, CALIFORNIA

May 18, 1951

Mr. R. E. Frowenfeld
124 PRESIDIO AVENUE
San Francisco 15, California

Dear Mr. Frowenfeld:

In accordance with your request to me on April 30th, I have carefully gone over all the data that I have which relates to the Altoona Mine in order to aid you in obtaining government assistance for exploration of said mine thru Mineral Order 5 under the Defence Production Act of 1950 and especially to furnish you the answers to questions 23 and 24 of Form MF-103.

The Altoona Mine has a very good production record and ranks as the 12th largest quicksilver mine in California in point of total production. The greater part of the production was made before 1900. It was idle for many years due to its isolated location. In recent times, new roads, trucks and a power line to the property have largely removed the handicaps of isolation.

The mine was last in operation in 1943-44 when it was equipped with a 25ton per day reduction plant. This operation was handicapped by inadequate financing and partly by indifferent management. For the first 5 months of 1944 (151 days) of which I have a detailed record and during which time the mine operation was in competent hands, an average of 21.7 tons per day was treated in the plant, producing 739 flasks of quicksilver from ore that had an average content of 17.1 pounds of quicksilver per ton. This gives a fair idea of what the mine can do when properly operated and certainly suggests that it merits exploration and development.

At present the mine is closed down, the collar of the shaft has caved, the mine is full of water and all machinery used in former operations has been removed from the property.

In order to explore and develop the Altoona Mine it will be necessary to rehabilitate the camp. There are four houses left on the property, one of which is the cook house. These are in need of repair. A new water line to the camp, roughly one mile long, will have to be installed. I estimate that a total crew of ten men will be needed to open the mine and do the necessary exploration work.

The order in which this work should be done is as follows:

1. Rehabilitate the camp, houses, water line, power connection.

2. Repair collar of shaft. Erect headframe. Install hoist.

3. Unwater the shaft and repair shaft to the 450 foot level.

4. Open and retimber where necessary the 450 foot level to the winze. (This was last done in 1945.

5. Unwater the winze and repair timbering to the 600 foot level.

6. Open, and retimber where necessary the 600 foot level.

7. Diamond drilling from the 500 and 600 levels as suggested by E.E.Erich in his report of July 1946, and drifting and crosscutting on the 600 level as will suggest itself after examination of the lower level.

Equipment needed for the work of exploring the mine:

10-tons 16 lb. rail, with plates, bolts & spikes - - - - - - - - - - - -	$ 2,000.00
1000-ft. 10" #22 gauge, galv. air pipe, @ $87.10 - - - - - - - - - - - -	871.00
1 - 10" American Blower, with 5 HP motor and starter - - - - - - - - - -	410.00
1 - 50 HP Single Drum Mine Hoist, capacity 4000# at a rope speed of 400 ft. per minute, complete with drum controller, sheave wheel and cable, all reconditioned -	1,750.00
1 - 440-Ft. Ingersoll-Rand type XB-2 compressor, size 15 - 9 x 12, complete with 75-HP motor, starter, air receiver and necessary piping, all reconditioned -	2,250.00
1 - 1250# Ingersoll-Rand type EUA single drum air hoist, with 500 ft. 1/4" cable, all reconditioned -	400.00
3 - Sullivan Jackhammers, 55# late machines (365) - - - - - - - - - - - -	1,095.00
2 - Sullivan Jackhammer mountings (180) - - - - - - - - - - - - - - - - -	360.00
2 - Sullivan Sets Column Bars, 3" with arm, saddle (150) - - - - - - - -	300.00
3 - Pcs. 50' Lgths 3/4" Air Hose Cpld (32) - - - - - - - - - - - - - - -	96.00
3 - Pcs. 50' Lgths. 1/2" Water Hose Cpld. (23) - - - - - - - - - - - - -	69.00

5 - Sets 1" QO. Drill Steel, Threaded and Shanked:
2' @ 4.75; 42" @ $6.20; 60" @ $7.60; 72" @ $8.50;
Total $27.00 - 135.00

500 - Timkin Bits, three gauges @ 44¢ - - - - - - - - - - - - - - - - - - 220.00

1 - Sullivan Diamond Drill, Model HS-15, Air, outfit complete (300') - 2,100.00

1 - Blacksmith Shop outfit, tools, etc. etc. - - - - - - - - - - - - - - 300.00

7000 Ft. 2" Standard Black Pipe, NEW $34.27/100' - - - - - - - - - - - 2,399.00

8 - Mine cars, 16-Ft. 18" ga. roller bearing (200) - - - - - - - - - - 1,600.00

1 - "Layne & Bowler" Deep Well Turbine pump #A-C-20 Head
450-Ft. 8" Column, 450-Ft. 1-11/16" Rods, #10 -
14- Stage bowls, with 75-HP Motor, 1750-r.p.m. with
starter, delivered, Redding, California.
This pump good for 500/gals/min. for 450' Head. - - - - - - - - - - 8,325.00

1 - "Layne & Bowler" Deep Well Pump, Turbine, #A-C*20 Head,
(6" Column, 200-Ft.) 200 Ft. 1-3/16" Rods.
#10 - 7-Stage Bowls, with 40-HP Motor, 1750-rpm.
Capacity: 500-Gallons minute, for 200-Ft. Head.
Price, delivered cars, Redding, California - - - - - - - - - - - - - 3,255.00

1000 - ft. electric cable @ $1.25/ft. - - - - - - - - - - - - - - - - - 1,250.00

1 Truck - 2,500.00

Deposit on Power Connection - 3,500.00
($2,500.00 of this deposit returnable)

Total 35,185.00

NOTE:- I am quoting specific items of equipment on which I obtained prices. If other makes are preferred the price should be about the same.

Thus the total outlay for the necessary machinery would be about - 35,200.00
The rehabilitation of the camp would cost about - - - - - - - - - 3,000.00
Timber and lumber would cost about - - - - - - - - - - - - - - - - - 2,500.00
Miscellaneous tools and supplies - - - - - - - - - - - - - - - - - - 2,000.00
Engineering, surveying, consultants, etc. - - - - - - - - - - - - 1,900.00
A crew of 10 men would come about as follows:

1 - superintendent - - - -	$500/ month	
1 - cook - - - - - - - - - -	300	
1 - hoistman - - - - - - - -	350	
1 - pump man & mechanic -	350	
2 - miners - - - - - - - - -	600	
2 - muckers - - - - - - - -	600	
2 - timbermen - - - - - - -	600	
TOTAL	3,300/month	
POWER	500/ "	
	3,800/ " for 1 year - - - - - - - -	45,600.00
Grand Total		90,200.00

R E P O R T

on the

ALTOONA QUICKSILVER MINE

Located in

Trinity County, California

. . . . . .

By

E. E. Erich

July, 1946

. . . . . .

INDEX

	Page
Foreward	1
Summary and Conclusions	2
Recommendations	3
Location	4
Property	4
Early History and Production	5-6
Recent History and Production	6-7
Development	7
Ore and Ore Geology	7-10
Possibilities for New Ore	10-12
Proposed Development Program	12-13
Cost of Development Program	14
Equipment	14
Camp	14-15

INDEX OF MAPS

MAP NO. 1 - District Map (compiled from old records).

MAP NO. 2 - CLAIM MAP (SURVEYED BY R. U. THORNBURGH).

MAP NO. 3 - Underground Workings (from surveys of Alf Baltzell, C.E.)

MAP NO. 4 - Section Through Mine (compilation).

. . . . .

FOREWORD

This report has been made at the request of Mr. Richard E. Frowenfeld, President of Altoona Quicksilver Mining Co.

The writer's experience with this property dates back to 1930 and 1931 at which time he carried out extensive investigations and studies of the geology of the ore occurrence. Later, during the war period (1943 to 1944) the writer again became interested in the property through the war needs and government incentives offered for the production of strategic quicksilver. During 1943 and 1944, under the writer's direction, the surface plant was rehabilitated and most of the upper portions of the mine which have been closed for over forty years (since 1902) were made accessible. The development work accomplished resulted in locating new ore which was mined with a resulting production of over 1100 flasks of quicksilver.

The development work accomplished verified certain theories of ore occurrence in this property and the results of this work are made the basis for recommending continued development for ore in the lower levels of this property.

. . . . . .

SUMMARY AND CONCLUSIONS

From evidence obtained through development and geologic work carried out in this ore deposit by the writer, there are expected to exist in the lower portions of the mine several large, unexplored, ore-bearing conduits or veins and vein extensions, both above and below the Virginia level.

There are also expected to exist several smaller veins or conduits in both the upper and lower mine workings which, upon exploration, may yield additional important quicksilver productions.

With the present installations of electric power and pumping equipment, the water of the mine can be handled to the Frowenfeld or 450 level with no great difficulty or cost. A similar pumping installation can then be installed and operated in the winze which extends from the Frowenfeld (450) level to the Virginia (600) level. Thus the mine can be completely unwatered and the principal obstacle to development which caused the termination of operations by the early operators would be overcome and development of new ore in the lower levels of the mine could proceed.

The principal cost of carrying out a development program of the lower levels of the mine will be in the installation of pumping equipment and de-watering the 150 foot winze, which extends from the Frowenfeld (450) level to the Virginia (600) level. This is expected to cost between $10,000 and $15,000.

Once the lower workings are made accessible, their development can proceed and the results obtained would determine the extent to which operations would be carried out. The amount of at least $10,000, however, should be made available to carry out such work, making a total of $25,000 that may be involved to explore the lower ore extensions of the mine.

The location and development of new ore extensions in the lower levels of this property could and probably would result in an attractive profit. The return could far overshadow the initial risk taken in advancing the development funds.

The possibilities for continued ore are attractive and warrant the expenditure and effort involved to explore them.

RECOMMENDATIONS

The writer believes that the exploration and development of the lower levels of this ore deposit, as described in this report, will yield a profitable reward and recommends the expenditure of $25,000.00 for unwatering and developing the lower mine ore extensions.

Written by E. E. ERICH

JUDY, 1946.

ALTOONA QUICKSILVER MINE

LOCATION:

The Altoona Quicksilver mine lies in a high mountain area at an elevation of 4,800 feet in the northern portion of Trinity County, California. It is located about 24 miles east from Carrville and 25 miles west from Castella and is reached from either point via a fair but steep mountain auto road.

The nearest railroad is at Castella. From Castella the road follows along an old logging railroad grade four miles, then rises steeply, and finally crosses a high pass at an elevation around 6,000 feet and then drops gradually to the mine. From Carrville the road also rises steeply and crosses a high pass at an elevation of about 6,000 feet and then descents and rises alternately until the camp is reached.

During the winter months, usually throughout December to May, the roads, particularly in the high pass areas, are closed by snow ranging from 6 feet to 20 feet deep. Access to the property, however, is maintained by means of a caterpillar tractor which rides on top of the snow, thus making it possible to bring in food and emergency mining supplies.

Snow conditions at the mine are not as severe as those on the roads through the high pass areas and, with proper preparation, winter conditions have no serious effect on mining operations. With a large buldozer it is not a difficult task to keep the roads open.

A new road to the property is now under consideration by the U.S. Forestry Service. This road would eliminate the high mountain passes, thus permitting an all-winter route which can be kept open for auto and truck travel.

PROPERTY:

The Altoona Quicksilver mine property includes patented lode mining claims known as and containing acreage as follows:

Altoona	20.05	acres
Trinity	22.66	"
Blockade or Central	11.31	"

Also, parcels of timber land containing approximately 400 acres located in Sections 26 and 28, Twp. 38 N, R 6 W, MDM.

EARLY HISTORY AND PRODUCTION:

The Altoona Quicksilver mine was discovered in 1871 and was operated in a small way until 1875. From information obtained at that time it is indicated that the discoverers produced about 2,500 flasks of quicksilver. In 1875 the present owners acquired the property. Operations on a larger scale were commenced by building a road 12 miles long connecting the mine with the main highway; also, the erection of a bench of six retorts in which to reduce the cinnabar obtained by the process of concentration to a 40 per cent basis; that is to say, the crude ore as taken from the stopes of the mine was washed or sluiced under pressure through a double line of flumes, each being 2 feet wide and 12 inches deep, containing riffles to especially save the finer particles of cinnabar or crystals. No attention was paid as to the number of tons extracted or quality of ore. As high as 400 flasks of quicksilver per month were produced in this most primitive mode of production. From 1876 until 1880 over 8,000 flasks of quicksilver were produced of the value of $265,244.23 (averaging $33.15 per flask).

Owing to the litigation that arose among the stockholders no work was done from 1880 to 1894. In this latter year operations on an extensive scale were resumed. In connection with all other structures that make up a plant, a 30 ton dry ore furnace was also erected and the method of roasting ore adopted.

From 1895 to 1901 and embracing a working period of 70 months, there were extracted 58,708 tons of wet ore yielding 19,671 flasks of quicksilver, or 1.28 per cent wet ton and of the value of $750,415.69 (or $38.15 average per flask).

The heavy influx of water into the mine was the greatest obstacle in the development of the downward extension of the ore deposit. The expense of continued development of the ore below the lower levels became prohibitive, whereupon it was decided to drive a lower drain tunnel from a point near the junction of the North fork and East fork of the Trinity river.

Attempts at securing a right-of-way through adjoining mining ground failed and the drain tunnel project was abandoned. The mine was closed down in 1902, allowed to fill with water, and has been inaccessible since that date.

After the closing of the mine, and, commencing in 1902, leasers have worked over the waste dumps, producing 1633 flasks of quicksilver of the value of $61,878.07 (averaging $36.77 per flask).

In summarizing the early history it can be stated that the Altoona Quicksilver mine has produced approximately 30,000 flasks of quicksilver. The major production was terminated in 1902 and the mine has been under water since that time.

RECENT HISTORY AND PRODUCTION

The surface and upper portions of the property have more recently been worked by lessers, resulting in a small quicksilver production. The last lessee operated in a small way on what little money he could raise and equipment he could patch together. In 1940 he finally interested the Marsman Company of California, which company supplied this lessee with additional funds to continue operations. The project went ahead intermittently until 1943, during which time repair work was done, additional equipment was installed and a few flasks of quicksilver were produced.

The Marsman Company of California then made application to the Reconstruction Finance Corporation for a development loan. The loan was granted in 1943 and soon thereafter the Marsman Company made an arrangement with the writer to act as consulting engineer and manager of this operation.

Because the Altoona project presented a serious water handling problem, the writer provided in his recommendations a pumping arrangement which was applied with success at another mine where a similar water problem had to be handled. The pumping arrangement was installed and the mine was de-watered to a few feet below the 350 or Trinity level, which is the most extensively developed level of the mine.

Development work was then carried out in the de-watered levels with the result that during the period of 1943 to July, 1944, 1109 flasks of quicksilver were produced from approximately 6600 tons of new ore and stope fills.

The writer's connections with the Marsman Company were terminated toward the end of June, 1944, Subsequently the main shaft was cleared below the 350 foot level and the mine de-watered to the 450 or Frowenfeld level. This level was made accessible to the winze which extends 150 feet below the Frowenfeld

level and to the Virginia level (the lowest level of the mine). Preparations for pumping out this winze were made; however, the work was not completed. The winze was not unwatered and, consequently, the main objective - to reach the bottom of the mine - was not accomplished.

Except for a few flasks of quicksilver produced from remaining ore in the upper mine stopes, no further production has resulted and the contract held by the Marsman Company of California was recently terminated.

DEVELOPMENT:

According to the available records, the Altoona ore deposit has been developed to a depth of approximately 600 feet by means of two shafts and levels extended from approximately 45, 90, 130, 230, 290, 350, 410, 450, 500 and 600 foot depths as shown on the accompanying map No. 4.

The main shaft was extended vertically from the surface to a depth of 450 feet to the Frowenfeld level. From this level, about 225 feet northwest from the main shaft, a vertical winze was sunk 150 feet to the Virginia or 600 foot level, the lowest level of the mine.

There is a question as to the depth of the above-mentioned 150 foot winze. Mr. Porter, former manager of the mine, stated to the writer that this winze is 250 feet deep. However, the available records indicate that the winze is only 150 feet deep. This difference in depth has a most important bearing on calculating and projecting of ore extensions. This subject is further discussed in this report under - "POSSIBILITIES FOR NEW ORE".

ORE AND ORE GEOLOGY:

The ore of this deposit is cinnabar although occasionally free quicksilver is found. The ore occurs in and along veins and conduits in a faulted and fractured area of light-colored quartz diorite and feldspatic porphyry which is pyritized and oxidized near the surface. Large and small bodies of serpentine containing mariposite occur in the porphyry and usually strike parallel to the fractures. Serpentine often underlies the porphyry and the ore-bearing conduits or veins appear to follow along and near the porphyry-serpentine contacts. Ore does not appear to extend and ap reciable distances into serpentine.

The principal rocks of this deposit are more particularly described as follows:

Serpentine: This is a fine-grained, green rock, probably a serpentinized dunite, characterized by slick, waxy surfaces.

Quartz Diorite Porphyry: This is a fine-grained, dark greenish black rock that weathers to a rusty brown color. The phenocrysts are hornblende and ground mass is a fine-grained mixture of feldspar, quartz and hornblende.

Feldspar Porphyry: This rock is closely related to the quartz diorite porphyry. Its mineral composition is similar and differs chiefly in that the phenocrysts are feldspar instead of hornblende and it is coarser grained.

Carbonate Rock: This is a hard, fine-grained, dark, grey-green to greenish-black rock resulting from the replacement of the quartz diorite porphyry by carbonate and possibly some quartz. This alteration and replacement appears to have taken place along contacts where this rock is often filled and cut by white carbonate veinlets.

Three principal veins, No. 1, No. 2, and No. 3, as well as several smaller veins, have been mined in the Altoona ore deposit.

These veins represent strong fractures in and along which cinnabar has been localized. The widths of the veins vary from a few inches to over fifteen feet. The old stopes show mined average widths varying around 4 feet to 10 feet and extending along the strike for distances varying from 100 feet to 300 feet.

In general it can be stated that ore is localized in and along fractures in the porphyry or, more particularly, where openings have occurred in these fractures. Wherever these openings were large usually a large concentraction of ore occurred and where the fractures contracted the ore did likewise.

The irrefular occurrence of ore in this deposit is attributed to its type; that is, evidently this is a hot spring deposit containing

many irregular conduits in and along which cinnabar has been localized. Also, along these conduits are numerous open, as well as collapsed vugs which have caused weakened and broken walls and fractures into which cinnabar was deposited.

Development carried out by the writer encountered such a vug or ore concentration in No. 2 vein which resulted in most of the production made from this property during the writer's management.

According to descriptions by the former mine manager and mine superintendent of the ore in the lower levels of the mine, a much larger vug was encountered.

Following is a statement made by Mr. Joseph Porter, former manager of the Altoona Quicksilver mine:

> "In regard to the Virginia level in the Altoona mine, wish to say that when we struck the vein on the east end of the pay-shoot it was 2 1/2 feet wide and continued to increase in width as we went west.
>
> "At a distance of one hundred feet it widened to 12 feet. It held this width for about fifty feet and then opened out to thirty-two feet in width. This wide body of ore was about 100 feet long and the vein then ran down to about 6 feet in width where we struck a header in the west end. The total length of the pay-shoot that we uncovered was three hundred and sixty-five feet. The ore ran 1-1/3% quicksilver.
>
> "It always seemed to me that we must have struck the top of a big pay-shoot on this level as when we went up with stopes the body did not seem so solid and the pay began to pinch out. There is no question in my mind that there is a large body of ore along the Virginia level.
>
> "Drifting on the vein, on the Virginia level, encountered a 'lake of water' (or vug) 10 feet to 12 feet wide, taking the longest stringer we could get down into the mine, and extending 75 feet to 100 feet. It plumbed 70 feet deep and we filled it up with waste. The sides of this vug were crusted with cinnabar and the ore was mined into each wall a maximum distance of two sets."

Mr. Porter states further:

"Sinking in this amount of water was out of the question. We, therefore, undertook to make an arrangement for a right-of-way through the adjoining mining claims for a tunnel which would extend under the lowest mine workings at a depth of 500 feet. Apex rights were insisted upon by the adjoining property owners, hostilities developed and the plan failed."

POSSIBILITIES FOR NEW ORE:

From the evidence obtained through development and geologic work accomplished at this property it is the writer's conclusion that in the lower levels of the mine there exist important unexplored veins (or conduits) and vein extensions both above and below the Virginia level.

The foregoing conclusion is supported by the following:

(1) According to the 'Old Timers' there actually is ore going down in the bottom levels of the mine. The writer, although he has not been in the bottom levels of the mine, has made the effort to interview those who have worked there, particularly the former mine superintendent and manager. These men insist that they had plenty of high grade ore in the bottom but could not take it out because of being unable to cope with the influx of water.

(2) Through detailed geologic study of the accessible mine levels and projecting the known veins or conduits into the lower inaccessible levels. (See Map No. 4).

(3) The general character of this ore deposit. It has already been stated herein that this is a hot spring type of deposit in which ore was deposited in and along conduits consisting of openings and fractures in crushed and broken porphyry walls and along porphyry-serpentine contacts.

(4) Through lack of development in the lower workings. (See Maps No. 3 and No. 4). In comparison with the work accomplished in the upper levels, the lower levels are little explored. This statement is further amplified as follows:

We know that the high grade cinnabar ore of this property was deposited in and along veins and conduits resulting in a highly irregular ore pattern requiring, in the exploration for ore, the procedure of either 'following the ore' or extensive and systematic development by cutting up the ground.

Without doubt the 'Old Timers' had a difficult and expensive water handling problem and there appears to be little question that this problem was the cause of the limited development work accomplished in the lower levels.

With the present installation of electric power and modern pumping equipment the water can be handled easily. The present pumping installation now readily handles the influx of water into the main 450 foot shaft and a similar installation should handle the influx of water into the winze which extends from the 450 (Frowenfeld) level to the Virginia level (lowest level of the mine).

Thus the principal obstacle to development which caused the termination of operations by the early operators can now be overcome and the development of new ore in the lower levels of the mine can proceed without serious handicap.

(5) The work carried out by the writer reveals interesting possibilities for new ore as follows:

Information given the writer some years ago by Mr. J. Porter, former manager of the mine, was that the winze extended from the Frowenfeld (450) level to the Virginia level is 250 feet deep (mentioned in this report under 'Development'). A section map through the mine was compiled by projecting downward to a 250 foot depth (below the Frowenfeld level) the veins found in the levels above. This section indicates that it is not probable that veins No. 1 and No. 2 intersect as quoted by Mr. Porter, but, instead, veins No. 2 and No. 3 or veins No. 3 and No. 4 intersect.

A further search of the records indicates that Mr. Porter probably was mistaken in giving the depth of the winze as 250 feet rather than 150 feet. This is further substantiated by the engineering records compiled by Mr. Alf Baltzell, C. E. who gives the depth of the above-mentioned winze at 151.7 feet.

Mr. Charles Allenberg (former secretary of the Altoona Quicksilver Mining Company during the period of 1875 - 1916) in a statement written by him dated January 12, 1916, says:

> "The winze sunk from the Frowenfeld level reached an ultimate depth of 151 feet, making a total depth of 601 feet from the surface to what is called the Virginia level."

Without doubt the 'Old Timers' had a difficult and expensive water handling problem and there appears to be little question that this problem was the cause of the limited development work accomplished in the lower levels.

With the present installation of electric power and modern pumping equipment the water can be handled easily. The present pumping installation now readily handles the influx of water into the main 450 foot shaft and a similar installation should handle the influx of water into the mine which extends from the 450 (Ironwood) level to the Virginia level (lowest level of the mine).

Thus the principal obstacle to development which caused the termination of operations by the early operators can now be overcome and the development of new ore in the lower levels of the mine can proceed without serious handicap.

(5) The work carried out by the writer reveals interesting possibilities for new ore as follows:

Information given the writer some years ago by Mr. J. Porter, former manager of the mine, was that the vein extended from the Ironwood (450) level to the Virginia level is 250 feet deep (mentioned in this report under 'Development'). A section map through the mine was compiled by projecting downward to a 250 foot depth (below the Ironwood level) the veins found in the levels above. This section indicates that it is not probable that veins No. 1 and No. 2 intersect as quoted by Mr. Porter, but, instead, veins No. 2 and No. 3 or veins No. 3 and No. 4 intersect.

A further search of the records indicates that Mr. Porter probably was mistaken in giving the depth of the vein as 250 feet rather than 150 feet. This is further substantiated by the engineering records compiled by Mr. Alf Baltzell, C. E., who gives the depth of the above-mentioned vein at 151.7 feet.

Mr. Charles Allenbery (former secretary of the Algoma Quicksilver Mining Company during the period of 1875 - 1916) in a statement written by him dated January 14, 1916, says:

> "The vein sank from the Ironwood level reached an ultimate depth of 151 feet, making a total depth of 601 feet from the surface to what is called the Virginia level."

By projecting the veins to and below the Virginia level and placing the Virginia level at 150 feet below the Frowenfeld level instead of 250 feet, the 'big ore' intersection would have occurred between veins labeled No. 3 and No. 4. (See section map No. 4).

If this is correct, then:

(1) Vein No. 1 never has been cut and was missed entirely in the Virginia level.

(2) Vein No. 2 was cut but little explored in the Virginia level and its downward extension will intersect the downward extensions of the combined veins No. 3 and No. 4 at a point approximately 100 feet below the Virginia level.

(3) Veins No. 3 and No. 4 combined and made the 'big' orebody and the combined veins (No. 3 and No. 4) carrying good ore would be the vein which extends below the Virginia level.

(4) Vein No. 5 might also have an important bearing on ore localization through its possible intersection with combined veins No. 3 and No. 4 below the Virginia level.

(5) There is also an indicated intersection just below the Frowenfeld level between the main shaft and the 150 foot winze. This intersection would be made by the No. 1 vein and two smaller fractures encountered in the Goldstein and Frowenfeld levels. These fractures appear to be going down toward No. 1 vein extension and should intersect approximately 100 feet below the Frowenfeld level. (See Map No. 4).

The foregoing possibilities appear likely to exist and, obviously, are intriguing. The answer can be obtained only by unwatering the winze and making the Virginia level accessible.

PROPOSED DEVELOPMENT PROGRAM:

In view of what we know regarding the ore of the upper levels and also the indication of ore extensions in the lower levels of the mine, two development procedures are indicated and are described in the order of their importance as follows:

(1) Explore the main ore extensions of the lower levels. This exploration is of prime importance.

By projecting the veins to and below the Virginia level and placing the Virginia level at 180 feet below the Provencheld level instead of 250 feet, the "big eye" intersections would have occurred between veins labeled No. 3 and No. 4. (See section map No. 4).

If this is correct, then:

(1) Vein No. 1 never has been cut and was mined entirely in the Virginia level.

(2) Vein No. 2 was cut but little explored in the Virginia level and the assumed extension will intersect the downward extensions of the combined veins No. 3 and No. 4 at a point approximately 100 feet below the Virginia level.

(3) Veins No. 3 and No. 4 combined and made the "big" orebody and the combined veins (No. 3 and No. 4) carrying good ore would be the vein which extends below the Virginia level.

(4) Vein No. 5 might also have an important bearing on ore localization through its possible intersection with combined veins No. 3 and No. 4 below the Virginia level.

(5) There is also an indicated intersection just below the Provencheld level between the main shaft and the 150 foot winze. This intersection would be made by the No. 1 vein and two smaller fractures encountered in the Goldstein and Provencheld levels. These fractures appear to be going down toward No. 1 vein extension and should intersect approximately 100 feet below the Provencheld level. (See Map No. 4).

The foregoing possibilities appear likely to exist and, obviously, are intriguing. The answer can be obtained only by re-sectioning the mine and mining the Virginia level accordingly.

PROPOSED DEVELOPMENT PROGRAM:

In view of what we know regarding the ore of the upper levels and also the indication of ore extensions in the lower levels of the mine, two development procedures are indicated and are described in the order of their importance as follows:

(1) Explore the main ore extensions of the lower levels. This exploration is of prime importance.

The work would involve installing a 'deep well' pumping unit in the 150 foot winze extended from the Frowenfeld level and through this winze unwater the lower levels. Then carry out drifting and crosscutting in the lower levels and, also, install a 'short hole' diamond drill for exploration below the Virginia level and carry out a drilling program. (See map No. 4).

This effort should not be particularly costly and should establish the existence of ore in the vein extensions as well as the existence of important vein intersections.

Once this ore is located, the procedure of developing and mining it will not be a difficult task.

This could be accomplished by extending a crosscut from the Virginia level to a point directly underneath the main 450 foot shaft and then connecting by raising. Either shaft could then be extended to the desired depth below the newly located ore and the present 450 foot shaft would become the main ore outlet.

In 1930 the writer considered driving a long drain tunnel under this ore deposit (following the plan of the original operators of the property). This plan, however, was abandoned. In view of the present knowledge of the ore occurrence of this deposit as well as having demonstrated that the water problem can be handled economically with modern equipment, the writer is of the opinion that the better procedure would be to utilize the present mine openings and, should development work below the Virginia level find important new ore, the present main 450 foot shaft could be extended and used as the main haulage outlet. This procedure would be the least expensive and can be carried out in the shortest period of time.

(2) Explore and develop the smaller veins or conduits in both the upper and lower mine workings. This work could be carried out at the same time the work is being accomplished in the lower portions of the mine.

The work would involve principally drifting and raising on the smaller veins; also, diamond drilling of some of the likely places would be in order.

The combined work has excellent possibilities of locating important tonnages of new high grade ore.

The work would involve installing a 'deep well' pumping unit in the 150 foot mine extended from the Ironwood level and through this mine water the lower levels. Then carry out drifting and prospecting in the lower levels and, also, install a 'short hole' diamond drill for exploration below the Virginia level and carry out a drilling program. (See map No. 4).

This effort should not be particularly costly and should establish the existence of ore in the vein extensions as well as the existence of important vein intersections.

Once this ore is located, the procedure of developing and mining it will not be a difficult task.

This could be accomplished by extending a crosscut from the Virginia level to a point directly underneath the main 450 foot shaft and then connecting by raising. Either shaft could then be extended to the desired depth below the newly located ore and the present 450 foot shaft would become the main ore outlet.

In 1930 the writer considered driving a long drain tunnel under this ore deposit (following the plan of the original owner of the property). This plan, however, was abandoned. In view of the present knowledge of the occurrence of this deposit as well as having demonstrated that the water problem can be handled economically with modern equipment, the writer is of the opinion that the better procedure would be to utilize the present mine openings and, should development work below the Virginia level find important new ore, the present main 450 foot shaft could be extended and used as the main haulage outlet. This procedure would be the least expensive and can be carried out in the shortest period of time.

(2) Explore and develop the smaller veins or conduits in both the upper and lower mine workings. This work could be carried out at the same time the work is being accomplished in the lower portions of the mine.

The work would involve principally drifting and raising on the smaller veins; also, diamond drilling of some of the likely places would be in order.

The combined work has excellent possibilities of locating important tonnages of new high grade ore.

COST OF A DEVELOPMENT PROGRAM:

The cost of carrying out a development program will, of course, depend upon the extent work is carried out. A minimum program would cost somewhere between $20,000 and $25,000.

The principal cost of the program will be the installing of pumping equipment in the 150 foot winze on the Frowenfeld level and in making the lower workings accessible. This may cost between $10,000 and $15,000.

Once the lower workings are made accessible, the development program could proceed and the results obtained would determine the extent to which development would be carried out. An allotment for such development should be at least $10,000, making a total of $25,000 which should be made available to undertake this work.

The ore expected to be encountered should be similar to that mined by the early operators; that is, between 20 lbs. to 30 lbs. quicksilver per ton. This grade of ore, if available in sufficient quantities, would permit a profitable mining and furnacing operation.

EQUIPMENT:

At present the property is completely equipped with electrically driven mining and furnacing machinery. Electric power is delivered to a sub-station on the premises by the Oregon-California Power Company.

The furnace has a capacity of around 30 tons per day and is fairly efficient. However, in the event a considerable ore tonnage is developed, it would be desirable to install more efficient furnacing equipment.

The present pumping facilities in the main shaft are capable of handling the water and holding it at the Frowenfeld level.

CAMP:

The camp consists of a boarding house, combination office and bunk house and several small houses, permitting accommodations for about twenty men.

It is to be noted that the most of the equipment and boarding house facilities now on the premises belong to the

former lessee. However, the owner of the property has the privilege to use this equipment by paying a monthly rental.

SUMMARY AND CONCLUSIONS:

See page 2, this report.

RECOMMENDATIONS:

See page 3, this report.

Written by E. E. ERICH

JULY, 1946.

MAP
CINNABAR MINES
TRINITY COUNTY
CAL.
Sentinel
Invincible
Endurance
Ruby
Integral
Central
Eldon
Oxus
Carr
Colorado Spring
Rochester
Ivy
Triangle
Blackjack
Vanguard
Pilgrim
Picket Post Cinnabar
Lucania
Reserve
Guard
Picnic
Wm. Simpson
Crow Creek
Railroad
East
Scale 10 chains to 1 inch

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES

CALIFORNIA JOURNAL OF MINES AND GEOLOGY

Volume 46, Number 3
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CONTENTS

Needles Magnesite Deposit, San Bernardino County, California 357
Northern California as a Market for Chemicals 373
Skaggs Springs Quicksilver Mine, Sonoma County, California 385
The Altoona Quicksilver Mine, Trinity County, California 395
Health and Safety Work of the Bureau of Mines 405
Mines and Mineral Resources of Yolo County 421

DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

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FERRY BUILDING, SAN FRANCISCO 11
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DIVISION OF MINES
OLAF P. JENKINS, Chief

Headquarters
Third Floor, Ferry Building, San Francisco 11

District Offices
State Building, 217 West First Street, Los Angeles 12
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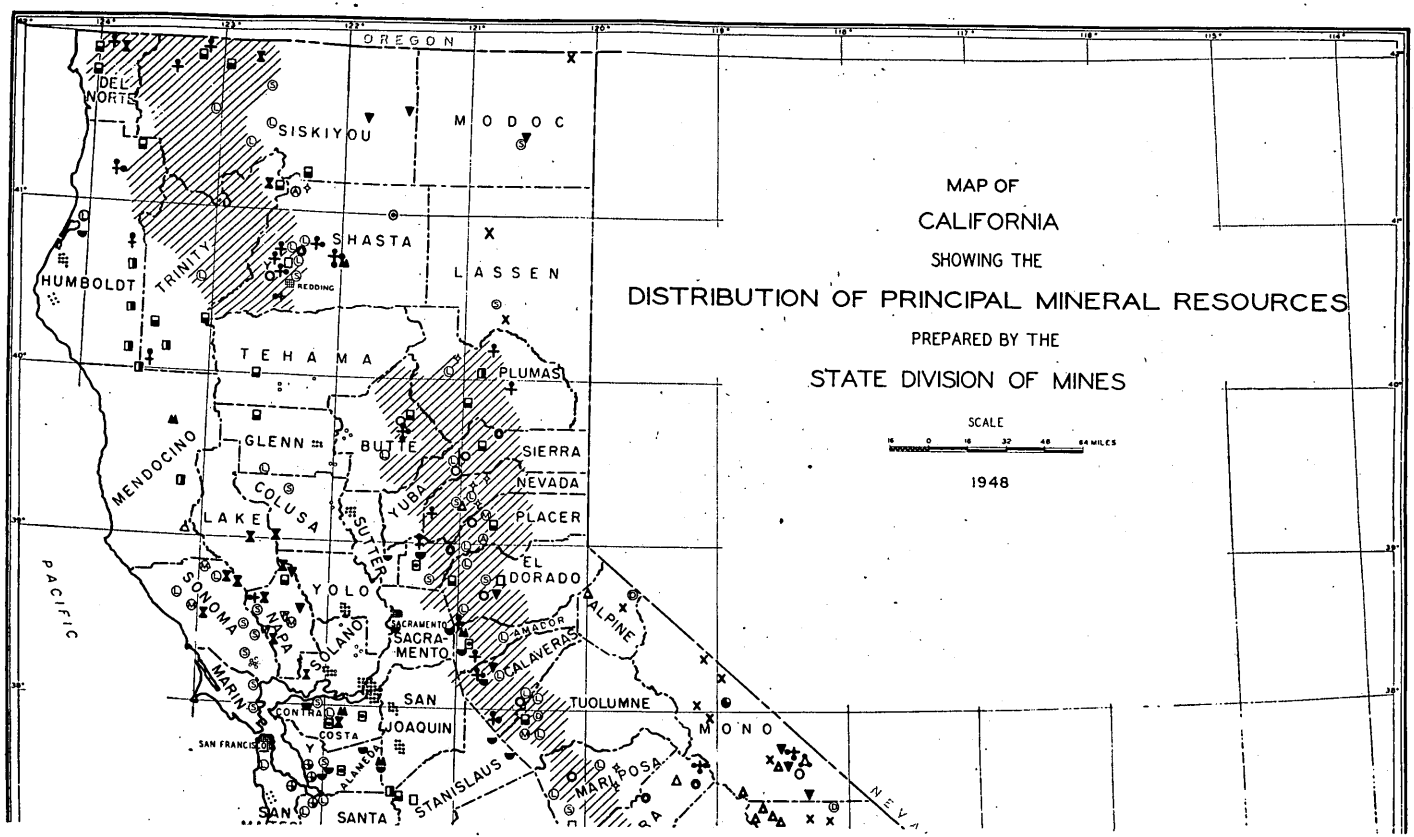
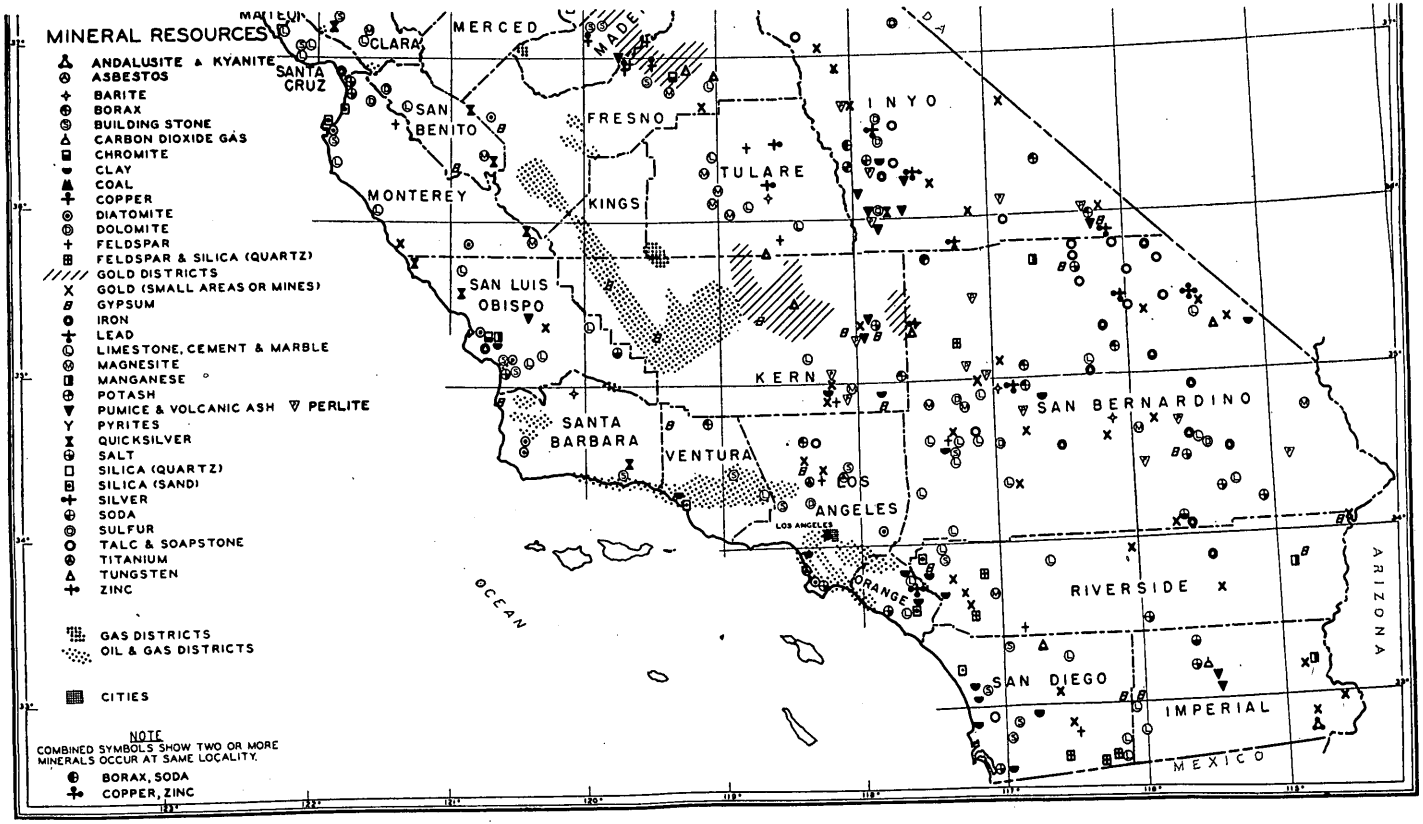

MAP OF
CALIFORNIA
SHOWING THE
DISTRIBUTION OF PRINCIPAL MINERAL RESOURCES
PREPARED BY THE
STATE DIVISION OF MINES
SCALE
16 0 16 32 48 64 MILES
1948
OREGON
DEL NORTE
SISKIYOU
MODOC
HUMBOLDT
TRINITY
SHASTA
REDDING
LASSEN
TEHAMA
PLUMAS
GLENN
BUTTE
SIERRA
NEVADA
MENDOCINO
COLUSA
YUBA
LAKE
SUTTER
PLACER
EL DORADO
YOLO
SONOMA
NAPA
SOLANO
SACRAMENTO
AMADOR
ALPINE
CALAVERAS
MARIN
CONTRA COSTA
SAN JOAQUIN
TUOLUMNE
MONO
SAN FRANCISCO
ALAMEDA
STANISLAUS
MARIPOSA
SANTA
PACIFIC


MINERAL RESOURCES
ANDALUSITE & KYANITE
ASBESTOS
BARITE
BORAX
BUILDING STONE
CARBON DIOXIDE GAS
CHROMITE
CLAY
COAL
COPPER
DIATOMITE
DOLOMITE
FELDSPAR
FELDSPAR & SILICA (QUARTZ)
GOLD DISTRICTS
GOLD (SMALL AREAS OR MINES)
GYPSUM
IRON
LEAD
LIMESTONE, CEMENT & MARBLE
MAGNESITE
MANGANESE
POTASH
PUMICE & VOLCANIC ASH
PERLITE
PYRITES
QUICKSILVER
SALT
SILICA (QUARTZ)
SILICA (SAND)
SILVER
SODA
SULFUR
TALC & SOAPSTONE
TITANIUM
TUNGSTEN
ZINC
GAS DISTRICTS
OIL & GAS DISTRICTS
CITIES
NOTE
COMBINED SYMBOLS SHOW TWO OR MORE MINERALS OCCUR AT SAME LOCALITY.
BORAX, SODA
COPPER, ZINC
MATEO
CLARA
MERCED
MADE
SANTA CRUZ
SAN BENITO
FRESNO
INYO
TULARE
MONTEREY
KINGS
SAN LUIS OBISPO
KERN
SAN BERNARDINO
SANTA BARBARA
VENTURA
LOS ANGELES
LOS ANGELES
ORANGE
RIVERSIDE
SAN DIEGO
IMPERIAL
MEXICO
ARIZONA
OCEAN

CONTENTS

	Page
Needles Magnesite Deposit, San Bernardino County, California, by Charles J. Vitaliano	357
Northern California as a Market for Chemicals, by E. William Eipper, Editor	373
Skaggs Springs Quicksilver Mine, Sonoma County, California, by Donald L. Everhart	385
The Altoona Quicksilver Mine, Trinity County, California, by C. Melvin Swinney	395
Health and Safety Work of the Bureau of Mines, by James Boyd	405
Mines and Mineral Resources of Yolo County, By J. C. O'Brien	421

PLATES

Plate 59.	Photograph southeast of mapped area showing contact between volcanics on top and lower dolomitic limestone below	364–365
60.	Photograph of Needles magnesite showing thinly laminated magnesite with thin partings between laminae	364–365
61.	Photograph of Needles magnesite deposit showing overturned folds in magnesite	364–365
62.	Exploration map, Needles magnesite deposit, Needles, California	In pocket
63.	Topographic and geologic map of the Needles magnesite deposit, Needles, San Bernardino County, California	In pocket
64.	Geologic sections of the Needles magnesite deposit	In pocket
65.	Geologic section exposed in trenches, Needles magnesite deposit, Needles, San Bernardino County, California	In pocket
66.	Geologic sketch map of the vicinity of Skaggs Springs quicksilver mine, Sonoma County, California	In pocket
67.	Composite map of underground workings, Skaggs Springs quicksilver mine, Sonoma County, California	In pocket
68.	Geologic maps of the underground levels of Skaggs Springs quicksilver mine, Sonoma County, California	In pocket
69.	Vertical sections through Skaggs Springs quicksilver mine, Sonoma County, California	In pocket
70.	Topographic and composite maps of the Altoona quicksilver mine, Trinity County, California	In pocket
71.	Geologic cross-section and level maps of the Altoona quicksilver mine, Trinity County, California	In pocket
72.	Map showing mines and mineral deposits of Yolo County, California	In pocket

NEEDLES MAGNESITE DEPOSIT, SAN BERNARDINO COUNTY, CALIFORNIA *

By Charles J. Vitaliano **

OUTLINE OF REPORT

	Page
Abstract	357
Introduction	358
History and development	359
Previous work	359
Field work	359
Acknowledgments	361
Geology	361
Pre-Cambrian rocks	361
Sequence of Tertiary formations at the Needles deposit	361
Quaternary deposits	362
Structure of the Needles deposit	362
Mineral deposits	363
Needles deposit	363
Capitan deposit	370

Illustrations

Figure 1.	Index map of San Bernardino County, California, showing location of Needles magnesite area	358
2.	Compass and pace map of the main pit, Capitan magnesite deposit, Needles, San Bernardino County, California	371
Plate 59.	Photograph southeast of mapped area showing contact (dashed line) between volcanics on top and lower dolomitic limestone below	364–365
60.	Photograph of Needles magnesite showing thinly laminated magnesite with thin partings between laminae	364–365
61.	Photograph of Needles magnesite deposit showing overturned folds in magnesite	364–365
62.	Exploration map, Needles magnesite deposit, Needles, California	In pocket
63.	Topographic and geologic map of the Needles magnesite deposit, Needles, San Bernardino County, California	In pocket
64.	Geologic sections of the Needles magnesite deposit	In pocket
65.	Geologic section exposed in trenches, Needles magnesite deposit, Needles, San Bernardino County, California	In pocket

ABSTRACT

Two deposits of bedded or sedimentary magnesite occur on the west side of the Sacramento Mountains, 14 miles southwest of Needles, San Bernardino County, California. In the Needles deposit, which is the better exposed of the two, the magnesite occurs in a shallow basin as a thin lens 600 feet wide and 2,400 feet long with a maximum thickness of 12 feet. The basement rocks, gneisses, and granites are believed to be of pre-Cambrian age. They are overlain by volcanic tuffs, breccias, and sedimentary rocks, all probably of Tertiary age. The sedimentary rocks enclose the magnesite layer. The magnesite is highly contorted, considerably faulted, and discon-

* Published by permission of the Director, U. S. Department of the Interior, Geological Survey.

** Geologist, U. S. Department of the Interior, Geological Survey.

tinuous within the lens-shaped area. Compared with similar deposits, the Needles magnesite is unusually pure. The CaO content ranges from 0.48 percent to 8.5 percent, SiO_2 may reach 6.0 percent, and the combined Al_2O_3 and Fe_2O_3 is generally less than 1.0 percent. Reserves in the Needles deposit are estimated at 117,000 tons of indicated ore and 410,000 tons of inferred ore.

The nearby Capitan deposit, only slightly exposed in 1944, consists of two parallel bands of magnesite, each about 8 feet thick, and associated material.

INTRODUCTION

The Needles area is on the western slope of the Colorado River Valley in the southwestern part of the Great Basin. The Sacramento Mountains in which the magnesite deposits occur, one of the major mountain ranges in the Needles area, are a bow-shaped range trending north, adjoined by the Mohave Mountains on the southeast and the Dead Mountains on the north. The mountain front on the east intersects a series of coalescing fans which slope at a uniform rate down to the Colorado River. On the west a remarkably straight, steep edge truncates the main range and separates it from the adjacent pediment and low-lying hills which occur to the west.

Two deposits of bedded or sedimentary magnesite are known in the Needles area, San Bernardino County, California (fig. 1). The Needles

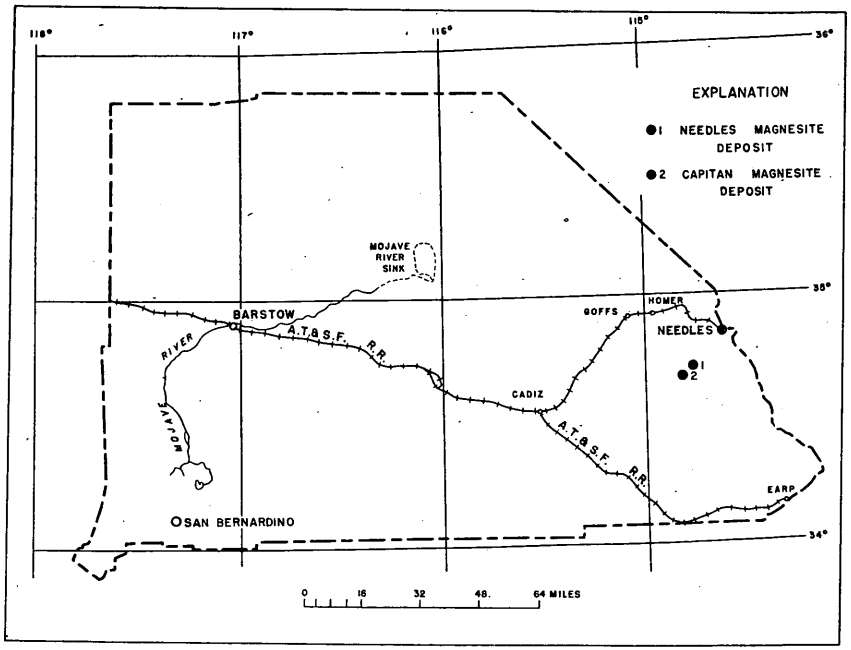


FIGURE 1. Index map of San Bernardino County, California, showing location of magnesite in the Needles area.

deposit is covered by four placer claims: White Moon nos. 1, 2, 3, and 4, in the S½ sec. 15 and in the N½ sec. 22, T. 8 N., R. 21 E., S. B. A desert road, which was in very poor condition during 1943, leads directly from the city of Needles to the deposit. This road is on a terrace on the southeast bank of Eagle Creek for a distance of 7 miles and then on the loose

gravels of the wash for the remaining 7 miles. A longer, though less arduous route follows U. S. Highway 66 for 20 miles over South Pass from the city of Needles to the Metropolitan Water Supply power line, then south along the power line road for 9 miles to the Beacon Tower road, and southeast along Beacon Tower road for 5 miles, partly in loose sand, to the property, a total distance of 34 miles. The Capitan magnesite deposit is on the pediment at the base of the western foothills of the Sacramento Mountains. The deposit is in the southwestern part of T. 8 N., R. 21 E., about 15 miles southwest of the Homer siding on the Atchison, Topeka and Santa Fe Railroad. The road from Homer siding follows the Metropolitan Water Supply power line southeast to the Beacon Tower road. A turn-off 2 miles along the Beacon Tower road from the junction leads directly to the property.

History and Development

The only work which had been done on the magnesite in the Needles area prior to September 23, 1935, consisted of three small prospect pits on the Needles deposit. At that time the California Chemical Co., now the Westvaco Chemical Division, Food Machinery and Chemical Corp., began an exploration program, during which sixty trenches were opened, and four diamond drill holes, totalling 157 feet, were drilled on the Needles deposit. All of the exploratory work was limited to an area of 60 acres which showed positive indications of magnesite. No further work was done on the Needles magnesite deposit until March 1943, when the property was leased to Mr. J. Lex Brown of San Bernardino, California, and associates. Machinery was brought to the property, and it was planned to mine the ore with a small power shovel. By April 1943, a small quarry had been opened, and one car of ore was shipped, after which operations are reported to have ceased.

When the Capitan deposit was first visited in March 1943, it contained only two prospect shafts, in both of which magnesite was exposed. An exploration program was in progress at the time, however, and when the property was revisited in July 1944, two large pits had been excavated exposing the magnesite.

Previous Work

The first geologic mapping of the Needles deposit was done in September 1935, by Gerald M. Kirwan, geologist for the California Chemical Co., during its magnesite exploration program. In December 1941, the property was examined and mapped by L. Fillaseta and H. Nye for Basic Magnesium, Inc., of Las Vegas, Nevada. In March 1942, J. A. Vandegrift of Los Angeles, California, made a sketch map of the deposit and made chemical analyses of 27 selected samples for Defense Plant Corporation. None of the above reports were published, as all were of a confidential nature.

The Needles deposit was briefly visited for the U. S. Geological Survey by Eugene Callaghan, John Loufborrow, and the writer, accompanied by J. A. Vandegrift, in October 1942.

Field Work

During February and March 1943, the writer and Alfred J. Bodenlos spent 5 weeks in the area mapping the Needles deposit on a scale of

1 : 2,400 and examining the Capitan prospect. Additional trenching was done, and samples were taken and analyzed. When the writer revisited the area in July 1944, with Ian Campbell of the Division of Geological Sciences, California Institute of Technology, and J. A. Vandegrift, a small quarry had been opened in the magnesite at the Needles deposit, and two pits had been excavated on the Capitan deposit. A sketch map of the main pit on the Capitan deposit is shown in figure 2.

Table 1. Stratigraphic column of the Tertiary rocks at the Needles magnesite deposit, sec. 22, T. 8 N., R. 21 E., San Bernardino County, California.

Thickness (feet)	Field name	Description
Unknown	Volcanics (agglomerate and latitic flows)	Agglomerate, buff to brownish matrix containing fragments of all volcanic and sedimentary rocks in area. Fragments up to 2 inches in diameter. Cavernous weathering surface. Latitic flows, massive flow rock, brick red, feldspar phenocrysts set in very fine-grained groundmass.
10+	Cherty dolomite	Light- to dark-gray to grayish-blue, fine- to medium-grained dolomite. Weathered surface is rough and pitted with rust-stained chert nodules and lenses commonly 10 feet long and 1 foot wide. The upper contact of the cherty dolomite with the overlying volcanics was not found in the mapped area.
80+	Dolomite, tuff, shale, and magnesite-bearing horizon	Dolomite, minimum thickness 12.6 feet. The lower 9.0 feet is thin-bedded, creamy-white dolomite. The upper 3.6 feet is massive dolomite, weathering into blocks as much as 2.5 feet in diameter. The upper part locally contains thin shale partings. Shales, interbedded dolomites, and tuffs (thickness 9 feet). Lower 2.5 feet of this member, light- to dark-gray, buff to brown fissile shale and interbedded thinly laminated light-gray to white dolomite. The shale portion weathers to a soft claylike consistency. Middle part of this member is 5.1 feet of light-gray tuff with dolomite fragments. Upper 1.6 feet of this member is thin-bedded, dark-brown shale with irregular fractures. A few thin zones of clayey material resembling fault gouge. At the top is 0.5 feet of dolomite. Dolomite, grayish white on fresh surface, weathering to white upon exposure. Beds range up to 0.2 inch in thickness separated by thin shaly partings. Thickness 5.0 feet. Magnesite, chocolate brown on freshly broken surface, drying to white, somewhat crumbly mass upon exposure. Fine-grained and thin-bedded, beds ranging from 0.5 inch to 6 inches, with bedding surface frequently slickensided. Commonly the beds are intricately folded. Shaly partings between magnesite beds up to 2 inches thick. About 10 inches of thin-bedded shale is found in places at top of magnesite horizon. **Dolomite.**—Thin-bedded, rusty-brown, with interbedded cherty layers ranging up to 1/10 inch thick. Chert layers are continuous and of uniform thickness. Total thickness of this horizon 4 feet plus. **Shale.**—Thin-bedded, fissile, white to grayish white. Upon exposure, the shale dries out and crumbles, and as a result areas underlain by shale are soft under foot and form depressions. The shales and the overlying magnesite are intricately folded and faulted.
30+	Volcanic tuffs and flows	(Andesite tuff.) Bedded pyroclastics and flows, predominantly brownish-yellow with greenish, whitish, and red varieties. Beds 1 foot to 3 feet thick, porous, highly jointed, with caliche deposited along joints; feldspar, biotite, and magnetite grains in a brownish-yellow, glassy groundmass. Interbedded flow layers; euhedral feldspar and hornblende grains in a banded glassy groundmass.
7+	Dolomitic limestone	(Occurs just outside area mapped.) Fine-grained, thin-bedded, grayish-white dolomitic limestone. (Exact thickness unknown owing to incomplete exposure.) Exposed only on crest of anticline just outside magnesite-bearing area, below and in contact with andesite tuff.

Acknowledgments

The writer wishes to express his thanks to the Westvaco Chemical Division, Food Machinery and Chemical Corp., for making available the maps and chemical analyses in Gerald M. Kirwan's report on the Needles deposit and to Mr. J. A. Vandegrift for making available a report containing chemical analyses of the magnesite. To Eugene Callaghan the author is indebted for guidance and helpful criticism in the field and in the preparation of the report. Grateful acknowledgment is accorded to A. J. Bodenlos, whose very able assistance in the field and in the drafting of the map of the Needles deposit helped considerably in the final preparation of this report.

GEOLOGY

The major geologic units in the Needles area are the pre-Cambrian metamorphic rocks, the Tertiary volcanic and associated sedimentary rocks, and the Quaternary sediments.

Pre-Cambrian Rocks

The pre-Cambrian rocks, greenish to gray gneisses injected with pink to gray granite, are exposed in the Sacramento Range and in the bottoms of the washes along the roads leading into the mountains. The injected rock is coarsely crystalline, in places essentially pegmatitic. Close folding of foliation bands is common in the gneiss along the road leading up Eagle Wash.

Sequence of Tertiary Formations at the Needles Deposit

The Tertiary rocks in the Needles magnesite area are volcanic tuffs and andesitic flows associated with a series of sedimentary rocks in which the magnesite bed occurs.

The stratigraphic column at the Needles magnesite deposit consists of a series of volcanic tuffs and flows, shales, dolomites, limestones, magnesite, and cherty dolomite. Because of the intense disturbance of the sediments, the measurement of a true stratigraphic section is difficult. Trench no. GS (pl. 62) was excavated by the U. S. Geological Survey across the strike of the sedimentary rocks in an area where the rocks appeared to be relatively undisturbed. The section from the top of the andesite tuff upward to the cherty dolomite was exposed (see table 1). A few seams of fault gouge were uncovered, but upon checking, these proved to be very local and due to small-scale movements. The thickness of the andesite tuff and flows was measured just beyond the southeastern limit of the mapped area, where the volcanics are in contact with the underlying dolomitic limestone (pl. 59). The thickness of the exposed part of the cherty dolomite was measured within the mapped area in the southeastern part of the section. The full thickness of this member is unknown, because nowhere in the district is the cherty dolomite found in contact with the overlying younger volcanic rocks.

Although no direct evidence of the age of the sedimentary rocks was found, they are classified here as Tertiary because of their association with the tuffs and flows which are similar to Tertiary [1] volcanic tuffs and

[1] Schrader, F. C., Mineral deposits of the Cerbat Range, Black Mountains, and Grand Wash Cliffs, Mohave County, Arizona: U. S. Geol. Survey Bull. 397, p. 37, 1909.

flows in the Chemehuevi Mountains and Mojave Mountains in San Bernardino County, California, and in the Black Mountains, Mohave County, Arizona, just across the Colorado River.

Newberry [2] described briefly the geology of the Chemehuevi Valley, the Mohave Mountains, the Mohave Valley, and particularly the western slope of the Colorado River Valley leading up to the mountains (the present Sacramento Mountains), and Dead Mountain. The volcanic tuffs and flows and the associated sedimentary rocks were classified as of Tertiary age.

Lee [3] and Schrader [4] have described the geology of Mohave County, Arizona. Schrader's map shows that the Sacramento Mountains and the surrounding region west of the Colorado River are underlain by "undifferentiated, principally pre-Cambrian, granitoid series with local areas of Tertiary volcanics (andesites, trachytes, rhyolites, etc.) and some Quaternary (?) basalts."

Quaternary Deposits

Sediments composed of coarse pebbles of sedimentary and volcanic rocks are found in the present washes, especially in the vicinity of the Needles magnesite deposit. These sediments are mainly unconsolidated, but some of the gravels and conglomerates within the magnesite-bearing area are cemented. Generally the sediments are flat lying and unfaulted except in several localities, especially east of the Needles magnesite deposits, where the sediments have been tilted as much as 10°. The loose gravels and the fine alluvium in the present washes constitute the latest deposits.

STRUCTURE OF THE NEEDLES DEPOSIT

The Needles magnesite deposit is in a physiographic basin rimmed by hills on three sides and open on the fourth side. The sedimentary rocks, which include limestones, dolomites, cherty dolomite and shale, as well as magnesite, dip outward and beneath the younger volcanic rocks at the periphery of the amphitheater. Thus the geological structure of the magnesite area is a dome. Superimposed upon the major dome structure is a series of minor folds in the sedimentary and interbedded volcanic rocks. In general the axes of the minor folds are parallel and trend about N. 10° to 20° W. Outcrops of the more resistant cherty dolomite beds form zigzag ridges on the limbs of the folds. On the map of the magnesite deposit, the distribution of the thin-bedded dolomite, shale, and magnesite horizon indicates the pattern of the folds in the sedimentary rocks (pls. 63 and 64). A few cross-folds occur, and in these the axial trend is eastward.

A series of major normal faults and innumerable minor normal faults cut the sedimentary rocks in the mapped area. The major faults are parallel and trend north, making an angle of 25° with the axes of the northwest-trending folds. There are five major faults in the area, but only two of them have affected the magnesite horizon as it now is exposed. In the southeastern part of the mapped area three parallel faults bring the lower andesite tuff into contact with the capping of cherty dolomite.

[2] Newberry, J. S., in Lt. J. C. Ives' Report of the Colorado River of the West, pt. 3, pp. 29-54, 1861.

[3] Lee, W. S., Geologic reconnaissance of a part of western Arizona: U. S. Geol. Survey Bull. 352, 1908.

[4] Schrader, F. C., op. cit., pl. 1.

The throw on all faults is small, probably at no place exceeding 50 to 75 feet.

One reverse fault of small throw was mapped in the extreme northwest part of the area, and another was mapped along the southern part of the northeastern contact between the pre-Cambrian granite and the sedimentary rocks. The tilting of the gravels and the displacement of the alluvium along some of the faults indicate recent movement along the faults in the area.

MINERAL DEPOSITS

Needles Deposit

The magnesite in the needles area occurs as thin-bedded, very fine-grained, white rock. Thin shaly partings up to 2 inches thick separate the individual magnesite layers (pl. 60). In contrast to the magnesite found in altered serpentine deposits of western United States, the magnesite from the Needles area is not hard and lacks conchoidal fracture. Similar soft sedimentary magnesite has been described from Bissell, Kern County, and Afton, San Bernardino County, California.[5] The Needles magnesite has a rudimentary subconchoidal fracture on which are slickensided surfaces as a result of local gliding. The magnesite is chocolate brown on freshly broken surfaces, but upon exposure changes to white and becomes powdery.

The magnesite in the Needles deposit is limited to a single lens-shaped horizon, thinning out toward the edge. The lateral extent of the lens may be small, as shown in cross sections GG′, HH′, or II′, or the lens may thin out gradually, as in sections CC′, and DD′. The incompetence of the magnesite is reflected in the severe folding of the beds and the pinching out of the magnesite in many places (pl. 65). Probably most of the variation in thickness of the magnesite horizon is due to pinching. In some places intense folding actually has resulted in breaking and thrusting the magnesite so that magnesite ore abuts against dolomite (see pl. 65, trench 11), but elsewhere the thickness of the magnesite is increased by tight folding and overturning (see pl. 65, trenches 30 and 31, and pl. 61).

The magnesite outcrops are limited to an area 600 feet wide and 2,400 feet long, elongated northwest. In this area folding of the magnesite and the adjacent sediments may carry the magnesite to depths as great as 100 feet (see pl. 64, cross sections DD′ and II′). The pattern of the folds in the sedimentary rocks is indicated by the zigzag outcrop of the white magnesite beds in the northern part of the mapped area. In addition, the magnesite in the central part of the ore-bearing area has been displaced by normal faulting. The maximum throw on any of the faults is generally less than 75 feet.

The main impurities in the magnesite are CaO, SiO_2, and Al_2O_3 and Fe_2O_3. The Al_2O_3 and Fe_2O_3 content is generally low as indicated in all the chemical analyses (see tables 2, 4, 5, 6). In all the chemical analyses made by the U. S. Geological Survey, the Al_2O_3 and Fe_2O_3 content was determined collectively as R_2O_3, which, with one single exception, did

[5] Gale, H. S., Late developments of magnesite deposits in California and Nevada: U. S. Geol. Survey Bull. 540, p. 515, 1912.
Bradley, W. W., Magnesite in California: California Min. Bur. Bull. 79, pp. 49, 75, 1925.
Rubey, W. W., and Callaghan, Eugene, in Hewett, D. F., et al., Mineral resources of the region around Boulder Dam: U. S. Geol. Survey Bull. 871, pp. 114-118, 1936.

not exceed 1.9 percent and in most samples did not reach 1 percent. It was found that the SiO_2 content generally depended upon where the sample had been collected. Within the magnesite horizon the SiO_2 content was generally less than 10 percent and in many samples was less than 5 percent. Samples with the SiO_2 content in excess of 10 percent were either shaly or clay-like in appearance in the field and generally were not part of the magnesite horizon. SiO_2 was frequently reported as insoluble.

The CaO content in the analyzed samples ranged from 0.30 percent to more than 28 percent. It is believed that CaO is combined with MgO and CO_2 to form dolomite, the carbonate impurity in the magnesite horizon. Excess MgO over the amount required to make up the carbonate minerals magnesite and dolomite is probably combined with SiO_2 and H_2O to form a hydrous magnesium silicate.

Six complete analyses made from samples taken in trench GS excavated by the U. S. Geological Survey, are given in table 2. Two of these are combined samples made in order to determine whether or not a given thickness of sediments containing some obvious layers of dolomite could be mined and treated as a unit.

Table 2. Chemical analyses of samples taken from U. S. Geological Survey trench, Needles magnesite deposit.

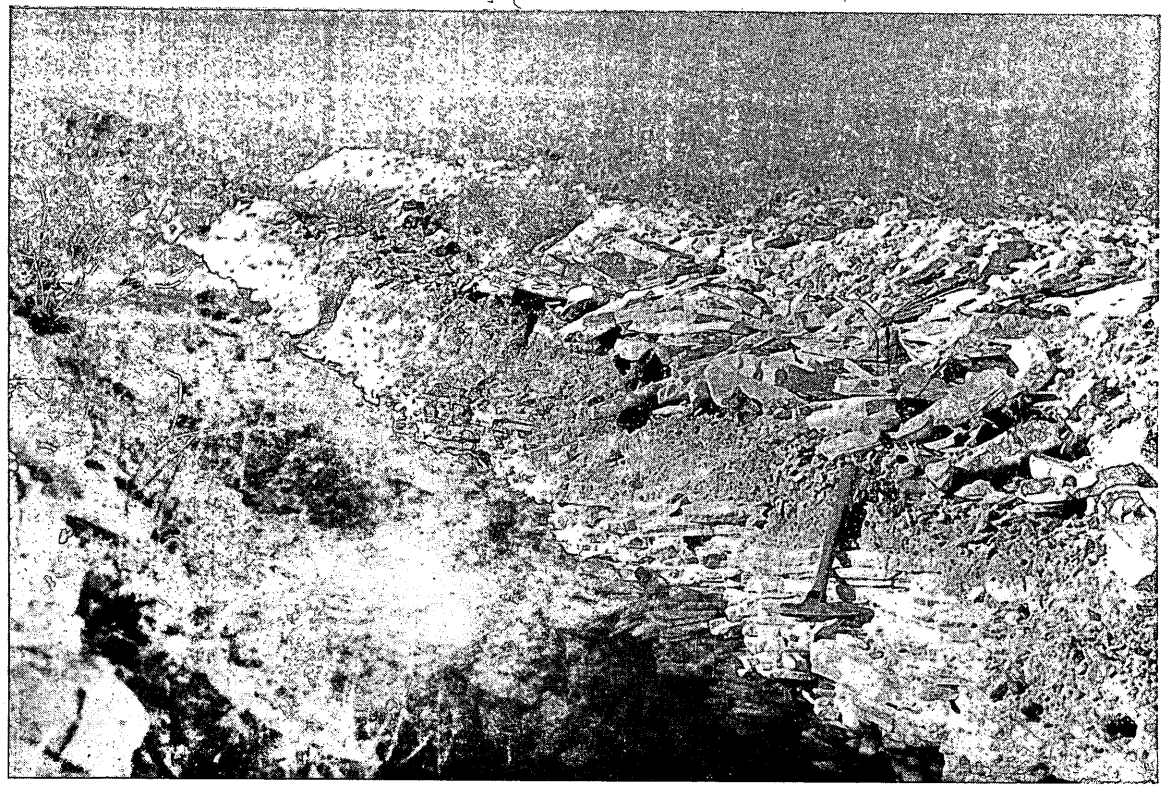
Sample	GS-h	GS-i	GS-r	GS-s	GS-1	GS-2
SiO_2	12.97	28.65	10.09	5.27	5.82	14.31
Fe_2O_3	.24	.32	.08	.34	.16	.22
Al_2O_3	.40	1.51	.69	.26	.60	.59
Cr_2O_3*	----------	----------	----------	----------	----------	----------
TiO_2*	----------	----------	----------	----------	----------	----------
CaO	24.06	13.99	16.86	13.18	17.02	23.17
MgO	22.94	25.70	30.02	34.52	29.01	23.27
CO_2	34.47	22.50	39.22	45.19	41.69	35.28
H_2O	2.01	7.35	3.13	1.30	5.93	2.97

GS-h: 0.11 feet——whitish, thin-bedded dolomite, V. North, analyst.
GS-i: 1.95 feet——soft, whitish, thin-bedded shale, V. North, analyst.
GS-r: .83 feet——white, thin-bedded, dolomitic magnesite, V. North, analyst.
GS-s: 4.90 feet——whitish, thin-bedded, dolomitic magnesite, V. North, analyst.
GS-1: 5.50 feet——combined sample white magnesite with thin dolomite seams and with thin layer (2 feet) of impure magnesite, V. North, analyst.
GS-2: 4.70 feet——combined sample buff, gray, gray-brown to brown, impure dolomite with argillaceous layers, V. North, analyst.

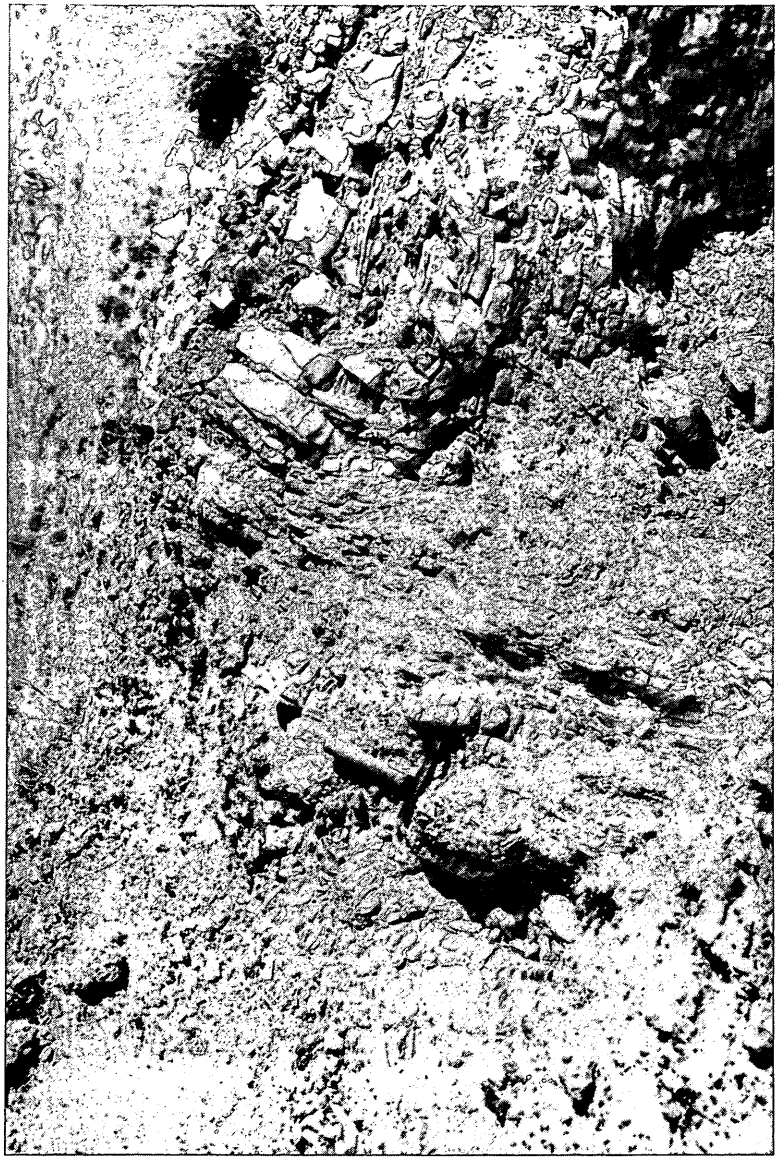
* Cr_2O_3 and TiO_2 were not found, although specific tests were made.

The magnesite in the Needles deposit is remarkable for its low content of insoluble material and of R_2O_3. The chemical analyses of specimens taken by both Westvaco Chlorine Products Corp. and the U. S. Geological Survey show that the insoluble content for specimens high in $MgCO_3$ is almost invariably less than 5 percent and generally less than 2.5 percent. In comparison with sedimentary magnesite from other deposits in California and Nevada, the insoluble content of the Needles deposit is very low. Published analyses of the samples from the Bissell magnesite deposit

Photograph southeast of mapped area showing contact (dashed line) between volcanics on top and lower dolomitic limestone below.



Photograph of Needles magnesite showing thinly laminated magnesite with thin partings between laminae.



Photograph of Needles magnesite deposit showing overturned folds in magnesite.

in Kern County, California, show a SiO_2 content of 7 percent.[6] Additional analyses from the Bissell deposit by the U. S. Geological Survey show insolubles ranging from 4.75 percent to 10.6 percent.[7] Analyses of specimens from the Bissell deposit, which had been exposed to weathering for several seasons, showed 5 to 10 percent SiO_2. The combined Al_2O_3 and Fe_2O_3 content in the analyzed specimens from the Bissell deposit is much higher in general than in those from the Needles deposit. The published analyses range from 0.76 percent to 10.05 percent R_2O_3, with the greater number of analyses showing slightly more than 2 percent. At Needles the R_2O_3 content (combined Al_2O_3 and Fe_2O_3) in all analyzed specimens is very low. In only three specimens was there more than 1 percent R_2O_3, and none contained more than 1.9 percent.

In the Afton magnesite deposit in San Bernardino County, California, the insoluble content analyzed in specimens taken by the U. S. Geological Survey ranges from 5.1 percent to 26.4 percent. The total Al_2O_3 and Fe_2O_3, analyzed separately in the specimens from this deposit, is more than 3 percent in all the specimens in which these constituents were determined.[8] The magnesite from the Horse Spring formation at Overton, Clark County, Nevada, is another example of sedimentary magnesite in which the tenor of the ore is lower than at the Needles magnesite deposit. All of the specimens analyzed from this deposit show an insoluble content in excess of 10 percent.[9] In the Bauer magnesite deposit, also in Clark County, Nevada, the analyses show an insoluble content ranging from 4 to 6.2 percent.[10]

The consistently lower content of insolubles and R_2O_3 in the magnesite from the Needles deposit is of considerable interest, especially in view of the fact that this deposit was considered as a possible source of ore for the Basic Magnesium, Inc., plant at Las Vegas, Nevada, during the early part of World War II.

Origin. The origin of magnesite of the sedimentary type has been discussed by Longwell [11] and by Rubey and Callaghan.[12] Longwell has suggested that the magnesite in the Overton magnesite deposit was probably deposited as a sediment in a playa lake. The source of the magnesium is given as hot springs of deep-seated origin at a time of widespread dolomitization in the area.

Rubey and Callaghan have concurred with Longwell on the sedimentary origin of the magnesite in the Overton magnesite deposit. The exceedingly fine grain of the carbonates, the excellent preservation of all details of depositional bedding, the diverse composition of successive thin beds, and the uniform composition of individual beds traced laterally are stated as evidence of a sedimentary origin. In connection with the problem of the origin of sedimentary magnesite, some experimental work was done in the laboratories of the U. S. Gelogical Survey by P. G. Nutting and R. C. Wells on the solubility of magnesite, dolomite, and parasepiolite. Based upon the assumption that waters coming into the

[6] Bradley, W. W., Magnesite in California: California Min. Bur. Bull. 79, p. 49, May 1925.
[7] Rubey, W. W., and Callaghan, Eugene, op. cit., p. 116.
[8] Bradley, W. W., op. cit., pp. 72-75.
Rubey, W. W., and Callaghan, Eugene, op. cit., pp. 117-118.
[9] Rubey, W. W., and Callaghan, Eugene, idem., pp. 119-139.
[10] Rubey, W. W., and Callaghan, Eugene, idem., pp. 140-141.
[11] Longwell, C. R., Geology of the Muddy Mountains, Nevada: U. S. Geological Survey Bull. 798, pp. 82-85, 1928.
[12] Rubey, W. W., and Callaghan, Eugene, op. cit., pp. 134-138.

playa lake at the time of the formation of the Overton magnesite deposit were highly magnesian, it was shown that composition, concentration, and temperature, plus environmental conditions, would govern what phase would be deposited or dissolved at any given time. Thus, either magnesite, dolomite, or parasepiolite could be deposited at one time, and at a later time any phase could be dissolved and removed.

Similarly, at Needles, California, the uniformity of thin laminations, the well-preserved depositional bedding, continuous laterally for hundreds of feet, the persistence of partings of material higher in CaO and SiO_2 content, and concordance with both overlying and underlying sedimentary rocks indicate a sedimentary origin for the magnesite in this area. The magnesite and the associated sedimentary rocks were deposited in an inland lake.

Although the magnesite beds at Needles are of sedimentary origin, the source of the magnesium in the waters flowing into the lake is not definitely known. It is suggested that spring water rising through the andesitic volcanic rocks which underlie the carbonate rocks in the area may have dissolved some of the magnesium from the volcanics. It is probable, however, that a deeper-seated source was responsible for most of the magnesium carried by the water entering the lake.

Estimate of Ore Reserves at the Needles Deposit. The factors which required consideration in estimating the reserves of magnesite at the Needles deposit are the contorted condition of the magnesite beds, the variation in the thickness of the beds from outcrop to outcrop, and the lack of sufficient information on the lateral extent of the magnesite lens, particularly in the northeastern part of the mapped area.

In order to facilitate estimation of the magnesite reserves, the ore-bearing area was divided into eight parts (see pl. 62), each of which was treated as a separate ore body. The final estimates are the summations of the eight separate ore blocks.

Description of the ore-bearing areas.

Area No. 1 This area contains the southernmost magnesite outcrops of any consequence. The sedimentary rocks are folded into a syncline bounded on the west by a normal fault. The magnesite in this area may be overlain by as much as 200 feet of consolidated sedimentary rock and alluvium (pl. 64, section II′).

Area No. 2 The generalized structure of the sedimentary rocks in area No. 2 is a gentle syncline on the west passing over to an anticline on the east and bounded on the eastern edge by a normal fault. The magnesite in this area is overlain by not more than 50 feet of consolidated sediments and alluvium (pl. 64, section GG′).

Area No. 3 In area No. 3 the sedimentary rocks are highly folded, and they are bounded on the west by a fault. The magnesite ore determined in this area is calculated entirely as "inferred" (pl. 64, section HH′).

Area No. 4 In area No. 4 the sedimentary rocks are highly folded. The magnesite outcrops at the east side are cut off on the west by a fault (pl. 64, section II′).

Area No. 5 The rocks in area No. 5 are folded into a gentle anticline and syncline. Area No. 5 contains the largest outcrops of magnesite ore in the deposit. The magnesite in this area is overlain by a maximum of about 100 feet of sedimentary rock and alluvium (pl. 64, section EE′).

Area No. 6 In area No. 6 the sedimentary rocks are folded into a gentle northward-plunging anticline. The magnesite in area No. 6 is estimated as mostly "measured ore" and occurs near the surface (pl. 64, sections BB′ and CC′).

Area No. 7 In area No. 7 the beds of the sedimentary rocks are highly folded. Area No. 7 is a continuation of area No. 6. The magnesite in this area is estimated as "inferred ore," and may have a maximum overburden of 150 feet (pl. 64, sections DD′ to BB′).

Area No. 8 Area No. 8 is the eastward extension of areas No. 5 and No. 7. The sedimentary rocks in area No. 8 are a series of northward-plunging folds. In this area the magnesite is estimated entirely as "inferred ore" (pl. 64, sections FF′ to CC′).

Reserves were computed as "indicated ore" where positive information such as sample pits, diamond drill holes, and outcrops indicate the occurrence of magnesite, and as "inferred ore" where no exploratory information was available, and the assumption of the existence of magnesite was based solely upon the projection of surface geology. In addition, a certain amount of ore reserves were calculated as existing beyond a depth of 50 feet down the dip from all outcrops and sample pits. The estimated reserves in this last category are included under "inferred ore."

The grade of the ore was determined from samples taken and analyzed by the U. S. Geological Survey, augmented by analyses made by the California Chemical Corp. Almost all the samples were taken from the pits excavated by the California Chemical Corp. The analyses from each area were weighted and averaged. The reserves were calculated on the basis of (1) less than 5 percent CaO, (2) more than 5 percent and less than 10 percent CaO, and (3) more than 10 percent CaO.

Table 3. Summary of estimated ore reserves *

Area	Tons of indicated ore			Tons of inferred ore		
	5 percent CaO	5-10 percent CaO	10+ percent CaO	5 percent CaO	5-10 percent CaO	10+ percent CaO
1	2,000	2,000	5,000	10,000	20,000	40,000
2				5,000	5,000	7,000
3	2,000	5,000	7,000			
4	1,000					
5	35,000	45,000	45,000			
6				100,000	120,000	
7	25,000			150,000		
Totals	65,000	52,000	57,000	265,000	145,000	47,000

* Estimates of 117,000 tons of "indicated ore" and 410,000 tons of "inferred ore" are made for the Needles magnesite deposit, based upon a maximum limit of 10 percent CaO.

In attempting to mine the magnesite ore on a commercial basis the variation in thickness of the overburden, the grade of ore and its variation, the lack of water at the mine, and the need for an access road must be taken into account. The variation in thickness of overburden depends mainly upon the geologic structure. The cross sections depict the condition which may be expected at any given point in the Needles magnesite-bearing area. The grade of ore which may be expected and the variation

from place to place are shown in tables 4 and 5. Water probably could be developed somewhere in the vicinity of the deposit. A few moist spots were observed along the Eagle Wash road between the city of Needles and the magnesite deposit. Improvement of the present access roads would solve the transportation problem. Metallurgical treatment of the ore would require some means of controlling dust losses in view of the tendency of the ore to powder readily upon exposure.

Table 4. Chemical analyses. Samples by U. S. Geological Survey.

Number	Area	Insol. 1:3 HCl	R_2O_3	CaO	MgO	$CaCO_3$ (calc.)	$MgCO_3$ (calc.)
N-1	1.	2.66	0.32	0.48	44.22	0.86	92.50
N-2	1.	5.43	0.36	25.46	23.31	45.40	48.81
N-3	1.	2.67	0.20	7.59	39.98	13.52	83.61
N-4	1.	1.66	0.88	26.76	22.52	47.76	47.12
N-5	1.	10.26	0.72	2.06	39.62	3.68	82.86
N-6	1.	11.14	1.58	22.78	21.73	40.66	45.54
N-7	1.	5.54	0.74	27.00	21.62	48.18	45.24
N-8	1.	7.18	0.54	26.08	21.48	46.54	44.94
N-9	1.	6.32	0.80	25.50	21.64	45.52	45.26
N-10	2, 5	1.38	0.40	1.10	46.32	1.96	96.20
N-11	2.	1.34	0.18	0.78	43.84	1.39	91.70
N-12	2.	2.34	0.18	1.00	45.72	1.78	95.70
N-13	2.	5.24	1.90	17.38	28.22	31.02	59.00
N-14	2.	1.34	0.88	7.16	39.41	12.78	82.46
N-15	2.	7.83	0.49	1.22	42.79	2.18	89.50
N-16	2.	3.76	0.12	0.30	45.69	0.54	95.58
N-17	2, 3	3.48	1.04	10.58	36.24	18.88	75.78
N-18	2, 3	5.60	0.76	5.56	39.92	9.92	83.48
N-19	2, 3	6.90	0.98	15.06	28.99	26.88	60.63
N-20	2, 3	10.34	0.92	8.26	34.42	14.74	72.00
N-21	2, 3	0.46	0.48	4.46	43.08	7.96	90.12
N-22	3, 4	2.52	0.53	4.44	42.61	7.92	89.03
N-23	5, 6	2.50	0.33	2.58	44.24	4.60	92.57
N-24	5, 6	7.52	0.79	1.72	42.39	3.07	88.62
N-25	5, 6	7.32	0.42	6.70	38.48	11.96	80.46
N-26	5, 6	2.20	0.32	3.86	42.60	6.89	89.12
N-27	5, 6	7.49	0.19	5.59	39.34	9.98	82.34
N-28	5, 6	1.74	0.44	16.30	32.20	29.09	67.34
N-29	5, 6	0.78	0.24	6.06	41.12	10.82	86.02
N-30	5, 6	7.98	0.70	6.64	37.68	11.85	78.82
N-31	5, 6	7.52	0.68	5.64	39.00	10.07	81.58
N-32	5, 6	6.86	0.88	11.42	32.12	20.38	67.18
N-33	5, 6	3.10	0.50	2.30	42.32	4.10	88.64
N-34	5, 6	4.42	0.62	0.60	44.54	1.07	93.16
N-35	5, 6	8.62	0.80	13.00	31.86	23.20	66.64
N-36	5, 6	10.45	0.38	8.30	35.51	14.80	74.37
N-37	7.	2.56	0.68	1.70	44.44	3.03	92.96
N-38	7.	1.52	0.32	0.86	44.62	1.53	93.34
N-39	7.	4.08	0.36	1.68	43.88	3.00	91.78
N-40	7.	6.04	0.76	8.84	34.42	15.78	71.98
N-41	7.	1.82	0.86	1.78	43.20	3.18	90.36
N-42	7.	11.06	0.98	7.50	32.04	13.39	67.00
N-43	7.	10.46	0.48	6.94	36.68	12.38	76.68

N– 1 Field number 63, channel sample to represent 2 feet, white, rather blocky magnesite, from trench 63. Norman Davidson, analyst.

N– 2 Field number 63b, channel sample to represent 3.2 feet, white blocky dolomite, just below N–1 in trench 63. V. North, analyst.

N– 3 Field number 63c, channel sample to represent 3 feet, white, thin-bedded, impure magnesite, just below N–2 in trench 63. N. North, analyst.

N– 4 Field number 65a, channel sample at top of the face of trench 65 to represent 1.7 feet, thin-bedded, white dolomite. Norman Davidson, analyst.

N– 5 Field number 65b, channel sample at bottom of the face of trench 65 to represent 2.3 feet of rather blocky magnesite. Norman Davidson, analyst.

N– 6 Field number 66, channel sample to represent 3.3 feet of impure dolomite across face of trench 66. Norman Davidson, analyst.

N– 7 Field number 67, channel sample to represent 3.9 feet of blocky dolomite across the face of trench 67. Norman Davidson, analyst.

N– 8 Field number 68f, channel sample to represent 4.5 feet of dolomite across face of trench 68. Norman Davidson, analyst.

N– 9 Field number 68w, channel sample to represent 4 feet of dolomite along wall of trench 68. Norman Davidson, analyst.

N–10 Field number 4a, channel sample to represent 2.5 feet of magnesite in trench 4. Norman Davidson, analyst.

N–11 Field number 9, channel sample to represent 3.5 feet of magnesite in south wall of trench 9; 10 feet from the face. Norman Davidson, analyst.

N–12 Field number 14, channel sample to represent 4 feet of thin-bedded white magnesite in the south wall of trench 14. V. North, analyst.

N–13 Field number 15, channel sample to represent 3.4 feet of magnesitic dolomite across the face of trench 15. Norman Davidson, analyst.

N–14 Field number 16, channel sample to represent 1.2 feet of white unconsolidated dolomitic magnesite in trench 16. Norman Davidson, analyst.

N–15 Field number 31a, channel sample to represent 3.5 feet of magnesite in face of trench 31. V. North, analyst.

N–16 Field number 32, channel sample to represent 2.7 feet of massive magnesite in the north wall of trench 32. V. North, analyst.

N–17 Field number 39, channel sample to represent 2.5 feet of dolomitic magnesite from face to trench 39. Norman Davidson, analyst.

N–18 Field number 40a, channel sample to represent 1.3 feet of thin-bedded magnesite in trench 40. Norman Davidson, analyst.

N–19 Field number 49b, channel sample to represent 0.8 feet of thin-bedded impure magnesite just below sample N–13 in trench 40. Norman Davidson, analyst.

N–20 Field number 40c, channel sample to represent 1.3 feet of clay gouge below sample N–19 in trench 40. Norman Davidson, analyst.

N–21 Field number 45, channel sample to represent 1.9 feet of magnesite in the south wall of trench 45. Norman Davidson, analyst.

N–22 Field number 61, channel sample to represent 1.3 feet of magnesite in south wall of trench 61. V. North, analyst.

N–23 Field number 5a, channel sample to represent 1.7 feet of magnesite in trench 5. V. North, analyst.

N–24 Field number 5b, channel sample to represent 2.8 feet of impure magnesite just below sample N–23 in trench 5. V. North, analyst.

N–25 Field number 6, channel sample to represent 5.1 feet of thin-bedded magnesite and thin shaly partings combined in trench 6. Norman Davidson, analyst.

N–26 Field number 8a, channel sample to represent 1.7 feet of thin-bedded impure magnesite in trench 8. Norman Davidson, analyst.

N–27 Field number 8b, channel sample to represent 3.9 feet of impure magnesite directly below N–26 trench 8. V. North, analyst.

N–28 Field number 11a, channel sample to represent 1 foot of magnesitic dolomite in south wall of trench 11. Norman Davidson, analyst.

N–29 Field number 11b, channel sample to represent 3 feet of impure magnesite on top of sample N–28 in trench 11. Norman Davidson, analyst.

N–30 Field number 21, channel sample to represent 2.5 feet of impure magnesite in trench 21. Norman Davidson, analyst.

N–31 Field number 22, channel sample to represent 1 foot of impure magnesite in trench 22. Norman Davidson, analyst.

N–32 Field number 28a, channel sample to represent 2.3 feet of thin-bedded dolomitic magnesite on hanging wall of small fault in trench 28. Norman Davidson, analyst.

N–33 Field number 28b, channel sample to represent 3.5 feet of magnesite in footwall of small fault in trench 28. Norman Davidson, analyst.

N–34 Field number 29a, channel sample to represent 2.9 feet of thin-bedded magnesite in trench 29. Norman Davidson, analyst.

N–35 Field number 29b, channel sample to represent 2.3 feet of dolomitic magnesite underneath N–34 and separated from it by 1.6 feet of shale and dolomite. Norman Davidson, analyst.

N–36 Field number 34a, b, and c, combined channel sample to represent 3.9 feet of magnesite and shaly partings in trench 34. V. North, analyst.

N–37 Field number 7, channel sample to represent 2.3 feet of magnesite in trench 7. Norman Davidson, analyst.

N–38 Field number 12a, channel sample to represent 2 feet of magnesite below unconformity in trench 12. Norman Davidson, analyst.

N–39 Field number 23a, channel sample to represent 1.7 feet of magnesite in footwall of shear zone in trench 23. Norman Davidson, analyst.

N–40 Field number 23b, channel sample to represent 0.8 foot of magnesite in hanging wall of shear zone in trench 23. Norman Davidson, analyst.

N–41 Field number 25, channel sample to represent 3.0 feet of magnesite in trench 25. Norman Davidson, analyst.

N–42 Field number 35, channel sample to represent 3.4 feet of dolomitic magnesite in trench 35. Norman Davidson, analyst.

N–43 Field number 36a, b, and c, combined channel sample to represent 4.8 feet of dolomitic magnesite in trench 36. V. North, analyst.

Table 5. Chemical analyses of samples from the Needles magnesite deposit. Samples taken and analyzed by Westvaco Chlorine Products Corporation.

Ore samples					
Sample number	CaO	$CaCO_2$	SiO_2	Fe_2O_3	Al_2O_3
3261	1.03	1.84	3.35	.03	.015
3254	.53	.95	1.49	.03	.25
3255	2.68	4.79	1.64	.04	.12
3263	1.56	2.79	1.95	.02	.17
3268	.91	1.63	3.52	.08	.36
3264	4.84	9.53	3.31	.04	.14
3283	2.23	3.98	1.85	.05	.24
3276	1.28	2.29	1.19	.04	.13
3252	.48	.85	.48	.09	.08
3289	7.57	13.52	2.88	.05	.20
3284	.60	1.08	4.35	.04	.16
3226	1.56	2.78	3.45	.03	.07
3202	20.86	37.40	1.68	.03	.25
3203	4.82	8.60	1.20	.04	.16
3207	21.30	38.00	3.54	.05	.37
3208	7.94	14.20	8.88	.05	.43

Sample number	Sample width represented	Sample locality
3261	3 feet	Pit No. 1, area 2
3254	2 feet	Pit No. 3, area 2
3255	3 feet	Pit No. 3, area 2
3263	6 feet	Pit No. 3, area 2
3268	3 feet	Pit No. 7, area 1
3264	6 feet	Pit No. 10, area 2
3283	2 feet	Pit No. 13, area 4
3276	3 feet	Pit No. 24, area 2
3252	Sample from outcrop	Pit No. 26, area 2
3289	1 foot	Pit No. 27, area 2
3284	2 feet	Pit No. 31, area 4
3226	2 feet	Pit No. 39, area 4
3202	5 feet	Pit No. 62, area 3
3203	3 feet	Pit No. 62, area 3
3207	5.5 feet	Pit No. 64, area 3
3208	2 feet	Pit No. 64, area 3

Capitan Deposit

The Capitan deposit consists of six claims held by O. Hendrickson, G. W. Justice, and T. Hayes of Needles, California. When the writer first visited the area in 1943, a small amount of prospecting represented the only work done on this deposit. When the area was revisited in May 1944, an exploratory program was in progress at this deposit. Two large pits had been excavated, in one of which magnesite was exposed.

White, thinly laminated magnesite of sedimentary origin occurs in a series of thin-bedded Tertiary dolomitic limestone. The sediments are strongly folded, but the same types of intricate minor folds and faults so prominent in the magnesite at the Needles deposit were not noticed in the Capitan deposit. The steeply dipping sediments are covered by a thin veneer of alluvium, through which the more resistant dolomitic limestone crops out intermittently. The conformable relationship between the magnesite beds and the associated sediments indicates the sedimentary origin of the magnesite.

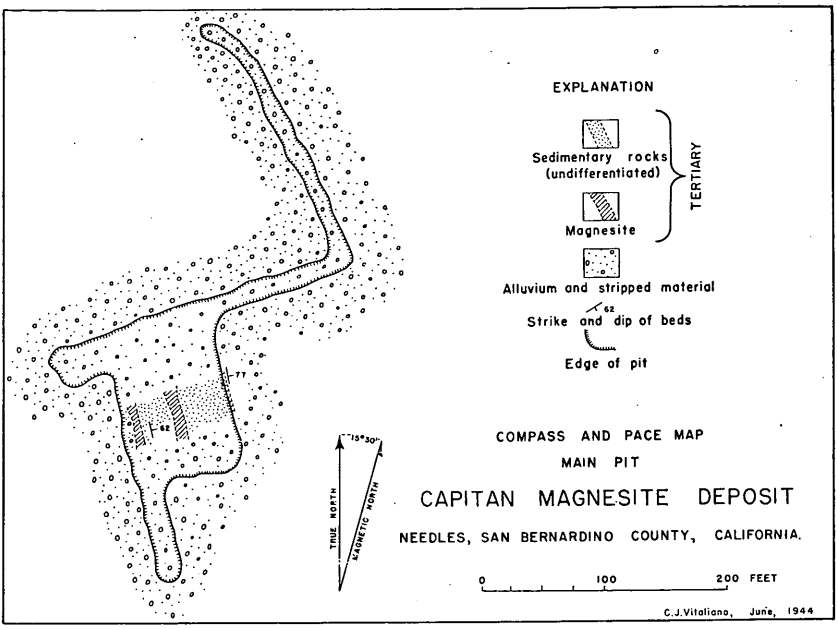


FIGURE 2. Compass and pace map of the main pit, Capitan magnesite deposit, Needles, San Bernardino County, California.

The magnesite is white, fine-grained, rather porous, and of lower specific gravity than the magnesite of the Needles deposit. The ore crops out in two parallel bands, each approximately 8 feet thick and dipping 62° NE. (fig. 2). Whether the two bands are outcrops of two separate beds or of the two limbs of an isoclinal fold is not certain.

No estimate of the magnesite reserves in the Capitan deposit was made because the exploration program was not far enough along at the

Table 6. Chemical analyses of samples from the Capitan magnesite deposit, Needles, California *

Sample number	CaO	MgO	R_2O_3	Insoluble material	Loss
1	1.4	45.1	0.2	4.3	49.1
2	1.1	44.7	0.2	5.1	48.7
3	1.1	46.3	0.3	2.5	49.8
4	2.1	44.3	0.2	4.6	48.8
5	3.8	44.2	0.6	1.6	49.7
6	2.5	45.3	0.3	2.5	49.9
7	3.1	44.1	0.76	3.9	48.1

* Samples 1-7. Analyses of picked samples from widely scattered places in deposit. Samples taken by Basic Magnesium, Inc., Las Vegas, Nevada. Analyst, Basic Magnesium, Inc., Las Vegas, Nevada.

time of the last examination to provide sufficient data. Chemical analyses of selected samples (table 6) show a low content of CaO and moderate amounts of insoluble material.

Mining operations at the Capitan deposit would be confronted with the same problems as at the Needles deposit. Transportation, however, would not be so difficult, as the property is considerably more accessible.

NORTHERN CALIFORNIA AS A MARKET FOR CHEMICALS *

E. WILLIAM EIPPER, EDITOR **

OUTLINE OF REPORT

	Page
Introduction	373
Plastics and resins	373
Surface coatings	374
Processing of natural oils	378
Petroleum refining	378
Agriculture	379
Rubber	381
Pharmaceutical manufacturing and processing	382
Explosives	382
Industrial cleaning	383
Food processing	384
Summary	384

INTRODUCTION

Northern California, particularly the nine counties comprising the "Bay Area," has witnessed a remarkable growth in the chemical and chemical consuming industries. Central location for serving the western market along with excellent availability of rail, water, motor and air transportation, manpower, public utilities, industrial sites, and natural resources have encouraged industrial expansion of all types. To be more specific the investment in new plants and in plant expansions in the area has amounted to almost $400,000,000 during the first four post-war years. An appreciable increase in chemical and petrochemical activity in the area has taken place and has contributed to this impressive total. Industrial expansion of this magnitude in the chemical manufacturing and chemical consuming industries has materially increased the market for chemicals.

The information which we will present is incomplete but affords a preview of northern California as a market for chemicals. Though a wide variety of chemical consuming industries are located in the area, it has been possible to estimate satisfactorily the chemical consumption of only a limited number. These we will consider individually.

PLASTICS AND RESINS

Plastics manufacture, that is the production of the chemical monomer or polymer, is almost non-existent in the area. There is, however,

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** Oronite Chemical Co.

The editor wishes to acknowledge the assistance of the following co-authors: Kenneth Bayha, Commercial Solvents Corporation; Raymond H. Ewell, Stanford Research Institute; William E. Hosken, Stanford Research Institute; Herman J. Jordan, E. I. du Pont de Nemours & Co., Inc.; Richard F. Schlecht, Standard Oil Co. of California; and Charles D. Thurmond, Monsanto Chemical Company.

a modest sized molding industry which we estimate consumes the following quantities of molding compounds:

Molding compound	Pounds per year
Polystyrene	400,000
Cellulose acetate (and acetate-butyrate)	400,000
Thermosetting resins (mostly phenol-formaldehyde)	900,000

Likewise, there is a reasonable consumption of liquid laminating resins, estimated to be about 1,250,000 pounds a year of product containing 70 percent solids.

The production of resins is a larger field. There is an installed alkyd resin kettle capacity totalling over 35,000 gallons, 60 percent attributable to one resin producer and the remainder to about nine paint manufacturers.

The production of phenolic resins has leaped ahead due to a new local requirement for a phenolic bonding resin. Oil soluble varnish resins are also produced and there is one manufacturer of ion-exchange resins.

Total consumption of the principal chemicals used in resin production in Northern California is estimated:

Resin production	Pounds per year
Phthalic anhydride	5,000,000
Maleic anhydride	500,000
Other acids	100,000
Glycerine	2,225,000
Pentaerythritol	750,000
Ethylene glycol	200,000
Oils and fatty acids	12,000,000
Phenol	1,750,000
Formaldehyde	1,850,000
Solvents	15,000,000

Other chemicals are used in minor quantities.

SURFACE COATINGS

Drawing from a wide variety of government and other publications, and making certain assumptions, we have developed a series of estimates which we will present in very condensed form.

Based upon the value of finished products in 1947 and the 1948 index of production it is estimated that the surface coatings industry in California represents approximately 10 percent of the national industry. This represents commercial production only and does not include the considerable production by the U. S. Navy at the Mare Island Navy Yard. All of our data are based on the Census of Manufactures. It does not include data collected from government facilities.

The northern California production is less than half the total for the state, but would probably exceed this level if the production by the Mare Island Navy Yard were included. Though the pattern of chemical

consumption by the paint industry in California is reasonably identical to the national pattern, there is some deviation within the state. We will therefore enlarge all our estimates to include the industry on a state-wide basis, but excluding the Navy production.

Those interested in estimating the requirements of either the northern California or southern California industry may respectively take 40 percent and 60 percent of our figures as reasonable approximations. Likewise, a rough estimate of the west coast requirements outside of California could be obtained by taking about 15 percent of our figures.

To begin with it is estimated that the finished products of the California surface coatings industry amounted to over $120,000,000 in 1948.

Finished products	Gallons per year
Oil pigment paints [1]	18,650,000
Varnishes	9,500,000
Nitrocellulose lacquers	7,650,000
All other lacquers	1,550,000
Enamels	9,000,000
Bituminous paints	1,800,000
Water thinned paints	1,650,000
Stains	900,000
Spirit varnishes	700,000
Metallic paints	600,000
Total	52,000,000

[1] Includes miscellaneous paints not included in other categories.

The raw materials are divided into five general classifications, some of which are further subdivided. Let us examine and discuss tables 1 to 5 inclusive.

In the field of white pigments (table 1) it is of interest that titanium dioxide has now reached about 50 percent of the total. The estimate may be low on this item.

Colored pigments (table 1) were more difficult to estimate, particularly the organic lakes and toners, chrome colors, and the mineral earth colors. The latter appear to represent approximately 50 percent of the total colored pigments.

The extender pigments (table 1), commonly used in the lower cost whites and calcimines, amount to more than we anticipated.

In the field of drying oils (table 2) linseed oil is still the large volume item with consumption running about three times that of either soybean oil or tung oil. Dehydrated castor oil appears to be gaining favor.

In the field of resins (table 3) alkyds are dominant. Our figure includes all types of alkyds and modified alkyds.

"Other synthetic resins" includes vinyl resins, polystyrene, acrylic esters, silicones, rubber derivatives, coumarone-indene resins, and other products.

Rosin is the principal natural resin used; as indicated our figure does not include the quantity used to make esters and adducts. The consumption of the other natural resins is difficult to estimate.

We have made our estimates on solvents (table 4) in gallons instead of in pounds as in the other tables. Petroleum solvents represent over two-thirds of all solvents used without inclusion of toluene and xylene

which could also be from petroleum sources. We have included both low and high boiling alcohols in one figure though the ethanol and propanol probably represent over two-thirds of the total. The biggest items in the ester and ketone group are ethyl acetate, n-butyl acetate, methylethyl ketone and methylisobutyl ketone, though others are used in smaller quantities.

Among the miscellaneous materials (table 5) we have included chemical plasticizers. This figure is probably largely the phthalate esters and tricresyl phosphate.

Table 1. Estimated raw material consumption, California surface coatings industry, 1948.

Pigments	Pounds per year
White Hiding Pigments	
White lead	8,200,000
Lithopone	20,900,000
Zinc oxide	5,400,000
Leaded zinc oxide	13,000,000
Titanium dioxide	46,500,000
Total	94,000,000
Colored Hiding Pigments	
Organic lakes and toners	1,600,000
Chrome colors	3,600,000
Inorganic blues	800,000
Red lead	2,200,000
Litharge	900,000
Mineral earth colors	11,700,000
Carbon and lampblack	1,200,000
Metal powders	1,000,000
Total	23,000,000
Extender Pigments	
Talc	21,900,000
Whiting	11,100,000
Silica	6,000,000
Barite	6,000,000
Clay	4,700,000
Mica	2,800,000
Other extenders	1,500,000
Total	54,000,000
Total pigments	171,000,000

Table 2. Estimated raw material consumption, California surface coatings industry, 1948.

Drying oils	Pounds per year
Linseed oil	31,300,000
Soybean oil	10,000,000
Tung oil	9,200,000
Dehydrated castor oil	3,800,000
Other oils [1]	4,700,000
Total	59,000,000

[1] Includes non-dehydrated castor oil.

Table 3. Estimated raw material consumption, California surface coatings industry, 1948.

Resins	Pounds per year
Synthetic Resins	
Alkyd resins	28,000,000
Phenolic resins	5,700,000
Urea and melamine resins	2,400,000
Rosin esters	6,300,000
Rosin adducts	500,000
Nitrocellulose	3,800,000
Other cellulose derivatives	300,000
Other synthetic resins	3,000,000
Total	50,000,000
Natural Resins	
Rosin [1]	6,700,000
Shellac	2,200,000
Copal, damar, and other fossil resins	1,500,000
Casein and other proteins	1,600,000
Total	12,000,000
Total resins	62,000,000

[1] Does not include rosin to make rosin esters and rosin adducts.

Table 4. Estimated raw material consumption, California surface coatings industry, 1948.

Solvents	Gallons per year
Petroleum solvents	21,000,000
Toluene, xylene and coal tar naphthas	2,700,000
Turpentine	1,700,000
Alcohols	1,900,000
Esters, ketones, and alcohol-ethers	2,700,000
Total	30,000,000

Table 5. Estimated raw material consumption, California surface coatings industry, 1948.

Miscellaneous	Pounds per year
Chemical plasticizers [1]	1,000,000
Driers [2]	3,000,000
Asphalt and pitch	10,000,000
Total	14,000,000

[1] Includes phthalate and phosphate esters, does not include castor oil.
[2] Naphthenates, linoleates, tallates, resinates, oleates, etc.

Driers are used in all types of coatings which use drying oils. They are the metallic salts (for example, cobalt, lead, manganese) of various acids and include the naphthenates, linoleates, tallates, oleates, resinates, 2-ethylhexoates and others.

PROCESSING OF NATURAL OILS

The conditioning of vegetable, animal, and fish oils for use in edible products, and in the production of surface coatings is a sizable field. It is interesting to note that the utilization of natural oils (on a national basis) is distributed about 70 percent for edible use, 20 percent for soap, and only 10 percent for the production of coatings and resins, though chemicals find their largest application in the upgrading of oils for the latter use.

Though quantitative information for this area is unavailable, some of the principal chemicals used include:

Salt	Hydrogen
Sulfuric acid	Catalysts
Caustic soda	Maleic anhydride
Lime	Pentaerythritol
Soda ash	Styrene
	Dicyclopentadiene

PETROLEUM REFINING

The northern California petroleum refining industry consists of the local installations of the four major companies. These companies use somewhat different refining processes and a chemical which is a large volume item at one refinery may not be procured at all by the other three. The complete list of chemicals purchased may include several hundred items, yet as pointed out by E. H. Weaver,[1] about 40 items represent approximately 85 percent of the chemical expense. He published the first ten chemicals based upon dollar value; we have developed a similar list but have taken the chemicals used in the greatest tonnage in northern California. Our list includes most of Weaver's ten products; we have added tetraethyl lead compound and litharge.

Estimated consumption of chemicals in northern California petroleum refining industry—ten largest volume products

	Pounds per year
Sulfuric acid	280,000,000
Caustic soda	60,000,000
Tetraethyl lead compound	16,000,000
Tallow and fatty acids	6,500,000
Catalysts	6,000,000
Ammonia	4,000,000
Phenol	3,200,000
Methylethyl ketone	2,500,000
Sulfur dioxide	2,000,000
Litharge	2,000,000

[1] Weaver, E. H., The western petroleum industry as a consumer of chemicals: Paper presented before Western Chem. Market Research Group, Pacific Chem. Exposition, San Francisco, October 21, 1947.

The industry procures several million pounds of crude bulk salt per year, but it is believed that this is not for direct process use and was, therefore, not included in our table.

A word regarding the relationship of the industry in northern California to the statewide industry and the national total may be of interest. The refining in California comprises about one-sixth of the national total and northern California has about one-third of the state's total or a little over 5 percent of the national total. This can be based on total potential crude oil consumption or cracking capacity, as shown:

	Northern California	California	U.S.
Crude oil charge capacity, B/D	330,800	1,047,800	6,515,500
, % U.S.	5.1	16.1	
, % Calif.	31.6		
Cracking capacity, B/D [1]	[2] 209,600	518,150	3,752,400
, % U.S.	5.6	15.4	
, % Calif.	36.3		
Employment (Prod. and related works—Dec. 1948)	5,100	12,400	113,300
% U.S.	4.5	10.9	
% Calif.	41.1		

[1] Thermal cracking, catalytic cracking, and reforming.

[2] Includes 42,000 B/D crude oil feed to thermal cracking and coking processes.

AGRICULTURE

California agriculturists are unusually progressive in their scientific approach to crop production. This is attributable to factors such as crop specialization and the necessity for producing a high quality product to compete in the eastern market.

Chemical manufacturers, government laboratories, and agriculturists cooperate in the continuing evaluation of both new and old chemicals in terms of the need to be filled and the potential economic realization. This method seems to be very satisfactory. Cash farm income in 1948 was approximately $2,000,000,000 derived from over two hundred types of crops.

Chemicals played an important part in the production of this wealth as evidenced by these expenditures for California (estimated by the State Bureau of Chemistry):

Commercial fertilizers	$42,000,000
Economic poisons	20,000,000
Agricultural minerals	6,000,000
Auxiliary plant chemicals	2,000,000
Total	$70,000,000

Fertilizer consumption has increased markedly with a 1948 California consumption of approximately 550,000 tons compared to the

1937-41 prewar average of about 230,000 tons per year. The pattern of use may be of interest and the reported segregated tonnage is shown in table 6.

Table 6. California consumption of commercial fertilizers, segregated commercial fertilizer tonnage, 1948.

Material	Tons	Material	Tons
Mixed fertilizers	207,209	Potassium sulfate	3,200
Superphosphate, normal	70,590	Urea	1,447
Ammonium sulfate	69,827	Bone meal	1,168
Ammonium nitrate	41,078	Blood meal	922
Ammonium phosphate-sulfate	31,602	Tankage	735
Superphosphate, treble	17,092	Fish meal	557
Sodium nitrate	11,983	Seed meals	447
Nitrogen solutions	11,977	Ammoniated superphosphate	410
Mixed fertilizers, liquid	10,732	Ammonium phosphate-nitrate	200
Calcium cyanamid	8,289	Miscellaneous	3,599
Calcium nitrate	8,152	Not segregated by registrant	26,559
Sewage sludge, activated	7,220	Correction by audit	1,170
Ammonium phosphate	6,011		
Potassium chloride	3,335	Total	548,744
Liquid phosphoric acid	3,233		

Agricultural mineral sales for 1948 in California reached almost 500,000 tons about 70 percent of which was gypsum used as a soil conditioner. The segregated tonnage is shown in table 7.

Table 7. California sales of agricultural minerals, segregated agricultural minerals tonnage, 1948.

Material	Tons	Material	Tons
Gypsum	349,979	Hydrated lime	1,130
Sewage sludge	28,920	Phosphate rock	364
Soil sulphur	20,304	Miscellaneous *	20,759
Limestone and shells	12,697	Not segregated by registrant	1,243
By-product lime	10,927	Correction by audit	587
Mixed goods	3,581		
Metallic salts	1,392	Total	451,883

* Includes lime sulfur solution 3,728 tons, sulfur dioxide 708 tons, sulfuric acid 10,593 tons.

The field of economic poisons has been marked by a high rate of obsolescence and a rapid and widespread acceptance of the variety of newly developed organic pesticides. These products have had some acceptance problems, many of which can be attributed to improper utilization. The arsenicals declined with the advent of the organics. Products which were in the experimental stages in 1948, but are now expanding, include lindane (99 percent gamma isomer of hexachlorocyclohexane) and parathion. In the field of herbicides much remains to be accomplished in developing better means of controlled application and in straightening out the liability problems encountered.

Table 8. Estimated pesticide consumption in northern California, 1948.

Material *	Pounds
Pyrethrum (all forms)	25,000
Rotenone	50,000
Nicotine (base or sulfate)	50,000
Lead arsenate	750,000
Calcium arsenate	250,000
Sulfur	20,000,000
Lime sulfur	500,000 (gallons)
Fluorine compounds	200,000
DDT, tech	1,000,000
DDD	200,000
Hexachlorocyclohexane, 12 percent gamma isomer	250,000
Hexachlorocyclohexane, 99 percent (lindane)	Experimental
Chlordane	50,000
Toxaphene	50,000
TEPP	100,000
Parathion (thiophos)	Experimental
Spray oils	2,500,000 (gallons)
Copper compounds	1,000,000
Mercury compounds	10,000
Ethylene dibromide	250,000
Dichloropropane-dichloropropene mixture	150,000
2,4-D	50,000
Trichloro-acetic acid	----------
Other herbicides	----------

* All quantities are for concentrated form except where indicated.

RUBBER

Though the western rubber industry is usually thought of as concentrated largely in southern California, there are a few medium sized manufacturers in the San Francisco Bay area. We have an aggressive tire manufacturer, one of the largest producers of camelback, a tile manufacturer, and at least seven manufacturers of mechanical rubber goods. Raw material requirements are impressive and are estimated to include:

Raw materials	Pounds per year
Rubber	
GR-S	8,500,000
Natural	6,500,000
Latex	150,000
Neoprene (and other synthetics)	750,000
Accelerators	
(All types)	160,000
Antioxidants	
(All types)	110,000
Plasticizers, Softeners, and Tackifiers	
Process oils	750,000
All others	50,000
Miscellaneous	
Sulfur	400,000
Carbon black	6,000,000
Zinc oxide	750,000
Stearic acid	180,000

PHARMACEUTICAL MANUFACTURING AND PROCESSING

The chemical requirements of the pharmaceutical manufacturing and processing industry are characteristically diverse. The wide variety of small volume end-products gives a raw material list more impressive for length than for tonnage. We have attempted to divide a partial list of the chemicals consumed into three categories:

Over 100,000 pounds per year	25,000-100,000 pounds per year	Under 25,000 pounds per year
Phosphoric acid	Phenylacetic acid	Butanol
Caustic soda	Acetone	Octadecanol
Dextrose	Ethylene glycol	Mono-potassium phosphate
Lactose	Misc. natural oils	Sodium acetate
Sucrose	Calcium carbonate	Sodium sulfate
Amyl acetate (mixed)	Sodium chloride	Procaine hydrochloride
Lard oil	Mono-sodium phosphate	Glycerine
Filter aids	Diphenylamine	Many others
Ethanol	Formaldehyde	

EXPLOSIVES

The total dynamite production in northern California is about 50,000,000 pounds a year or roughly 40 percent of the total produced on the west coast.

There are in the area two large producers of nitroglycerine base dynamite and one large manufacturer of dynamite based on nitrostarch. One of the former companies produces black-powder and also operates chemical plants for the production of ammonia, nitric acid, and ammonium nitrate. The nitric acid and ammonium nitrate facilities are adequate to take care of the mixed acid and ammonium nitrate requirements of all three plants. Spent acid (sulfuric) is returned to the manufacturer for fortification or sold to the fertilizer manufacturing industry. For simplicity we will consider the industry on the basis of chemicals consumed rather than chemicals purchased. The black-powder raw material requirements are omitted. Estimated total chemical consumption in production of dynamite is as follows:

Chemical consumption in production of dynamite	Pounds per year
Glycerine	2,500,000
Ethylene glycol	2,000,000
Cornstarch	3,250,000
Mixed acid	25,000,000
Ammonium nitrate	16,000,000
Sodium nitrate	15,000,000
Dinitrotoluene (oil)	650,000
Nitrocellulose	200,000
Zinc oxide	30,000
Aluminum (powder)	300,000
Aqua ammonia (20 percent)	1,100,000
Fillers:	
Diatomaceous earth	Almond shell meal
Sawdust	Wood flour
Apricot pit meal	Potato starch
Corncob meal	

INDUSTRIAL CLEANING

The industrial cleaning field as a whole comprises a market of considerable magnitude. We will briefly discuss several subdivisions in this group but do not have coverage of the entire industry.

Airline Operation and Maintenance. The location of the United Air Lines maintenance base at South San Francisco is the principal contributing factor in the total chemical requirements for this industry. Since many of the products used are compounded materials, a specific breakdown on a poundage basis is difficult. On a dollar basis the total requirements are over $100,000 a year, from which we have estimated the following breakdown:

Chemicals used in airline operation and maintenance	Pounds per year
Solvents	600,000
Chemical cleaners	250,000
Isopropanol	250,000
Methanol	125,000
Specialty products and proprietary items	25,000

Industrial Degreasing. It is estimated that industrial degreasing operations in northern California consume approximately 2,500,000 pounds of trichloroethylene and 150,000 pounds of perchloroethylene annually.

Dry Cleaning. In the dry cleaning industry a variety of specialty products are used along with a relatively large volume of petroleum solvents. We have attempted to estimate only the chemical solvents and suggest that the annual northern California consumption amounts to approximately 3,000,000 pounds of perchloroethylene and 1,750,000 pounds of carbon tetrachloride.

Commercial Laundries. The commercial laundries in northern California do an annual business of over $30,000,000 per year. Purchases of wash-room chemicals run about $1,200,000 annually. The specific requirements are estimated to include:

Chemicals used by commercial laundries	Pounds per year
Soap (and synthetics)	3,500,000
Alkaline builders	7,500,000
Bleach (20 percent)	300,000 *
Blueing (dry basis)	2,000
Sour	550,000
Starch	----------

* Gallons.

The use of synthetic detergents, particularly in compounds with builders, in commercial laundry operation is on the increase, but at the present time represents only a small portion of the total. The ratio of alkaline products to soap used has also increased materially from pre-war

practice. Caustic soda is the principal alkali used with silicates, causticized silicates are second, and soda ash is third in importance. Bluing is difficult to estimate due to the tremendous difference in the amount required of the various types. Our figure has been converted to the concentrated "Zanzibar Blue" type.

FOOD PROCESSING

The food processing industry is large in the northern California industrial picture. A fairly large volume of chemicals is utilized and the list is certainly diverse. Some statistics have been available on a national basis and a paper on the subject *Chemicals in the Food Industry* was prepared by Dr. T. L. Swenson in 1947.[2]

The food industry is one industry where national statistics do not give good indications of regional usages. Stanford Research Institute made a study of chemicals used in food processing and developed a list of over 1,400 items. They concluded that information regarding the quantities utilized in any given area could be obtained only by a comprehensive survey.

To give an idea of the volumes involved—it is estimated that per year in northern California, food processing consumes 13,000,000 pounds of salt, 4,000,000 pounds of sulfur, and 3,000,000 pounds of caustic soda. The wide use of food supplements and vitamins, flavoring and preserving agents, and stabilizers leads to high dollar volume and an attractive market.

SUMMARY

Since the report is not comprehensive and does not cover such major items as general inorganic and organic chemical manufacturing, it cannot sum up a meaningful regional total for any specific chemical. Also, it should be noted that a very limited number of items are consumed by more than one or two industries. The items of general consumption include the heavy chemicals—salt, caustic soda, chlorine, sulfuric acid —and a few organic chemicals.

As an example glycerine in northern California totals almost 5,000,000 pounds a year in the resins and explosives industries, glycol about 2,200,000 in the same fields, phenol amounts to approximately 5,000,000 pounds a year if resins and petroleum refining are totaled. Going back to the heavy chemicals, it is safe to say that yearly caustic soda consumption in northern California probably totals over 100,000,000 pounds and sulfuric acid over 300,000,000 pounds. These totals are still not all inclusive and are probably exceptions; however, they do serve as aids in assessing the magnitude of the area's chemical requirements.

[2] Presented at the conference on Western Chemical Markets before the Western Chemical Market Research Group at the Pacific Chemical Exposition, October 21, 1947.

SKAGGS SPRINGS QUICKSILVER MINE, SONOMA COUNTY, CALIFORNIA *

By Donald L. Everhart **

OUTLINE OF REPORT

	Page
Abstract	385
Introduction	386
Location	386
History, ownership, and production	387
Field work and acknowledgments	387
General geology	387
Skaggs Springs quicksilver mine	389
Workings	389
Geology of the mine	389
Mineralization	389
Structural control	390
Summary	392
Grade of ore	392
Suggestions for further development	392

Illustrations

Figure 1.	Index map of part of central California, showing the location of Skaggs Springs	386
2.	Index map of California quicksilver mining districts and mines on which reports have been published by the United States Geological Survey and the Division of Mines. These reports are the results of geological work by the United States Geological Survey in World War II strategic minerals investigations	393
Plate 66.	Geologic sketch map of the vicinity of Skaggs Springs quicksilver mine, Sonoma County, California	In pocket
67.	Composite map of underground workings, Skaggs Springs quicksilver mine, Sonoma County, California	In pocket
68.	Geologic maps of the underground levels of Skaggs Springs quicksilver mine, Sonoma County, California	In pocket
69.	Vertical sections through Skaggs Springs quicksilver mine, Sonoma County, California	In pocket

ABSTRACT

The Skaggs Springs quicksilver mine is 33 miles from the Pacific Ocean in Sonoma County, California. It is accessible by 15 miles of paved road from the town of Healdsburg, which lies to the southeast. In the period between the discovery of the ore deposits in 1928 and the closing of the mine in 1944, 330 flasks of quicksilver were produced, with the peak of production in 1941 and 1942.

The mine workings, totaling 1,825 feet in length, lie within a block of interbedded sandstone and shale of Cretaceous (?) age that is bounded by two northwest-trending faults separating it from rocks of the Franciscan group of Upper Jurassic (?) age. These older rocks include sandstone and a little shale, greenstone, and mica, chlorite, and amphibole schists.

Several hot springs occur in the younger sedimentary rocks along faults that appear to have formed part of the structural control for the quicksilver deposit.

Metacinnabar, associated with the yellow crystalline hydrocarbon, curtisite, is finely disseminated through the Cretaceous (?) sandstone, and is the chief ore mineral of the deposit. Less commonly, the sandstone is impregnated with small cinnabar grains.

* Published by permission of the Director, U. S. Geological Survey.
** Geologist, U. S. Department of the Interior, Geological Survey.

The ore minerals are concentrated in a massive sandstone bed beneath a hanging-wall contact with conformably interbedded, fine-grained, relatively impervious shale and sandstone. Northwest-striking, southwest-dipping faults cut the sandstone and shale beds and are in turn cut or offset by later east-striking, gently north-dipping fractures and faults that cause local flattening of the hanging wall. These two fault groups and the impervious shale capping constitute the main structural control of the ore shoots.

The ore mined thus far at Skaggs Springs has yielded an average of about 3 pounds of quicksilver per ton, but the grade of ore must be materially increased by more selective mining if production is to be carried on at a profit, even with high prices.

INTRODUCTION

Location

The Skaggs Springs quicksilver mine, also known as the Star Springs mine, is in the California Coast Range in the north-central part of Sonoma County (fig. 1). The property includes parts of secs. 23, 24, and 26, T. 10 N., R. 11 W., M. D., the mine itself is at an altitude of about 400 feet above sea level in a small valley about a quarter of a mile south of the Skaggs Springs hotel and resort (pl. 66). The hotel is 33

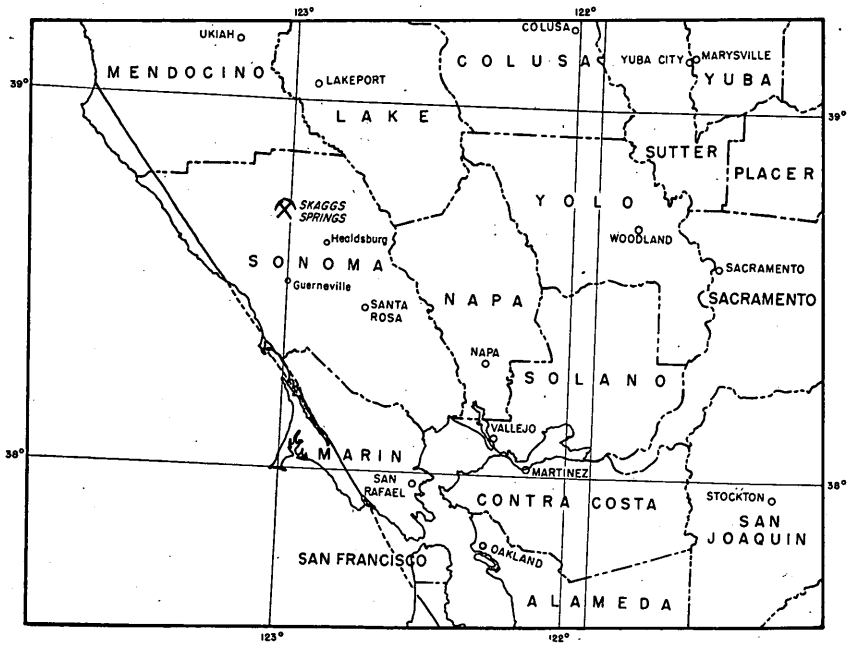

FIGURE 1. Index map of part of central California, showing the location of Skaggs Springs.

miles from the coast, and good paved roads lead from it to the towns of Cloverdale, 12 miles to the north, and Healdsburg, 15 miles to the southeast.

The topography around Skaggs Springs is moderately rugged with relief of about 1,700 feet. The mountains are heavily timbered with conifers and oaks, and the valleys, such as those in which the hotel and the mine are located, are open meadowlands.

History, Ownership, and Production

The quicksilver deposits at Skaggs Springs were discovered, somewhat by accident, in 1928.[1] According to Ransome and Kellogg [2] "Quicksilver ore was first noted as occurring in commercial quantities on this property in 1925." Mr. Curtis collected specimens of an unfamiliar yellow mineral from fractures in the sandstone outcrops along the creek near the resort, and sent them to the Carnegie Institution of Washington for identification. The Institution reported the yellow crystals to be a new hydrocarbon mineral, subsequently named curtisite for the discoverer, and also reported that the specimens contained a considerable amount of metacinnabar.

The sandstone containing the finely disseminated matacinnabar and curtisite was mined throughout the next 10 years, and during a 90-day period in 1934 Mr. Curtis recovered 42 flasks of quicksilver with the use of a small retort. During the late 1930's, under the supervision of the late Charles Cavagnero, ore from part of the upper workings of the present mine was extracted and yielded nine flasks of quicksilver. The mining operations were taken over in October 1940 by Star Springs Mercury, Inc., of Hollywood. This company expanded the workings of the mine to the extent mapped in this investigation, and produced about 250 flasks. A reduction plant with a daily capacity of 20 tons was erected in June 1941, and production from it began in September 1941 and continued until September 1942 when Star Springs Mercury, Inc., was liquidated.

The mining property was leased in January 1943 by Mr. Edward J. Bumstead of Skaggs Springs, who began operations early in February 1943. An extensive program of sampling and assaying was undertaken as a guide to further development, and as a result an additional 30 flasks of quicksilver was produced before the mine was closed in 1944.

The total production of the mine has been approximately 330 flasks.

Field Work and Acknowledgments

Mr. W. Bradley Myers and the writer, of the U. S. Geological Survey, spent 4 days during July 1942 mapping the underground workings of the mine on a scale of 1 inch to 10 feet. In February 1943, the writer spent 2 days in similar underground mapping and 2 days in plotting the surface geology of the mine area on an aerial photograph at an approximate scale of 1:20,000. During this investigation, hearty cooperation was given to Mr. Myers and the writer by Mr. Tracey Pierce, mine foreman, and by Mr. Leo Curtis and Mr. E. J. Bumstead of Skaggs Springs.

This study was made as a part of the U. S. Geological Survey's wartime investigation of strategic-mineral deposits. The problems of mineralization and associated hot springs activity should receive much more study before the ore deposits at Skaggs Springs can be fully understood.

GENERAL GEOLOGY

In the Skaggs Springs area the most important geologic feature is a block of sandstones and shales, tentatively considered to be Lower

[1] Oral communication from Mr. Leo Curtis, proprietor of the hotel and owner of the property.

[2] Ransome, A. L., and Kellogg, J. L., Quicksilver resources of California: California Jour. Mines and Geology, vol. 35, no. 4, p. 469, October 1939.

Cretaceous in age, which has been down-faulted into rocks of the Franciscan group of Upper Jurassic (?) age (pl. 66). The quicksilver mine itself is entirely within the younger sandstone and shale. These rocks are cut by numerous fractures along some of which there has been small displacement. The fractures have acted as important controls in the emplacement of the ore bodies. Much of the area underlain by rocks of the Franciscan group immediately west of the mine is covered by a large landslide, and the Cretaceous (?) sedimentary rocks in the vicinity of Skaggs Springs are covered extensively by alluvium.

The rocks of the Franciscan group, which border the Cretaceous (?) rocks on two sides in the vicinity of the mine, are mostly massive, medium- to coarse-grained arkosic sandstone. This sandstone is altered and is greenish-brown. The alteration, lack of regular bedding, and massive character of the sandstone in the Franciscan group distinguish it from the Cretaceous (?) sandstone. Small bodies of massive chert and of greenstone, and lenses of mica, chlorite, and amphibolite schist have been mapped in the Franciscan group. Serpentine, found in many Coast Range quicksilver districts, was not observed in place within the mapped area, although a few pieces of serpentine float were found in the landslide west of the mine.

The Cretaceous (?) rocks can be divided into at least three units in the immediate vicinity of the mine. The uppermost and lowermost are lithologically similar, and consist of interbedded, fine-grained, light-gray sandstone and very fine-grained dark-gray shale in beds as much as 4 inches in thickness. The middle unit consists of medium-grained, light-gray, massive sandstone beds. At least 80 percent of the sandstone is rounded and frosted quartz grains; oligoclase grains, which are rather thoroughly sericitized, make up 10 to 15 percent of the rock. In the immediate vicinity of the mine, the quartz and feldspar grains are cemented by opal.

The beds of Cretaceous (?) sedimentary rocks have a general strike of N. 65°-75° E. They dip 50°-70° SE. in the lower mine levels, but in the upper levels are considerably flatter. Northwest of the mine, near the western boundary fault of the Cretaceous (?) rocks, the strikes are more westward, turning in a few places to a slightly northwest direction. Across the valley to the east, the beds strike northeast and dip 40°-50° SE.

Faults that bound the area underlain by the Cretaceous (?) sedimentary rocks enclose a block 950 to 1,600 feet wide, which trends northwestward. The southwest boundary appears to be a straight-line fault contact with the massive, moderately altered sandstone of the Franciscan group. The fault, which is covered by the above-mentioned landslide for a distance of at least 1,000 feet just southwest of the mine, strikes N. 35° W. The northeast boundary of the Cretaceous (?) band of rocks is a nearly parallel but curving fault that strikes N. 25°-65° W. To the northwest the strike becomes more northward.

Although no fossils have been found in the younger sediments of this band, Stalder [3] has correlated these rocks with his Walker Ridge sandstone and shale of the Rainbow series, which he tentatively has designated as post Franciscan and older than upper Miocene [4] in age. This

[3] Stalder, Walter, Preliminary reconnaissance report on the oil possibilities in the vicinity of Skaggs Springs, Sonoma County, California: Unpublished private report, p. 2, November 1922, San Francisco, California.

[4] Stalder, Walter, Humboldt County: California Min. Bur. Bull. 69, p. 449, 1914.

correlation was made solely on general lithologic characteristics, but in this report the age determination is assumed to be correct.

The large landslide covers much of the northeast slope of the high ridge to the west of the mine. Typical hummocky topography characterizes the slope, none of the rocks appear to be in place, and the relatively sparse timber may indicate that the mass beneath was moving in 1943. Two cliffs, about 40 feet and 70 feet high, along the southwest side of the fault west of the mine, may be part of a poorly defined fault scarp. The oversteepening of the slope by continued upthrow of the southwest side of the fault may have caused the landslide.

SKAGGS SPRINGS QUICKSILVER MINE

Workings

The Skaggs Springs quicksilver mine, with 1,825 feet of workings, has five levels and three main raise stopes, and extends to a depth of 135 feet below the collar of the inclined shaft (pl. 67). The main entry to the mine is a shaft inclined at a slope of 38°. This shaft develops the mine to a vertical depth of 100 feet. Levels have been driven from the shaft at depths of 16, 50, 73, and 100 feet (pl. 68). A winze from the 100-foot level connects with the 135-foot level. Raise stopes have been mined from the 50-foot level to the 16-foot level, from the 100-foot level to the 50-foot level, and from the 135-foot level to the 100-foot level (pl. 68). These raise stopes are larger than ordinary raises in most mining districts but are smaller than most stopes. They do not exceed 20 feet in height or width, and the stope lengths are 75, 180, and 45 feet respectively, between the three lower levels. In general the raise stope outlines are irregular, although the shapes are roughly pipelike.

A bulldozed prospect pit, about 40 feet in diameter and 10 feet in maximum depth, explores mineralized sandstone about 300 feet northwest of the collar of the inclined shaft.

Geology of the Mine

A massive ore-bearing sandstone 50 to 60 feet thick, which strikes about N. 65°-75° E. and dips about 55° SE., contains a large proportion of the workings of the Skaggs Springs mine. The hanging wall of the deposit is formed by interbedded shales and sandstones that conformably overlie the thick ore-bearing sandstone. The footwall, which is exposed only on the 73 and 100-foot levels, and in the shaft from a depth of 55 feet to its base, is similarly interbedded shales and sandstones that lie conformably below the ore bed.

Mineralization

Numerous fractures, joints, and faults with small offsets, which cut the hard, massive sandstone bed, have been open to ascending solutions that, in structurally favorable places, have partly filled the fractures and formed veins. Most common of the minerals filling the fractures is hard, dark opal that is locally mixed with fine-grained quartz and chalcedony, similar to the material that cements the sandstone. The opaline veins are cut by later fractures that in places are filled with bright greenish-yellow, crystalline curtisite (probably $C_{24}H_{18}$).[5] Realgar (AsS) and orpiment

[5] Dana, E. S., A textbook of mineralogy, 4th ed., p. 776, New York, John Wiley and Sons, Inc., 1932.

(As_2S_3), the red and yellow sulfides of arsenic, are the other two chief non-ore vein minerals in the Skaggs Springs mine. Metacinnabar, the black mercuric sulfide, is the principal ore mineral, and occurs in veins and more abundantly in minute isometric grains disseminated through the massive sandstone near the hanging wall. Cinnabar, though present in the mine, is so rare as to be a minor ore mineral.

Metacinnabar. The mode of occurrence of the metacinnabar has led to great difficulty in mining, for it is hard to recognize the mineral in the rock and virtually impossible to estimate the content. The metacinnabar-bearing veins, which locally are half an inch thick, almost invariably contain some curtisite, which is considered to be a guide to ore. Unfortunately, however, most of the ore taken from the mine has not contained well-defined veins of metacinnabar, but has consisted of fractured sandstone that contains disseminated metacinnabar. These black metacinnabar grains in the gray sandstone are extremely difficult to distinguish from small blobs of nearly black opal and other dark constituents of the sandstone. Underground it is almost impossible to distinguish between ore and "waste" because the appearance of the two is identical.

Cinnabar. The cinnabar in the mine occurs as fine-grained impregnations, which color the rock a pale pink, adjacent to small fractures in both the massive ore-bearing sandstone and the sandstone of the hanging wall. Most of these impregnations occur on the 100-foot level, and although cinnabar was noted as far as 35 feet below the hanging wall, nearly all of it is much closer to the contact. The small fractures that cut the cinnabar-bearing rock are commonly filled with curtisite, but as no metacinnabar has been observed in direct association with cinnabar, the relationship between the two ore minerals is not known.

Curtisite. The curtisite veins are nowhere more than 0.2 inch thick, and they pinch out in the plane of the vein within 3 or 4 feet in all directions. In many places, slickensided surfaces of small faults are coated with curtisite, and with it are other dark-brown to black, pitchy, amorphous hydrocarbons. The greatest concentrations of hydrocarbons, especially curtisite, are near the hanging wall in the raise stopes between the 50 and 100-foot levels and the 16 and 50-foot levels. Some curtisite is found on all the levels except the 135-foot level, but it is nowhere more than a few feet from the hanging wall.

Realgar and Orpiment. Realgar is much more widespread than orpiment in the Skaggs Springs mine, but neither is abundant except locally on the 135-foot level at and near the hanging wall. Along the creek 250 to 600 feet northwest of the shaft collar, however, much realgar is being deposited, together with metacinnabar, as irregular masses in open spaces along the siliceous veins around the five hot springs.

Structural Control

At the Skaggs Springs mine, deposition of the ore was controlled partly by differences in lithology of the host rocks and partly by certain fractures and fracture intersections.

The lithologic control was exerted by interbedded shale and fine-grained sandstone that overlie porous massive sandstone. The shale beds have acted effectively as a relatively impervious cap to solutions that

ascended through the porous sandstone below; all the ore in the mine is found in the porous sandstone just beneath the shale beds.

The faults and fractures that controlled the ore deposition can be divided roughly into three sets. All of them apparently occur largely within the sandstone, and are considered to have provided conduits for ore solutions ascending to the hanging-wall contact. The oldest set is a series of northwest-striking, southwest-dipping faults thought to be related to the southwest boundary fault of the Cretaceous (?) rocks and the Franciscan group. Locally, metacinnabar and cinnabar occur along and near these faults, and curtisite more generally is distributed adjacent to them. In the extreme south corner of the 100-foot level, where one of the faults of this oldest group intersects the hanging-wall contact, there are local concentrations of ore, and large quantities of cold water and bubbles of methane rise into the floor of the drift along the fault. The localized ore concentrations and the gas and water emanations are evidence that the fault acts and has acted as conduit for solutions.

A second smaller and less important group of faults mapped in the mine strikes N. 15°-55° W., but dips gently northeast, and is younger than the northwest-trending, southwest-dipping faults described above. The intersection of one of these younger faults, which is exposed in the raise stope between the 100-foot level and the 135-foot level, with the hanging-wall contact and a fault of the first group is the apparent control for the high-grade ore shoot mined in the raise stope. (See pl. 69, section BB′). Other smaller faults of this group are exposed on all levels except the 73-foot level, but have negligible offsets, and seem to have played little or no part in the control of the ore deposits.

The youngest, and perhaps economically most important, fault group is made up of east-striking, gently north-dipping fractures that are numerous throughout all levels and stopes in the mine. The faults of this group are highly irregular in attitude, and tend to split into many branching fractures. These faults are not all contemporaneous, but because of their complicated relations they have not been subdivided. In some places, steeper faults of the group seem to be cut off by later, flatter faults, but in other places, steep and flat faults intersect with no apparent offset on either fault. Offsets are generally small, ranging from a few inches to 5 feet. Some of the well-exposed flat faults in the large raise stope between the 50-foot level and the 100-foot level, however, have apparent offsets whereby the lower part of the hanging-wall contact has been displaced a total distance of nearly 55 feet to the southeast. The effect of these gently north-dipping faults is best shown in cross section A-A′ (pl. 69), which longitudinally bisects the large raise stope. The hanging wall flattens markedly between the 50 and 100-foot levels, and in this distance the stopes are bunched beneath the flattest parts. The same flattening is shown in cross section B-B′ (pl. 69). A large part of the ore taken from the mine has come from the stoped areas shown in cross section A-A′; curtisite is more abundant here than in any other part of the mine. This particular part of the hanging wall, which is abnormally flattened by faulting, therefore, apparently is the most effective structural trap in the deposit. Other flat, or nearly flat, parts of the hanging wall have been almost as productive.

The surface expression of the faults observed underground is not clear. Only two of the faults of the first group described can be found at

the surface. A prospect pit that is about 300 feet N. 60° W. from the inclined shaft collar has been dug in the soft, altered sandstone and shale underlying the slope. The material from this pit contains considerable quantities of extremely fine-grained metacinnabar and averages about 4 pounds of quicksilver to the ton. The mineralized area is approximately on the projected strike of a fault of the oldest set exposed underground, and the solutions that deposited the metacinnabar at the surface probably rose along this large fracture, or along fractures splitting from it. Second, the strongly sheared zone exposed in the extreme northeast corner of the 100-foot level (pl. 68) may be connected with the surface. Projected upward and northwestward along its dip and strike, the zone approximately lines up with the group of hot springs that are along the creek northwest of the mine, and may be part of a fault that may serve as a conduit for the hot springs.

Summary

The succession of events that immediately effected the formation of the quicksilver ore deposits at Skaggs Springs may be summarized as follows: Hydrothermal, silica-rich solutions rose along several sets of faults, filling the adjacent minor fractures in the sandstone with opal. For example, vein filling by opal has been especially active near the hot springs that occur along one of the northwest-trending faults that cut the rocks of Cretaceous (?) age. Later solutions deposited arsenic sulfides; hydrocarbons, especially curtisite; and metacinnabar and minor amounts of cinnabar. The highest concentrations of the hydrocarbons and the quicksilver minerals occur in the permeable sandstone where the conduits from below brought the solutions into the structural traps formed by the fault-flattened parts of the hanging-wall contact.

GRADE OF ORE

Reliable figures on the grade of ore that has been taken from the Skaggs Springs mine have been recorded only by Star Springs Mercury, Inc., during the 13 months of production from the rotary furnace. From the first of September 1941 through September 1942, approximately 5,500 tons of ore were treated, yielding 3.08 pounds of quicksilver per ton. Assays and the retorting of small tonnages of ore during this period, however, resulted in slightly higher yields to a maximum of 3.37 pounds per ton.

Mr. E. J. Bumstead took over the property in 1943 with the hope that careful sampling throughout the mine would enable him to mine more selectively than had been done before, thereby materially increasing the grade of ore actually treated, but this hope was not realized. The high degree of dissemination of the fine-grained metacinnabar in the sandstone, as pointed out in the discussion of the ore deposits, has defied estimation of grade in the past. The abundance of associated curtisite, commonly used in this mine as a guide to ore, is not necessarily a reliable criterion.

SUGGESTIONS FOR FURTHER DEVELOPMENT

Future exploration in the Skaggs Springs mine should follow the hanging-wall contact westward from the present workings to the boundary fault and eastward at least as far as the northwest-trending fault

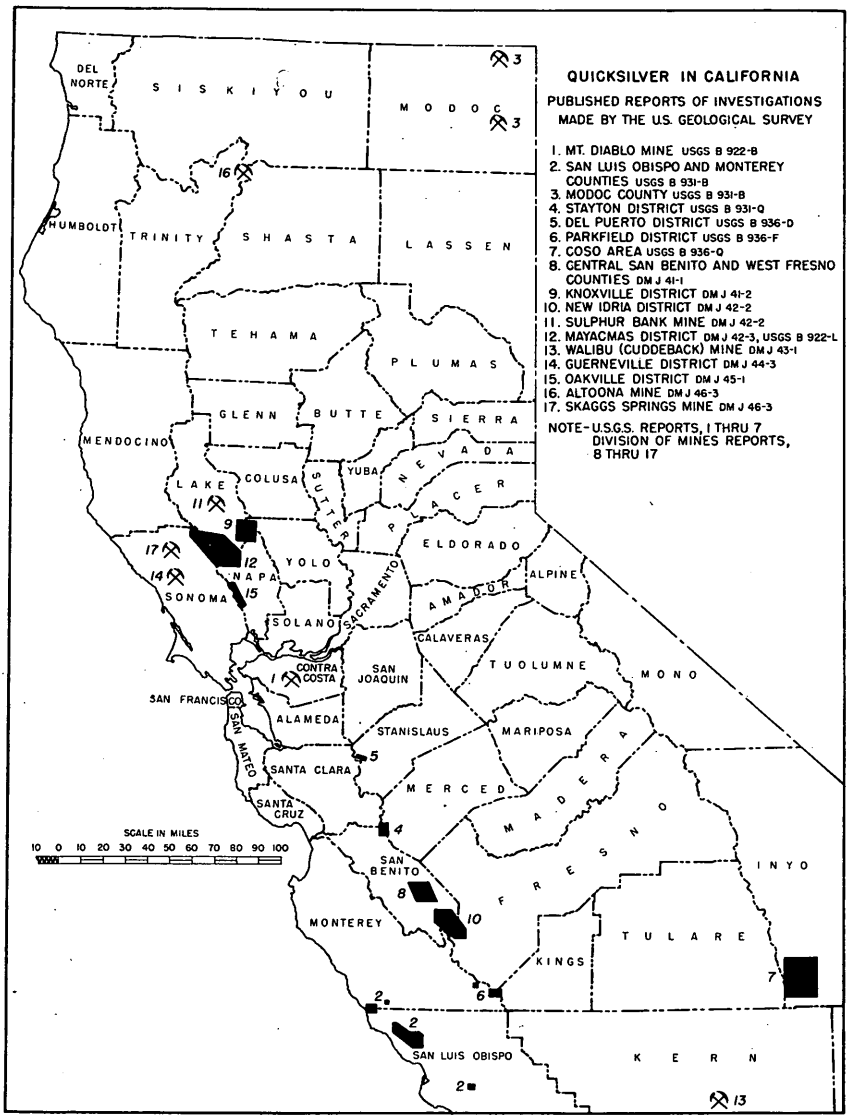

FIGURE 2. Index map of California quicksilver mining districts and mines on which reports have been published by the United States Geological Survey and the Division of Mines. These reports are the results of geological work by the United States Geological Survey in World War II strategic minerals investigations.

zone exposed on the 100-foot level. Those levels where the effective hanging wall is flattened by north-dipping flat faults should be especially explored. In addition, the necessary amount of prospecting should be carried through the fault zone to the northeast to determine definitely the eastern terminaiton of the ore deposits.

Two ore bodies exposed on the surface, one in the bulldozed pit and one in the creek bottom below the ore bins, should be developed and followed at depth.

In this mine, it is all-important to employ accurate methods for distinguishing ore that yields considerably more than 4 pounds to the ton from lower-grade ore or waste rock, for in all past operations the over-all grade of the ore has been too low even at high war-time prices. The extensive and rapid sampling and assaying necessary for this may prove too expensive to be justified by the average low-grade ore in the mine, unless a suitable, cheap, simplified procedure is used.

THE ALTOONA QUICKSILVER MINE, TRINITY COUNTY, CALIFORNIA *

By C. Melvin Swinney **

OUTLINE OF REPORT

	Page
Abstract	395
Introduction	395
History and production	397
Mine workings	398
Geology	398
Rocks	399
Serpentine	399
Diorite	399
Altered rock	400
Geologic structure	400
Ore bodies	401
Outlook	402

Illustrations

Figure 1.	Index map showing location of the Altoona quicksilver mine, Trinity County, California	396
Plate 70.	Topographic and composite maps of the Altoona quicksilver mine Trinity County, California	In pocket
71.	Geologic cross-section and level maps of the Altoona quicksilver mine, Trinity County, California	In pocket

ABSTRACT

The Altoona quicksilver mine is in the northeastern part of Trinity County, California, about 12 miles west of Castella. It has yielded, from intermittent operations since its discovery in 1871, more than 33,000 flasks of quicksilver. The deposit is of exceptional interest geologically because it is outside the principal belt of California quicksilver deposits. The ore bodies, in which the economic minerals are cinnabar with a little native mercury, are steeply dipping tabular lenses that average about 5 feet in thickness and locally attain a length and depth of more than 200 feet. The average grade of all the ore that has been mined is about 1 percent mercury, but some ore that contained up to 3 percent mercury is said to have been mined in the late 1890's. The ore in sight at the time the property was examined in 1943-44 averaged about 18 pounds of quicksilver to a ton. It was profitable to mine ore of this grade at the then prevailing price of about $200 a flask (76 pounds of mercury). When the price of mercury dropped in 1945, the mine was closed.

The ore bodies are localized along faults that cut altered diorite, and probably extend into adjacent sheared serpentine. Along the continuation of these ore-bearing faults, undiscovered ore bodies of moderate size probably can be found, but, at a mine as isolated as this one, exploring and mining can be profitable only during a period when a high price for quicksilver is assured.

INTRODUCTION

The Altoona quicksilver mine (fig. 1) is on the East Fork of the Trinity River, in the southern part of the Klamath Mountains, California. It is in sec. 22, T. 38 N., R. 6 W., M. D., in northeastern Trinity County. The shipping point nearest to the mine is Castella, on the Southern Pacific Railroad and on U. S. Highway 99. From Castella the mine is readily reached in the dry season by 24 miles of well-maintained dirt road, but

* Published by permission of the Director, U. S. Geological Survey.
** Geologist, U. S. Department of the Interior, Geological Survey.

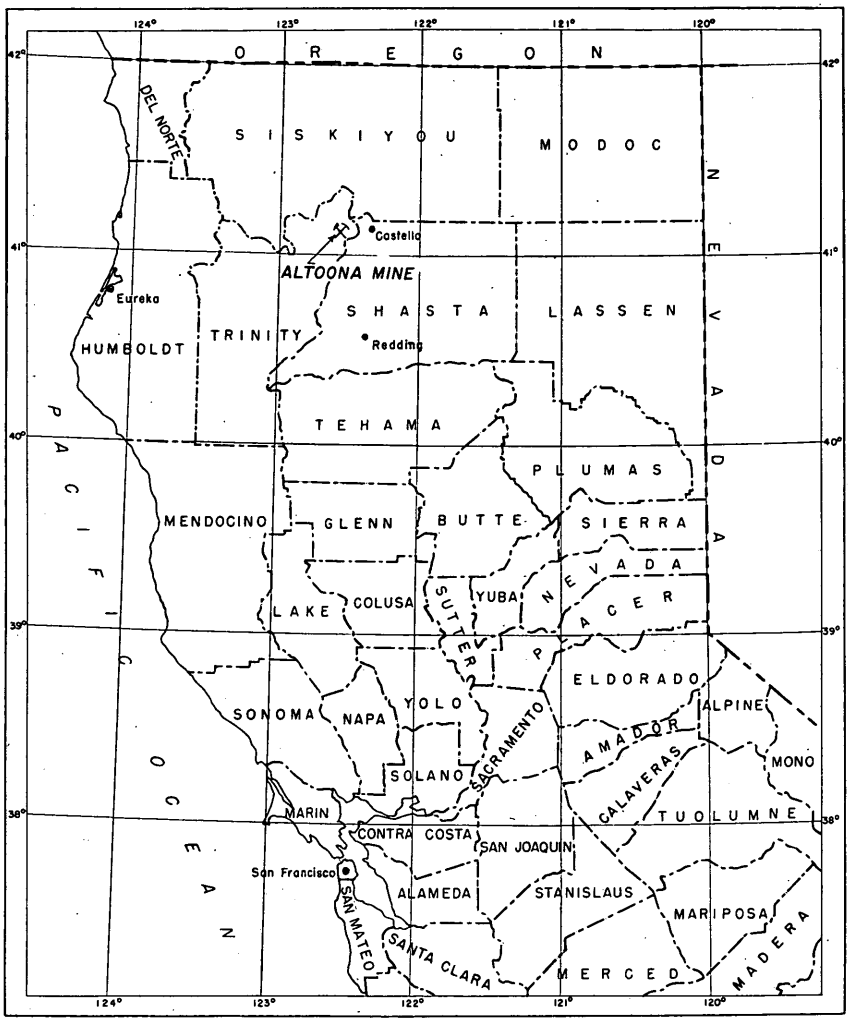

FIGURE 1. Index map showing location of the Altoona quicksilver mine, Trinity County, California.

during the wet and snowy winter months the road commonly is blocked for a week or more. The mine is at an elevation of about 4,600 feet above sea level in a region that is rugged and heavily forested. In spite of the strong relief, amounting to nearly 2,500 feet, exposures of bedrock at the surface are rare.

The field work for this report was done as a part of the wartime program of strategic minerals investigations of the U. S. Geological Survey. During September and part of October 1943, the surface and accessible underground workings were mapped, and in May 1944, the area was revisited in order to bring maps of the underground workings up to date. Specimens of the ores and rocks have not been studied in detail in the laboratory.

The writer gratefully acknowledges the friendly assistance of the mine owner, Mr. R. E. Frowenfeld of San Francisco, California, and the mine operators, Mr. C. W. Erickson of San Francisco and the Marsman Company of California. The writer was assisted ably by Philip F. Fix of the Geological Survey during much of the field mapping, and Mr. Fix contributed valuable ideas and suggestions in regard to the geology of the mine. Edgar H. Bailey of the Geological Survey critically read the manuscript and suggested many improvements.

The principal earlier reports dealing with the Altoona mine are by Becker,[1] Forstner,[2] Bradley,[3] and Ransome and Kellogg.[4] These reports show that the inaccessibility of much of the mine workings handicapped these authors as it did the writer.

HISTORY AND PRODUCTION

The first discovery of cinnabar reportedly in place was in 1871 in the area near the site of the present shaft. Until 1875 mining consisted principally of placer operations, the digging of open-cuts, and the driving of a few short adits. In 1875 the Altoona Quicksilver Mining Company, now owned by Mr. R. E. Frowenfeld of San Francisco, acquired the property and as a result of considerable underground exploration found ores which yielded over 7,000 flasks of quicksilver. By 1880 a depth of 132 feet had been reached, and an 800-foot drainage adit had been driven. At that time litigation among the stockholders resulted in a shut down of the mine. To reopen the mine in 1894 the present shaft was sunk to a depth of 450 feet, and soon thereafter a vertical winze was sunk 150 feet below the 450-foot level, making the total depth of the deepest workings 600 feet. Six levels were eventually driven from the shaft and two from the vertical winze. The period from 1895 to 1901 witnessed the greatest development and production of the Altoona mine, for during that interval the operators recovered 19,673 flasks of quicksilver, almost two-thirds of the total production at the time this report was prepared.

The mine was closed down and inaccessible for much of the time between 1901 and 1929, though sporadic work by lessees, principally the reworking of the old dumps, yielded a little quicksilver nearly every year. In 1929 the workings were reopened to the 132-foot level, and some mining continued until 1943, mostly on two new levels, the 50-foot and 100-foot levels. An attempt to unwater the mine below the 132-foot drainage level was begun in 1943, but in May 1944 the mine had been unwatered only to the 350-foot (Trinity) level. With the subsequent drop in the price of quicksilver, operations were curtailed in 1944 and the mine was shut down in 1945.

As the foregoing history shows, the Altoona mine has had only two periods of major operation, 1875-1880 and 1895-1901, and production during these two periods accounts for 27,200 flasks of the total of 33,820 flasks that the mine has yielded. The recovery of an estimated 240 flasks for 1890 was probably from the mine dumps or from placer material

[1] Becker, G. F., Geology of the quicksilver deposits of the Pacific slope: U. S. Geol. Survey Mon. 13, pp. 366-367, 1888.

[2] Forstner, William, The quicksilver resources of California: California Min. Bur. Bull. 27, pp. 192-193, 1903.

[3] Bradley, W. W., Quicksilver resources of California: California Min. Bur. Bull. 78, p. 200, 1918.

[4] Ransome, A. L., and Kellogg, J. L., Quicksilver resources of California: California Jour. Mines and Geol., vol. 35, no. 4, pp. 473-474, 1939.

below the mine area. During the year 1890 production from the Altoona mine area was about 20 flasks a month.[5] In the years since 1901, mining activity was by lessees and the annual production was slight. At the time the mine was visited in 1944, the Marsman Company of San Francisco was the operator, and production had been increased to about 100 flasks a month.

MINE WORKINGS

The underground workings of the Altoona mine total about 10,000 feet in length and extend to a depth of 600 feet, as shown in the composite map of the underground workings, plate 70. A two-compartment vertical shaft extends down to the 450-foot level (Frowenfeld level). A total of eight levels connect with this shaft and a vertical winze, 150 feet deep, connects the 500-foot (Porter) level and 600-foot (Virginia) level with the Frowenfeld level. Only one level, the 132-foot (Castella) level, has any other access to the surface and this opening is through the drainage adit, 885 feet long, which extends southeastward from the shaft.

Only 2,500 feet of workings, including the Castella drainage adit, were accessible at the time the writer examined the mine in 1943. The 350-foot (Trinity) level had been drained by the time the mine was revisited in 1944, but it could not be examined because of lack of ventilation. Plate 70, showing the workings of the Altoona mine, is a modification of an early company map with recent accessible underground workings added. The company maps did not show any geology or stopes on the various levels, but did indicate the general positions of "veins" (faults) on those levels. Knowledge of the mine below the Trinity level is scanty.

The mine, at the time of the writer's visits, was equipped for small-scale underground mining operations and had a 1½- by 42-foot oil-burning rotary furnace designed to handle 20 to 30 tons of ore per day. The electric deep-well pump that had been installed to unwater the workings below the Castella level easily handled up to 500 gallons per minute, even with a 450-foot lift, and was entirely adequate for the job, as it was estimated that the workings of the mine filled with water at an average rate of 200 gallons per minute. In addition, the mine had an electrically driven hoist, a blower and ventilating system, and an electrically operated air compressor. Ore cars, hoisted to the surface, were trammed by hand to either an ore bin, or to a waste dump. From the bin the ore was loaded into another car and trammed by hand to the furnace, a procedure requiring considerable handling of the ore.

GEOLOGY

The geology of the Altoona quicksilver deposit is of unusual interest because the deposit lies outside the well-defined major quicksilver belt of the California Coast Ranges. The Altoona region, which is one of metamorphosed Paleozoic and Mesozoic rocks invaded by ultramafic and later felsic igneous rocks, is geologically similar to the Sierra Nevada region. The Altoona quicksilver deposits, however, are unlike those along the eastern flank of the Sierra Nevada at Coso Hot Springs [6] or those

[5] Miller, Wm. P., Trinity County: Calif. Min. Bur. Rept. 10, p. 716, 1890.
[6] Ross, Clyde P., and Yates, Robert G., The Coso quicksilver district, Inyo County, California: U. S. Geol. Survey Bull. 936, pp. 395-416, 1943.

in the southern part near Tehachapi;[7] they are somewhat intermediate in character between the Coast Range deposits and the Sierra Nevada deposits.

The rocks exposed by the Altoona mine workings are intensely altered porphyritic diorite and serpentinized peridotite; the former probably intrudes the serpentine, but all observed contacts are faulted or sheared. Steeply dipping fault zones, that are defined clearly in the diorite but cannot be followed in the sheared serpentine, served as channels for the ore-forming solutions. The richest ore bodies formed in the fault zones as thin tabular lenses that averaged only 5 feet in thickness. These mineralized faults are always called veins in the district and are referred to as veins in this report. Some ore occurs in carbonate veins that cut the serpentine and the silicified and carbonatized serpentine and diorite which formed locally along the contact between the two rocks.

Rocks

The two major rocks within the area mapped around the Altoona mine are serpentine, which formed from peridotite or local dunite, and diorite. The latter was tentatively divided into two mappable varieties—a porphyritic hornblende diorite and a porphyritic feldspathized diorite. Texturally and mineralogically the two varieties are closely related; they differ chiefly in that one has phenocrysts of green hornblende, whereas the other has prominent phenocrysts of feldspar with minor phenocrysts of hornblende. Another rock type, herein termed "altered rock," is composed of quartz and calcium-magnesium carbonates.

Serpentine

Slickensided serpentine is exposed underground in the mine and also crops out in a few places at the surface. It is a massive dark-green rock which locally is veined with white carbonate, probably ankerite. Thin-sections show that the serpentine is composed largely of antigorite, showing the mesh structure characteristic of replacements of olivine, but also some scattered crystals of both ortho- and clino-pyroxenes were found. Small grains of magnetite tend to outline the mesh structure and also are scattered in irregular patches throughout the serpentine. All the exposures of the serpentine contacts, both on the surface and in the mine workings, are quite poor, and an adequate understanding of the relation between the serpentine and the diorite could not be obtained. Wherever exposed the contacts are clearly faulted, but whether this is true everywhere is not known.

Diorite

The two varieties of diorite, which probably are merely facies of a single intrusive, are described below.

Porphyritic hornblende diorite. Typical specimens of the porphyritic hornblende diorite consist of a green groundmass with dark-green phenocrysts of hornblende. The least altered specimens of this rock show in thin section phenocrysts of dark-green hornblende in a holocrystalline fine-grained groundmass composed principally of andesine (?), green

[7] Bailey, Edgar H., and Swinney, C. Melvin, Walibu quicksilver mine, Kern County, California: California Jour. Mines and Geol., vol. 43, no. 1, pp. 9-14, 1947.

hornblende, and a little quartz. Almost all the rock has been intensely altered, however, as follows:

Feldspar (andesine ?)	→	albite →	sericite
Hornblende	→	chlorite	
Ilmenite	→	sphene	
Apatite	→	no change	

The mineralogical changes are apparently the result of hydrothermal metamorphism.[8] However, considerably more work, both in the laboratory as well as in the field, will be necessary before the nature of the hydrothermal solutions can be established with certainty.

Porphyritic feldspathic diorite.[9] Macroscopically the porphyritic feldspathic diorite consists of euhedral phenocrysts of pale-pink to white feldspar and smaller phenocrysts of dark-green hornblende in a groundmass composed of fine-grained light-colored feldspar and minor amounts of hornblende. Like the porphyritic hornblende diorite, this rock also is altered, especially near the faults where it is soft, easily powdered, light colored, and stained by iron oxides. The light-colored feldspar phenocrysts give the altered rock a mottled appearance that distinguishes it from the hornblende diorite, which has a more uniform color and aspect.

A study of a few thin sections revealed the phenocrysts to be sericitized and argillized orthoclase (?) with carlsbad twinning, and green hornblende which is almost entirely altered to chlorite. The groundmass is a fine-grained intergrowth of plagioclase, green hornblende, and a little quartz. The plagioclase feldspar is altered to albite and sericite, and the quartz is a secondary replacement of some of the feldspar. The porphyritic (feldspathic) diorite as well as the hornblende diorite seems to have been affected by hydrothermal solutions.

Altered Rock

Locally, the serpentine, as well as the two varieties of diorite described above, is replaced by quartz and ankerite. Such replacement took place principally in the rock along the contact between the diorite and serpentine, but in some places extended well into the serpentine. The rock resulting from the replacement is a hard gray-green, fine-grained rock that somewhat resembles the "silica-carbonate rock" of the Coast Range quicksilver deposits. The term "altered rock" will be used in this report instead of "silica-carbonate rock" in order to avoid confusion, because the term "silica-carbonate rock" has become intimately associated with the Coast Range quicksilver deposits. Moreover, in the Altoona mine area the altered rock is not the principal host for ore deposition, whereas the silica-carbonate rock of the Coast Range deposits is often the ore-bearing rock.

Geologic Structure

The geologic structure of the accessible part of the mine is relatively simple. Two steeply dipping faults, striking northeast and ranging in dip from 53° NW. to vertical, cut across the diorite, and have served as channels for mineralizing solutions that have deposited cinnabar and

[8] Turner, F. J., Mineralogical and structural evolution of metamorphic rocks: Geol. Soc. America Mem. 30, p. 5, 1948.

[9] The term "feldspathic diorite" is here used to signify a relatively higher proportion of feldspar to amphibole in contrast to the darker, more hornblende-rich facies of the rock.

some native mercury in a gangue of carbonates, with subordinate barite, pyrite, quartz, and clay minerals. These faults, when they enter the serpentine, are dispersed or absorbed and contain no ore minerals.

One variation of the simple faults is worth noting. The No. 2 vein (fault) on the 132-foot (Castella) level, 175 feet southwest of the main shaft (pl. 71), is divided into two ore bodies that are separated by about 15 feet of barren rock. This division probably results from a local splitting of the fault and not an en echelon transfer of displacement from one fault to another. Eastward in the Castella level, north of the shaft, and upward on the 100- and 50-foot levels only one ore body was encountered on this vein.

ORE BODIES

The ore bodies examined in the Altoona mine are steeply dipping tabular lenses that average about 5 feet in thickness and locally attain a length and depth (down the dip) greater than 200 feet. They are distributed along the faults, and, as the cinnabar mineralization did not extend any great distance into the altered wall rock on either side of the fault zone, the ore bodies are invariably narrow.

The ore minerals are cinnabar and subordinate native mercury. The gangue minerals include ankerite, pyrite, barite, quartz, and clay minerals. Most of the stoped areas of the mine were inaccessible and observations, therefore, were restricted to small parts of veins No. 1 and No. 2 between the 50-foot level and the 132-foot (Castella) level. Although the 230-foot (Altoona) level and the 290-foot (Shelton) level were open, most of the stopes on these levels were almost entirely caved or back filled so that they could not be examined. The ore on the mine dumps indicates that two different types of vein material were encountered. One type, which has yielded most of the production, occurs in greatly altered, decomposed, ocherous porphyritic hornblende diorite and feldspathized diorite, where these rocks have been cut by the main faults (veins). The other type consists of cinnabar in veinlets of carbonate in the silicified rock.

The type of ore formed in the diorite was exposed in the accessible parts of the stopes in veins No. 1 and No. 2 on the Castella level. Both of these veins, which are about 10 feet wide on this level, strike northeasterly and dip 60° to 70° NW. The veins consist of sheared and altered ocherous porphyritic diorite, and where mineralized they contain disseminated cinnabar and native mercury. Carbonate veinlets, which also contain cinnabar, branch into the walls at numerous places.

At the time the mine was examined, loose fill in the south stope of vein No. 2 was being drawn into ore cars from the back of the Castella level, 175 feet southwest of the main shaft. Rich virgin ore consisting of small crystals of dark-red cinnabar and a little native mercury disseminated through the soft altered diorite was being stoped underhand from the same location. The ore is soft enough to be mined with a pick, and the grade was estimated at about 20 to 30 pounds of quicksilver per ton. The back fill in the old stope above the Castella level was estimated to average about 10 pounds per ton.

The granulated diorite in the fault zone has been largely replaced by quartz and carbonate, and at a first glance closely resembles a fine-grained sandstone. Examination with a hand lens shows the material in

the fault zone (vein), to be a fine-grained, friable, porous aggregate of subangular to angular, light-colored grains of quartz and carbonate loosely bonded by hydrous iron oxides. Thin veinlets of carbonate, shattered in the fault zone but continuous where they extend a short distance into the altered wall rock, are numerous. Small crystals of cinnabar occur in these veinlets and also in the surrounding material.

A considerable quantity of coarsely crystalline light-colored carbonate with small masses of cinnabar scattered through it can be seen on the dumps. Small vugs, lined with crystals of cinnabar and in places containing native mercury, commonly occur in the carbonate. It is not known from what part of the mine this material came. The native mercury is believed to be primary as the faces of the cinnabar crystals are smooth and show no evidence of corrosion.

In addition to veins No. 1 and No. 2, parts of which were accessible, the early company map of the underground workings (pl. 70) shows veins No. 3 and No. 4, as well as a possible fifth vein on the 600-foot (Virginia) level. It is reported locally that veins 1, 2, and 3 were approximately parallel and dipped northwest. The old map, on the contrary, indicates vein No. 3 dipping to the southeast. It has been said that the body of ore mined on the Virginia level was found at the junction of veins No. 1 and No. 2.

The fact that vein No. 1 splits into two separate parts on the Castella level suggests that similar complexity in the faults may exist elsewhere in the mine, although no actual evidence of any other splits was observed in the accessible workings. There is also the possibility that vein No. 4, indicated on the company map as striking about N. 45° W., dip not shown, may be a fault offsetting veins Nos. 1, 2, and 3. If so, it may account for the sharp bend in the ore body shown on the Virginia level.

OUTLOOK

The visible ore reserves of the Altoona mine in 1944 were not great, totaling not more than a few hundred flasks of mercury, but only a small percentage of the total workings along the veins were accessible. To judge the probable future outlook for the mine requires an estimate of the ore remaining, the cost of mining this ore, and the probable price of quicksilver. Based on a consideration of these factors, the writer believes the mine is capable of producing about 200 flasks of mercury per month if the price of quicksilver were maintained for a period of two or more years at about $125 a flask, with mining conditions as they were in 1944.

Mining operations at the Altoona mine are expensive. The mine is far from the main highway and railroad, and the transporting of men, fuel, and equipment involves considerable cost. In addition, during the winter months the road is closed by snow; thus if the mine is to operate all year, the road must be kept open and maintained during the winter. The mine workings below the Castella level must be constantly pumped out, for they fill with water at the rate of about 200 gallons per minute. On the other hand, the mine workings do not require a great deal of timbering, and much of the ore is soft enough to be mined with a pick. The ore from the mine is handled twice before arriving at the furnace. This is an extra expense that could be avoided by a more efficient arrangement of waste dumps, reduction plant, and ore bins.

About 75 percent of the underground workings were flooded from 1901 to 1943 and were not subjected to the small-scale mining operations carried on by lessees on all the levels from the Castella level to the surface. Such small-scale mining produced 280 flasks of mercury in 1943, mostly in the last four months of the year. This production was from areas on and above the Castella level. In January 1944, 224 flasks was recovered from ore mined between the Castella and Altoona levels. Part of this was high-grade virgin ore, but the bulk was back fill from the stopes.

It is believed that the average grade of the ore mined from 1871 to 1901 was about 25 pounds of mercury per ton. This estimate is based on the grade of ore in the old stope back fill and the virgin ore observed during the examination of the mine, as well as on the fact that the cost of supplies during the periods of full scale mining (1871-1880 and 1895-1901) was relatively high because of the isolation of the mine. The constant pumping of the mine was an added high cost. Therefore it seems quite likely that ten-pound ore was considered too low in grade to mine between 1871 and 1901, and there is thus an excellent possibility that much ore of that grade remains in the lower stopes.

If the early company map correctly shows the approximate extent of mined and prospected areas, considerable unprospected ground remains in spite of the fact that the mine is surrounded by other claims that limit the lateral extention of operations. However, it should not be overlooked that underground workings, especially shallow ones, probably exist and were never shown on the company map. For example, plate 1 shows several dumps south of the shaft, but the company map indicates no workings at all in this area.

On the basis of present knowledge of the Altoona mine, the following suggestions for future development and prospecting are made.

(1) Examine the stoped areas on the lower levels. The back fill and remaining ore in the old stopes may average about 10 pounds of mercury per ton. This material is easily mined and would maintain production while new areas are being developed.

(2) Explore the possibility of an intersection of veins No. 1 and No. 2 north of the main shaft. The early company map (pl. 70) indicates a convergence of the two in that direction.

(3) A brecciated zone (shown as gouge on pl. 70) on the Altoona level just west of the shaft should be investigated, although the extent and significance of the brecciation was not determined in the accessible workings.

(4) Explore vein No. 4, especially at depth. It is not known whether this vein is a fault similar to veins No. 1 and 2 or the sheared contact between serpentine and diorite. The early company map shows vein No. 4 only on the Castella level. A projection of vein No. 4 downward, from what is probably its surface outcrop (gossan), to its position on the Castella level indicates a steep dip to the northeast. The possible intersection of this vein with veins No. 2 and 3 should be explored. It is very possible that the ore body on the Virginia level, shown on plate 70, was controlled by such an intersection, especially in view of the sharp bend the ore deposit makes on that level.

(5) Explore vein No. 3 from the Trinity and Goldstein levels in order to determine its dip and to see if it is offset by vein No. 4.

(6) Explore the Virginia level ore body. The early company map indicates low-grade ore on the footwall. Such ore probably averages about 10 pounds of mercury per ton.

(7) Since a depth of 600 feet is unusually great for quicksilver deposits, plans for prospecting to a greater depth should be made only with great caution.

HEALTH AND SAFETY WORK OF THE BUREAU OF MINES

By James Boyd, Director *

OUTLINE OF REPORT

	Page
Introduction	405
Health work of the Bureau of Mines in connection with dust and ventilation problems	407
General investigations	407
Special investigations	407
Services and publications available	408
Approval testing of respiratory protective devices	410
History of the work of the Bureau of Mines on mine and tunnel ventilation	410
1910-21	411
1922-27	411
1928-41	412
1942-49	413
List of Bureau of Mines publications dealing with the ventilation of mines and tunnels	413
Bulletins	413
Monograph	414
Technical papers	414
Miners' circulars	414
Chart	414
Reports of investigations	414
Information circulars	416
Cooperative publications with the Public Health Service	417
Cooperative publications with the Federal Board for Vocational Education	418
Periodicals	418

INTRODUCTION

The Health and Safety Division of the Bureau of Mines comprises four branches: Safety, Coal Mine Inspection, Health, and Accident Analysis. These branches, functioning in related fields, are coordinated by the office of the Chief of the Division in Washington, D. C.

Laboratories and training headquarters are in the Bureau's building in Pittsburgh, Pennsylvania. Field activities, which are the major function of the Division, are carried on from field offices in centers of mining or mineral activity throughout the United States and Alaska.

The Safety Branch, employing engineers, safety instructors, and technicians, has as its activities:

First aid and mine rescue training.
Accident-prevention training; metal, nonmetal, metallurgical, and petroleum laboratories.
Routine dust and ventilation surveys at metal mines.
Conferences with mine and plant officials on safety problems.
Promotion of safety organizations and addressing safety meetings.
Exhibits, demonstrations, safety motion pictures.
Testing electrical and other equipment for permissibility.
Investigations of accidents and practices in the mineral industries.
Anthracite flood investigations.
Preparation of reports for publication.

The Coal Mine Inspection Branch, employing mine inspectors, engineers, and technicians, has as its chief activities:

Inspection of coal mines.
Routine dust and ventilation surveys at coal mines.

* U. S. Department of the Interior, Bureau of Mines.

Accident-prevention training, coal mining.
Investigation of coal-mine disasters and other accidents.
Attendance and talks at safety meetings.
Conferences with mine officials and miners' safety committees relating to mine safety conditions.
Mine fire control and prevention.
Engineering studies of coal-mine methods and practices.
Rescue and recovery operations.
Preparation of reports for publication.

The Health Branch, employing chemists, engineers, and technicians, has as its activities:

Health and sanitation studies in mines and mining communities.
Research on physiological effects of gases and dusts.
Detailed dust studies at mines and plants.
Analysis of air samples for Coal Mine Inspection and Safety Branches.
Testing and development of respiratory protective methods and devices.
Studies of mine ventilation.
Preparation of reports for publication.

The laboratory and testing work of the Health Branch is centralized at the Bureau laboratories at Pittsburgh, Pennsylvania.

The Accident Analysis Branch, employing mining engineers, statisticians, and clerks, has as its chief activities:

Collection, checking, compilation, and publishing of official injury statistics on all mineral and allied industries. This includes not only mining and quarrying but also cement mills, lime plants, primary smelters of nonferrous metals, ore-dressing mills, and coke plants.
Conducting five annual safety competitions.
Collection, checking, compilation, and publication of consumption and other data on industrial explosives.

From the earliest period of the existence of the Bureau of Mines one of the main objectives of the Bureau's work was the prevention of loss of life and limb and the protection of the health of those who make available the mineral products vital to the life and progress of this country.

During the years that have intervened since the Bureau of Mines came into existence in 1910, it has consistently and continuously conducted an educational campaign aimed toward fulfillment of the objectives mentioned; educational procedures were used partly because the Bureau of Mines has no legal authority to enforce any suggestions or recommendations as to health, safety, or efficiency, and partly because it is believed that if those engaged in the work are kept informed as to what can or should be done they will eventually place those measures in effect.

The Safety Branch has long specialized in the instruction of workers in the mineral industries in first aid, mine rescue work, and accident prevention. Investigative and educational work is conducted in various fields of the industry jointly with engineers and inspectors of the other branches.

Functions and services of the Bureau regarding health hazards from gases and dusts and on ventilation from the aspects of health and safety are discussed in detail in the reviews that follow. They relate the history and work of the Bureau in those respects and present the services available to the mineral industry.

HEALTH WORK OF THE BUREAU OF MINES IN CONNECTION WITH DUST AND VENTILATION PROBLEMS

The duties of the Health Branch, in accordance with the organic act of July 1, 1910, creating the Bureau of Mines, are the investigation of health hazards and the development of measures for improving health conditions in the mineral industries in connection with the mining, preparation, and utilization of mineral substances and the dissemination of information concerning these investigations in such manner as will best carry out the purpose of the act. The Coal Mine Inspections and Investigations Act of May 7, 1941, increased the Health Branch's possibilities of promoting health in the coal mining industry by authorizing and empowering the Bureau to make annual or necessary inspections and investigations in coal mines relating to health conditions and the causes of occupational diseases.

A few of the health investigations conducted by the Branch include (1) general investigations, (2) the properties and toxicity of gaseous atmospheric contaminants, (3) the properties and physiologic action of particulate atmospheric contaminants (dusts), (4) physical condition of the atmosphere of working places (abnormal temperatures and humidities), (5) activities resulting from federal coal-mine inspections, (6) approval testing of commercial respiratory protective devices.

General Investigations

The investigations of the Health Branch deal principally with the hygienic aspects of abnormal environmental conditions to which workers in the mineral industries are exposed. Consideration is given especially to atmospheric health hazards. Studies include the measurement of various forms of atmospheric pollution; evaluation of the significance of such measurements; and development of methods of controlling the hazards incident to exposure thereto. These methods include detection of toxic gases and dusts and determination of the extent of their occurrence.

Results of the investigations are used in forming standards of allowable concentrations of atmospheric contaminants and other abnormal environmental conditions recommended by such organizations as the American Standards Association, the American Society of Heating and Ventilating Engineers, the Industrial Hygiene Foundation, the American Public Health Association, the Governmental Industrial Hygienists, and several similar organizations. Members of the Health Branch are serving in various capacities with many of these organizations.

Special Investigations

The first investigation of silicosis in the mining industry in the United States was made in 1914-15 by the Federal Bureau of Mines in cooperation with the United States Public Health Service in the Joplin (Missouri) mining district. Of 93 men examined, 64 showed plain and definite evidence of pulmonary disease, 3 were suffering from nonpulmonary disease, and 26 were seemingly well. To gain a more accurate idea of the prevalence of consumption among the miners of the Joplin district, it was decided to examine a large number, and from May 15 to December 31, 1915, 720 miners were examined; 45.7 percent had silicosis and tuberculosis and 5.3 percent had tuberculosis. A later report (1927)

of this same investigation by Lanza and Childs included the results of the first detailed X-ray studies of silicosis made in the United States.

Investigations of mining conditions by Harrington and Lanza in Butte, Montana, in 1921, revealed that 42.4 percent of 1,018 miners examined showed definite signs of lung damage due to dust.

In 1923 the mining companies of the Tri-State district (comprising the zinc and lead-mining areas of southwestern Missouri, southeastern Kansas, and northeastern Oklahoma) requested the Federal Bureau of Mines to determine whether measures in use were adequate for the prevention of silicosis, and, if not, to recommend improvements. The 1923 investigation included the examination of 209 miners, 101 of whom were found to be negative, 114 doubtful, and 94 positive cases of silicosis. Of the positive group, 52 were in the first stage, 22 in the second stage, and 20 in the third stage of silicoiss.

From July 1, 1927 to June 30, 1932, the Metropolitan Life Insurance Co., the Tri-State Zinc & Lead Ore Producers Association, and the Federal Bureau of Mines operated a cooperative clinic at Picher, Oklahoma, to demonstrate to industry a workable method for diagnosing silicosis, to educate workers in preventive measures, and to serve as a model to industries presenting a dust hazard. Of 27,553 individuals examined during this period 5,366 had silicosis, 742 silicosis plus tuberculosis, and 320 uncomplicated tuberculosis. The 5-year study showed that, by careful physical examination and the application of proper dust-control measures, the incidence of silicosis and other dust diseases could be greatly reduced.

The following publications discuss the investigations mentioned above:

Lanza, A. J., and Higgins, Edwin, Pulmonary disease among miners of the Joplin District, Missouri, and its relation to rock dust in the mines: U. S. Bur. Mines Tech. Paper 105, 47 pp., 1915.

Higgins, E., Lanza, A. J., Laney, F. B., and Rice, G. S., Siliceous dust in relation to pulmonary disease among miners in the Joplin District, Missouri: U. S. Bur. Mines Bull. 132, 116 pp., 1917.

Lanza, A. J., and Childs, Samuel B., I. Miners' consumption—a study of the disease among zinc miners in southwestern Missouri; II. Roentgen-ray findings in miners' consumption: U. S. Public Health Bull. 85, 40 pp., 1917.

Harrington, Daniel, and Lanza, A. J., Miners' consumption in the mines of Butte, Montana: U. S. Bur. Mines Tech. Paper 260, 19 pp., 1921.

Sayers, R. R., Meriwether, F. V., Lanza, A. J., and Adams, W. W., Silicosis and tuberculosis among miners of the tri-state district of Oklahoma, Kansas, and Missouri, I. For year ended June 30, 1928; U. S. Bur. Mines Tech. Paper 545, 30 pp., 1933.

Meriwether, F. V., Sayers, R. R., and Lanza, A. J., Silicosis and tuberculosis among miners of the tri-state district of Oklahoma, Kansas, and Missouri, II. For the year ended June 30, 1929: U. S. Bur. Mines Tech. Paper 552, pp. 7-19, 1933.

SERVICES AND PUBLICATIONS AVAILABLE

The Health Branch has developed satisfactory methods for sampling and counting dust particles and for determining and analyzing them. At present various methods of analyzing dust are being studied. Some of these are by X-ray diffraction and petrographic, spectrochemical, and electrochemical procedures. However, the methods and instruments for determining air-dustiness developed by the Health Branch are used generally in the United States and make possible comparison of studies made in various industries.

Although no recent formal studies have been made on siliceous dust in relation to pulmonary diseases among miners, investigations and dust surveys are conducted regularly as requested by the mineral industry.

Many of the progressive mining companies have instituted and maintain excellent dust-control measures as a result of a series of dust studies conducted at their properties by Bureau of Mines engineers over a period of years. The mining engineers of the Bureau of Mines are available to the mining industry for such service at all times.

Numerous publications have been issued or are in preparation on various phases of the dust problem. These contain enough information, if properly applied, to greatly reduce or to eliminate the dust hazard in the mining industry. Some of these publications are listed below:

Littlefield, J. B., Feicht, F. L., and Schrenk, H. H., Bureau of Mines midget impinger for dust sampling: U. S. Bur. Mines Rept. Inv. 3360, 4 pp., 3 figs., 1937. Describes small, portable, hand-operated impinger; results obtained with silica dust agreed well with those obtained with regular impinger.

Schrenk, H. H., and Feicht, F. L., Bureau of Mines midget impinger: U. S. Bur. Mines Inf. Circ. 7076, 7 pp., 4 figs., 1939. Describes the midget impinger flash and suction apparatus developed by the Bureau, as well as the collecting and counting of dust samples; gives the results of laboratory tests with silica dust, lead dust, and lead fume and field tests on Catoctin greenstone and siliceous schist.

Brown, C. E., and Schrenk, H. H., A technique for use of the impinger method: U. S. Bur. Mines Inf. Circ. 7026, 20 pp., 4 figs., 1938. Describes procedure followed by Bureau of Mines in determining, by impinger method, number concentration of dust in atmospheres known to contain or suspected of containing pneumoconiosis-producing particulate matter.

Brown, C. E., Baum, L. A. H., Yant, W. P., and Schrenk, H. H., Microprojection method for counting impinger dust samples: U. S. Bur. Mines Rept. Inv. 3373, 9 pp., 4 figs., 1938. Supplements U. S. Bur. Mines Rept. Inv. 3289, which described new method for counting dust particles with microprojector, eliminating eyestrain. This applies same method to counting of impinger dust samples.

Brown, C. E., Midget microprojector for dust determinations: U. S. Bur. Mines Rept. Inv. 3780, 14 pp., 2 figs., 1944. Describes construction and application of small microprojector that is easy to use in making determinations of dust in atmosphere.

Brown, C. E., Filter-paper method for obtaining dust-concentration results comparable to impinger results: U. S. Bur. Mines Rept. Inv. 3788, 20 pp., 9 figs., 1945. A new filter-paper method for obtaining samples of air for dust analysis in health surveys is described. The device recovers dust from the air by drawing the atmosphere through a filter paper, instead of through liquid as in the "impinger" method long used for obtaining samples for scientific study.

Brown, C. E., and Yant, W. P., The microprojector for determining particle-size distribution and number concentration of atmospheric dust: U. S. Bur. Mines Rept. Inv. 3289, 8 pp., 3 figs., 1935. Describes apparatus and methods for examining samples of atmospheric dust by projecting images of the dust particles at a high known magnification onto a ruled translucent screen. Determination can be made with less eye strain, time, and effort than by direct visual microscopic methods.

Ballard, J. W., Oshry, H. I., and Schrenk, H. H., Some photometric instruments used in X-ray diffraction and spectrographic methods of analysis: U. S. Bur. Mines Rept. Inv. 3638, 13 pp., 9 figs., 1942. Describes such instruments in detail and discusses their application in the laboratory.

Brown, C. E., Beatty, R. L., and Kirby, T. B., Dust-counting cells: U. S. Bur. Mines Inf. Circ. 7331, 9 pp., 2 figs., 1945. This report contains information about dust-counting cells for scientists engaged in industrial studies of dust and its effect on health. Several types of counting cells, including a new dual cell, as well as methods of making simple and inexpensive ones are described in this paper.

APPROVAL TESTING OF RESPIRATORY PROTECTIVE DEVICES

To promote the development of safe, satisfactory, and reliable respiratory protective devices, the Bureau has established schedules of minimum requirements for self-contained oxygen-breathing apparatus, gas masks, supplied-air respirators (hose masks, airline respirators, and abrasive blasting helmets, hoods, or masks), mechanical filter respirators, and chemical cartridge respirators. With the exception of the self-contained oxygen-breathing apparatus, the Health Branch tests for approval all the types of apparatus mentioned. These devices are essential for protection against numerous gaseous and particulate contaminants present in the atmosphere of many industries.

Manufacturers of respiratory protective devices may submit their equipment to the Bureau for approval under the requirements of the schedules. Lists of approved devices are published periodically for the information of the public. About 158 devices of various types are on the latest list.

Some of the States and some municipalities require that apparatus used in their jurisdictions must be approved by the Federal Bureau of Mines.

HISTORY OF THE WORK OF THE BUREAU OF MINES ON MINE AND TUNNEL VENTILATION

The subject of mine and tunnel ventilation has two broad aspects; the health and safety aspect, that is, what atmospheric conditions to obtain in underground openings; and the engineering aspect, that is, how to maintain the desired conditions and particularly, how to do so efficiently. The health and safety aspect relates more particularly to quantity and quality requirements of ventilating systems, whereas the engineering aspect relates more particularly to pressure requirements. Both, therefore, determine power requirements, which is the deciding factor of practical importance in any system of mine or tunnel ventilation.

Both divisions of the subject have received considerable attention from the Bureau of Mines since its organization in May 1910, in the form of research, service, and correlation and dissemination of information. Numerous papers have been published on various phases of the subject, of which a selected list, numbered and arranged in chronological order by type of publication, will be found at the end of this paper. One of these, Technical Paper 705 (24),[1] gives a complete bibliography of Bureau of Mines publications dealing with health and safety. As is indicated by this selected list of publications, the health and safety aspect has received a major share of the attention devoted to this work, mostly because these have been dominant factors in Bureau policy but partly because this aspect lends itself to laboratory research and small-scale field studies. Although much attention has also been devoted to the engineering aspects of mine and tunnel ventilation, there has been only sporadic recognition of the vital effect this phase of the work could have on improving health and safety conditions.

[1] Number refers to publications listed at end of paper.

1910-21

In the early work of the Bureau, a few specific field studies (1, 2) were made in which the emphasis was largely on safety, particularly as regards mine gases (3, 14, 25, 26, 28, 117). Serious dust studies were started in the Joplin, Missouri, district in 1914, where ventilaton was not considered to be a problem. When these studies were continued in 1916 in the Butte, Montana, mines, where ventilation was a serious problem, there was developed a particular and intense interest in the health and safety features of ventilation.

During the period 1916-21, Dan Harrington continued a study of underground air conditions in Butte mines (4, 15) and directed a limited corps of engineers and Public Health Service doctors engaged in field studies of dust—ventilation conditions in various western mining districts, on which many general (30, 41, 118, 119, 120, 121) and specific (31, 32, 33, 34, 36, 37, 38, 40, 42, 43, 51) publications were based.

Vehicular-Tunnel Ventilation Studies. Starting late in 1919 and continuing through 1921, an extensive investigation of the problems involved in ventilating vehicular tunnels was carried out in cooperation with the New York State and New Jersey Interstate Bridge and Tunnel Commissions and related to ventilation of the Holland tunnels which were being constructed under the Hudson River. This investigation was divided into four separate and distinct problems, which include (1) amount of the composition of exhaust gases from motor vehicles, conducted at the Pittsburgh Station, (2) physiological effect of exhaust gases from motor vehicles, conducted at Yale University, (3) determination of empirical factors for calculating the pressure requirements for flow of air through concrete ducts, conducted in cooperation with the Engineering Experiment Station of the University of Illinois at Urbana, Illinois, (4) determination of the relative merits of various methods of transverse ventilation for the Holland tunnels, conducted in a model tunnel constructed in the Bureau's Experimental mine, Bruceton, Pennsylvania.

Detailed results of parts 1, 2, and 4 have been published (13, 29, 35), but the results of part 3 are only briefly summarized in the yearly reports of the two commissions involved. The Bureau devoted a large amount of time and effort to these problems, which developed a continuing interest in toxic combustion gases (39, 58, 63, 113, 114, 128), including those in railroad tunnels (16, 46, 56, 60), and led to the development of a carbon-monoxide recorder (17) now widely used in vehicular tunnels and in industry.

1922-27

A comprehensive study on coal-mine ventilation factors was started in the Experimental mine late in 1921, requiring considerable development and testing of instruments and methods of procedure. Arrangements were made to do similar work in cooperation with the Anaconda Copper Mining Co. in its metal mines at Butte, Montana. The Experimental mine test work (6) was completed in 1923. The work at Butte was relatively more extensive and difficult, and continued, with a few interruptions, into 1927. Rather elaborate tests were made of fan-tubing installations (48, 49, 50), of the resistance of typical metal-mine airways (5, 132), of laboratory and field methods of testing fans (18, 137), of

natural-draft ventilation (62), and of shaft air-temperature changes. Considerable attention was also devoted to a study of the application of air-conditioning to mines, then used only in one mine (52, 127) in Brazil, but no tests were made. Resistance tests on rough coal-mine airways were made in an Indiana coal mine and in the Moffat tunnel (135), Colorado, then under construction.

During the time the Butte work was in progress and largely resulting from underground observations (45, 109, 110) made previous to the tunnel-gas studies, a very extensive series of laboratory tests on the effect of air conditions on comfort was carried on at the Pittsburgh Station in cooperation with the American Society of Heating and Ventilating Engineers. The results, as reported in a series of Bureau of Mines (53, 55, 54), Public Health Service (111, 112), A. S. H. V. E. (122, 123, 124, 125, 126, 129), and other publications (140, 143, 144), resulted in the formulation of a new concept—effective temperature—for expressing the interrelation of air temperatures, humidity, and movement on sensations of comfort. Later, the Research Laboratory of the A. S. H. V. E. made numerous additional tests to amplify this subject and developed charts for practical application of this information which are published yearly in the A. S. H. V. E. "Guide."

During this same period extensive field studies were made of blasting gases (7, 59) in metal mines and tunnels and of the occurrence of rock-strata gases (8) in the mines of the Cripple Creek district, Colorado. Tests were also made in the Experimental mine at Bruceton on the recirculation of gas caused by auxiliary fans as used in coal mines, with results (136) that have guided mine inspection policies in this matter. A number of papers on particular activities (19, 44, 47, 61) or of general interest (57, 130, 131, 133, 134, 138, 139) to mine ventilation appeared also during this period.

1928-41

The Health Branch concerned itself mainly with laboratory studies, mostly of a pathological nature, on the effects of gases, toxic vapors, and dust. Few field studies were made, although interest in the physiological factors of mine ventilation (72, 76, 77, 80, 85, 100, 102, 142, 146) continued.

One large study made in 1941 stemmed directly from the previous tunnel-gas investigations made in connection with the Holland tunnels. At the request of the New York City Tunnel Authority, the Bureau conducted a series of wind-tunnel model tests to determine the rate of dilution of gases discharged from stacks (22), as a result of which the proposed design of the ventilation arrangements for the Manhattan end of the Battery-Brooklyn vehicular tunnel was radically altered.

During this period, incidental attention to ventilation (10, 11, 21, 64, 73, 74, 75, 78, 81, 82, 84, 87, 88, 89, 91, 92, 93, 94, 95, 96, 97, 98, 99, 101, 115, 116, 141, 146) produced a large number of short papers of both general and particular interest as regards the relation of ventilation and mine safety.

Studies of ventilation methods were made in a number of mining districts (9, 20, 79, 90) and individual mines, the available information on several phases was correlated (65, 71, 83, 86), and a general bulletin

on mine ventilation (12) was prepared, which is used not only as a textbook in many university mining courses, but also appears, in a condensed form, as the section (145) on mine ventilation in the mining engineers' "bible"—Peele's Mining Engineers Handbook. A special study was made of the conditions of jet flow at the discharge of fan-pipe lines in the Bureau's Mount Weather adit, Bluemont, Virginia; the results (66, 67) have been correlated with results of other jet research in a way that has served as a pattern for analyzing the results of later research in industrial ventilation.

1942-49

Immediately before and during the war the Bureau was engaged on many special war problems, several of which utilized the Bureau's experience in mine ventilation. The most interesting and important problem (108), and one that fully utilized the Bureau's experience in ventilation and toxic gases, was a study, carried out in cooperation with the Bureau of Ships of the Navy, of the ventilation of tank landing (LST) ships as required to combat the hazard of carbon monoxide poisoning of crew members during prolonged warming-up of tank and vehicle engines in closed holds.

In recent years, both the Health Branch and the Safety Branch have maintained an interest in ventilation problems, although mostly along educational lines (23, 27, 104, 105, 106, 147, 148). Special studies have been made on the use of Diesel engines underground (68, 69, 103, 107); engineering studies have been made in coal mines, particularly on the application of pressure-surveying methods, on the "stall" troubles introduced by axial-flow fans, and on the application of fan-tubing auxiliary ventilation; occasional surveys have been made in both coal and metal mines and developments in both have been closely followed; developments in the application of air-conditioning to mines have been followed continuously since 1936, for which purpose a special psychrometric chart (70) was recently perfected after a number of unsatisfactory attempts dating back to the early work at Butte in the twenties.

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MINES AND MINERAL RESOURCES OF YOLO COUNTY

By J. C. O'Brien *

OUTLINE OF REPORT

	Page
Abstract	421
Introduction	421
Mineral resources	423
Building stone	423
Clay	423
Gold	425
Limestone	425
Mineral water	425
Miscellaneous stone	425
Natural gas	431
Quicksilver	432
Mineral commodity survey	433
Tabulated list of mining properties	434

Illustrations

Figure 1.	State of California, Division of Highways equipment loading gravel from Cache Creek southeast of Woodland	428
Plate 72.	Map showing mines and mineral deposits of Yolo County, California	In pocket

ABSTRACT

Yolo County is one of the original 27 counties of California. It is situated in the southwestern part of the fertile Sacramento Valley and 85 percent of its 661,770 acres is in farm land. Its principal mineral production has come from the quicksilver mines in the northwestern corner of the county. These properties were idle when the field work was done for this report early in 1949. The principal activity at that time was in the production of sand and gravel from Cache Creek and Putah Creek. There are 444 acres of proven gas lands in the county with two wells on production and four standing shut-in. The record of the production of other minerals is included from earlier reports.

INTRODUCTION

Yolo County is one of the 27 California counties that were created February 28, 1850. Its name was derived from a corruption of Yoloy, the name of an Indian tribe which inhabited the county when it was first settled. The county occupies one of the most fertile portions of the Sacramento Valley. Farming is by far the leading industry and sugar beets are the principal crop. The county has a population of 34,000, an increase of 25 percent since the 1940 census. Woodland, the county seat and largest city, had a population of 8,500 in 1944. It is also the major industrial center with a sugar refinery, fruit and vegetable packing plants, and stock yards.

The climate is dry and generally rainless from May to October but an average of 17 inches of rain falls during the winter months. Snow rarely falls but killing frosts are expected between November 15th and March 20th. The normal mean temperature for January and February is 48 degrees. The average July temperature is 77 degrees. The crop growing season averages 268 days.

Geography. Yolo County is situated in the southwestern part of the Sacramento Valley. It is bordered on the north by Colusa, on the east by

* District Mining Engineer, California State Division of Mines.

Sutter and Sacramento, on the south by Solano, and on the west by Napa and Lake Counties. It includes 661,770 acres, of which 86 percent or 569,139 acres are privately owned; and 92,621 acres are public lands. There are 481,877 acres in farms and 87,262 acres in forest or grazing lands. Bounded on the east by the Sacramento River, most of the county is in the broad, level floor of the Yolo Basin. The land rises gradually westward into the low foothills of the Coast Range mountains which form the western border of the Sacramento Valley. Elevations are lowest from one to six miles west of the Sacramento River and highest along the western boundary, where a maximum elevation of 1,500 feet is reached. Drainage is northeastward toward the Sacramento River. The principal water resources are Cache and Putah Creeks and Willow Slough. Cache Creek flows from Clear Lake in Lake County and enters Yolo County at the northwestern corner. It flows southeastward and then eastward across the center of the county. Putah Creek rises in the mountains of Napa County and flows eastward forming the southern boundary of the county west of Davis. Both Cache and Putah Creeks are important streams during the rainy season but in the summer months their water disappears before entering the Yolo Bypass. They have cut their way through canyons in the mountains and deposited beds of sand and gravel in the broad valley.

Transportation. The main line of the Southern Pacific Railroad runs northward through Davis and Woodland. There are branch lines to Marysville, Winters, and Madison, and to Sacramento, which is on the main line to the east. The Sacramento Northern Railway and its branches operate freight trains in the eastern portion of the county. U. S. Highway 99 W is the main thoroughfare in the east central part of the county; State Highway 16 follows Cache Creek in the west connecting that area with Woodland and Sacramento; and State Highway 28 follows the southern boundary of the county connecting Winters, Davis, and Sacramento. In addition, a total of 875 miles of county and 112 miles of privately maintained roads complete the highway system.

Geology. The geology of Yolo County [1] is shown on the Geologic Map of California.

The eastern half of the county lying in the Sacramento Valley is covered with alluvium deposited by the Sacramento River and Cache and Putah Creeks in their flood periods. It includes some of the most fertile land in California. A belt of Pliocene non-marine sediments about 10 miles wide trends northwestward through the north-central portion of the county and a strip about four miles wide extends south along the Coast Range foothills to the southern border. Quaternary and Upper Pliocene sediments lie along the borders of the Pliocene non-marine sediments and the Quaternary alluvium. A narrow strip of upper Eocene marine sediments is exposed on the west side of Cache Creek for about 12 miles below Rumsey. The Coast Range, which forms the western border of the county, is covered with Upper and Lower Cretaceous marine sediments. In the extreme northwest corner of Yolo County, a small area of Tertiary volcanic rocks lies between Jurassic serpentine on the west and the Knoxville formation, which outcrops over an area of 25 square miles. Deposits of quicksilver have been mined in this small area and it is the

[1] Jenkins, O. P., Geologic map of California, scale 1:500,000: California Div. Mines, 1938.

only metal that has been produced in the county except for a small amount of gold and silver recovered from placers along Cache and Putah Creeks.

MINERAL RESOURCES

The principal resources of Yolo County are agricultural, and the value of farm products amounted to $42,957,714 in 1947. The total mineral production from 1873 to 1947 amounts to only $4,183,828. Quicksilver, produced from the mines in the northwestern corner of the county, was the chief mineral product, followed by miscellaneous stone, sandstone, and natural gas. A few thousand dollars in gold were mined from Cache and Putah Creeks. Some low grade gold quartz veins were found in the western foothills but no gold mines have been developed. Common brick was reported manufactured from clay beds near Woodland, Winters, and Capay,[2] but the industry has been idle for many years. Quicksilver mines are able to operate only in abnormal periods when the price of quicksilver is high. The mines were idle when the field work was done for this report. The principal activity was in the sand and gravel business, and practically all of this material was being used to build roads and driveways. Natural gas from two wells in the Fairfield Knolls gas field flows into the Rio Vista gas line, and there are four potential producing gas wells standing shut-in in the Dunnigan Hills area north of Woodland. There were 444 acres included in the proven gas fields in December, 1947.[3]

The mineral production of Yolo County, 1873-1947, is listed in table 1.

Building Stone [4]

Bluish-gray sandstone was quarried at the Devil's Gate, in Putah Canyon, about 9 miles west of Winters between 1894 and 1908. The stone occurs in beds from 12 to 15 feet thick, and it has frequently been split into slabs 14 feet long, 16 inches wide, and 10 inches thick. It has a smooth grain free from pebbles and was used for monuments and as a building stone for many years.

A volcanic tuff deposit occurs in the foothills west of Winters. Selected material was used to build houses in Winters many years ago. It is a soft whitish rock which becomes hard on exposure to the air and appears to weather remarkably well.

Clay

The manufacture of common brick was a thriving industry in the early days in Yolo County.[5] There were three brickyards operating in the southeastern part of Woodland. The clay was taken from a bed five to ten feet thick lying above a layer of sand. Both hand- and machine-made bricks were manufactured. They were burned in open kilns using willow and cottonwood wood for fuel. Hand-made bricks were made at Winters from a clayey loam taken from a bed about 20 feet thick which occurs on the north bank of Putah Creek. This material was mixed with some sand to make the brick. Bricks were also made in a brickyard near Capay from a clayey loam, which contained sufficient sand to prevent cracking.

[2] Watts, W. L., Yolo County: California Min. Bur. Rept. 10, pp. 791-792, 1890.
[3] California Oil Fields: California Div. Oil and Gas, vol. 33, no. 2, p. 82, 1947.
[4] Watts, E. L., Yolo County: California Min. Bur. Rept. 10, p. 791, 1890.
[5] Watts, E. L., Yolo County: California Min. Bur. Rept. 10, p. 791, 1890.

Table 1. Mineral production of Yolo County, 1873-1947.

Year	Quicksilver		Sandstone		Miscellaneous stone,[1] value	Miscellaneous and unapportioned		
	Flasks	Value	Cubic feet	Value		Amount	Value	Substance
1873	[2] 995	$79,928						
1874	3,000	315,540						
1875								
1876	965	42,460						
1877	1,516	56,547						
1878	1,640	53,956						
1879	1,110	33,134						
1880	422	13,082						
1881								
1894			2,500	$1,000				
1895			542	1,873				
1896			252	378				
1897								
1898			264	384				
1899			264	384				
1900			908	1,760				
1901			1,540	2,300				
1902			328	450				
1903			280	144				
1904			180	720				
1905			175	200				
1906			160	204				
1907			250	350				
1908			140	1,150				
1909								
1910								
1911								
1912								
1913								
1914	15	736						
1915	[3]				$1,200		$840	Other minerals.
1916					300			
1917	[3]				4,300		1,261	Other minerals.
1918	[3]				17,915		3,300	Other minerals.
1919	[3]				5,600		19,866	Other minerals.
1920					9,472			
1921					14,829			
1922					[3]		13,431	Unapportioned.
1923					[3]		16,957	Unapportioned.
1924					[3]		15,800	Unapportioned.
1925					23,060			
1926					20,560			
1927					17,895			
1928					17,200			
1929					14,400			
1930					2,700			
1931					21,500			
1932					21,625			
1933					16,694		129	Gold.
1934					37,850	1 fine oz.	1	Silver.
							176	Gold.
1935					33,950		715	Gold.
1936					71,434		175	Other minerals.
1937					40,765		1,330	Gold.
							4	Silver.
							2,072	Other minerals.
1938	[3]				44,598		3,634	Natural gas, quicksilver.
1939	[3]				61,057		2,087	Natural gas, quicksilver.
1940	[3]				24,208		85,612	Natural gas, quicksilver.
1941	[3]				130,085		151,218	Natural gas, quicksilver.
1942	[3]				150,066		467,352	Natural gas, quicksilver.
1943	[3]				38,653		326,523	Natural gas, quicksilver.
1944	[3]				52,724		341,575	Natural gas, quicksilver.
1945	[3]				118,309		361,501	Natural gas, quicksilver.
1946	[3]				203,936		283,876	Natural gas, quicksilver.
1947	[3]				70,276		191,152	Natural gas, quicksilver.
Totals	[3] 9,663	$595,383	7,783	$11,297	$1,287,161		$2,290,587	

Grand total value $4,184,428.

[1] Includes crushed rock, sand, gravel.
[2] Flasks of 76½ pounds, previous to June, 1904; of 75 pounds thence, through 1927; of 76 pounds since January, 1928.
[3] See under "Unapportioned."

Gold

Small scale placer mining has been done along the foothills of the Coast Range, and a small mining camp was located near the mouth of Putah Creek in the early days. A few thousand dollars in gold was produced from Putah Creek from 1933 to 1937.

Limestone

No limestone production has been recorded from Yolo County.[6] Years ago, mention was made of a limestone deposit reported to be in secs. 30 and 31, T. 10 N., R. 2 W., M. D., 3 miles south of Cadenassa Station.[7] Pliocene non-marine sediments occur [8] along the east side of this valley. The higher land on both sides of the valley is occupied by older marine sedimentary rocks, principally Upper Cretaceous, and in these rocks it is not unusual to find occasional small bodies of hard limestone. This is probably the explanation of the lumps and boulders of such limestone found, which could not be traced to a deposit in place. The soft limestone may eventually have value for agricultural use.

Table 2. Analysis of samples of "float" limestone, Yolo County.

Float limestone	J. H. Cranston	Stephens A. & L. Co.
SiO_2	6.60%	1.40%
R_2O_3	0.60	0.50
CaO	50.23	54.25
MgO	0.70	-----
CO_2	40.90	42.65
H_2O and volatile	1.00	1.10
	100.15%	99.90%

Mineral Water

There are a number of mineral springs in the hills in the western part of Yolo County [9] but none of them have been commercialized.

A saline spring flows on the line between secs. 25 and 26, T. 12 N., R. 5 W., M. D., near the Reed mine. There is a soda spring in the same area, and a sulphur spring above Fiske Creek, west of Rumsey on the Reed mine road. A sulphur-iron-magnesia spring located on the Smith Ranch, 4 miles west of Guinda, is used domestically but two white sulphur springs on the same property are unused.

There are several sulphur springs on Putah Creek near Devil's Gate, west of Winters.

Miscellaneous Stone

The principal mining activity in Yolo County in 1948 was the production of sand and gravel from pits on Cache and Putah Creeks. These creeks carry a considerable amount of water where they first enter the county but the volume decreases as they flow eastward. Cache Creek flows southeastward from the northwestern corner of the county, turns eastward in the vicinity of Capay, and continues through the central portion of the county towards the Sacramento River. Its banks are gravel, covered with sandy, tan soil. They are about 5 feet high where the stream

[6] Logan, C. A., Limestone in California: California Div. Mines Rept. 43, p. 350, 1947.
[7] Bradley, W. W., Yolo County: California Min. Bur. Rept. 14, p. 368, 1913.
[8] Jenkins, O. P., Geologic map of California, scale 1:500,000, California Div. Mines, 1938.
[9] Bradley, W. W., Yolo County: California Min. Bur. Rept. 14, p. 369, 1913.

enters the valley near Capay, but rise from 10 to 20 feet in places between Esparto and Yolo. Shifting seasonable waters have deposited sand, gravel, and silt in layers and lenses on terraces and bars half a mile wide in many places along its course. The few boulders and cobbles seldom exceed 6 inches in size. The cobbles and coarse pebbles are mostly red, green, and brown jasper, often having many thin seams of white quartz. The greatest amount of the gravel consists of subangular and rounded pebbles of volcanic origin, mostly andesite. Serpentine pebbles were noted only in the gravel taken from creeks in the western portion of the county.

Putah Creek rises in the mountains of Napa County and flows eastward to form 24 miles of the southern boundary of Yolo County. Like Cache Creek, it flows a torrent in the rainy season but it is confined in a narrower channel with banks 20 to 30 feet high. There are few boulders, and the gravel consists of subangular pebbles of volcanic origin including white and gray andesite and rhyolite, red basalt, angular fragments of quartz, red and green jasper, and some serpentine. Gravel pits are located on terraces and bars in Putah Creek south of Winters where the channel is about a quarter of a mile wide.

The Cache Creek Sand and Gravel Company (Yolo Gravel Company) is owned and operated by Leroy Kerr, Box 34, Yolo, California. It is located on the north bank of Cache Creek in the W½ sec. 14, T. 10 N., R. 1 E., M. D., on land owned by Kerr; an adjoining quarter of a mile northeast along the creek is leased from Lois C. Campbell of San Francisco. The gravel lies in two broad benches from 5 to 10 feet above the creek. It is 2,500 feet wide on the south end and 300 feet wide on the end half a mile northeast. There are no boulders and few cobbles at this location. The gravel is dug about 6 feet deep where a layer of clay is encountered. Equipment includes a Bay City dragline fitted with a 30-foot boom and a ½-cubic-yard bucket; a P & H dragline with a 30-foot boom and a ⅝-cubic-yard bucket; a P & H shovel with a ¾-cubic-yard bucket; and seven dump trucks having 4-, 5-, 7-, and 8-cubic-yard capacities.

The washing and screening plant includes a 25-cubic-yard wooden hopper into which the trucks discharge the material dug from the pit. An apron feeder below the hopper feeds a belt conveyor 18 inches wide and 175 feet long, which is driven by a 10-horsepower motor. The conveyor discharges the material into a trommel 4 feet in diameter and 16 feet long having ¾- and 1½-inch holes. Material over 1½-inch in size drops into a 20-cubic-yard bin and is hauled to a stock pile. It is sold principally for filling drains. The minus 1½-inch material goes to a 3- by 6-foot double-deck vibrating screen driven by a 5-horsepower motor. Bins holding 20 cubic yards each are provided for —1½ to +¾-inch, —¾ to +⅜-inch material, and sand. All the material is washed as it passes through the trommel and on the screens. Wash water is pumped from a well 187 feet deep by a Layne and Bowler pump driven by a 20-horsepower motor. The water in Cache Creek sinks beneath the surface in this pit at a horizon about 8 feet below the surface of the surrounding gravel. The sand is dewatered in a spiral classifier. Trucks are loaded through gates in the bottom of the bins.

Stock piles of screened gravel are maintained at the plant. The gravel is used for road base and shoulders, driveways, and corrals. Specified amounts of the washed and screened products of this plant were used for concrete aggregate in building the new highway bridge at

Rumsey. Floyd Duncan is superintendent, and nine men are employed. The Sanders pit is located about a mile southwest.

Frank B. Goodwin and son have been loading 300 to 400 cubic yards of gravel per month from the Sanders pit since 1946. The Sanders pit is located on the south bank of Cache Creek in the E½NE¼ sec. 23, T. 10 N., R. 1 E., M. D., on land owned by E. E. Sanders. The creek bed is a quarter of a mile wide here, and two broad terraces stand five and ten feet above the stream. The gravel on both banks is covered with about 12 feet of silty tan soil. A band of sandy silt about 5 inches thick lies above the gravel in the creek bed and marks the horizon that was covered in flood stage. Goodwin said that the holes they dig each year are filled again in the rainy season when the creek is in flood. The gravel is dug about 7 feet deep with a Hanson dragline equipped with a 30-foot boom and a ½-cubic-yard bucket. Power is supplied by a Hercules gasoline engine. The dragline and engine are mounted on a Studebaker truck chassis. There are no boulders and few cobbles in this pit, and the material looks clean and free from silt. It is used to build driveways and roads. A small amount is used as concrete aggregate for driveways and floors. Goodwin and his son work the pit without additional help. Sanders is paid a royalty on the material removed.

The Joe Schwarzgruber pit is located about half a mile southwest, and the Cache Creek Sand and Gravel Company pit operated by Leroy Kerr is located across the creek about a mile northeast.

Parish Brothers, general contractors of Benicia, are digging sand and gravel from Putah Creek about three-fourths of a mile southeast of the Winters Bridge on land owned by R. W. Rice. The gravel lies on a bar about 200 feet wide on the southeast side of the stream. It is about 3 feet higher than the water level in the dry season. The pebbles are smooth and subangular, 85 percent being less than 1 inch in size, and 50 percent less than a quarter inch. The material is dug 6 to 8 feet deep to a clay stratum with a No. 40 Lorain dragline equipped with a 50-foot boom and a ¾-cubic yard bucket. It is loaded into eight 5-cubic-yard dump trucks and hauled about three miles southeast to a Cedar Rapids crushing and screening plant. The loaded trucks are weighed on a 20-ton capacity Fairbanks-Morse platform scale.

At the crushing and screening plant the trucks dump the pit material into a steel hopper 8 feet square on top, with an inverted pyramid-shaped bottom. It is drawn from the bottom of the hopper onto a conveyor belt by a reciprocating feeder. The conveyor belt is 30 inches wide and 50 feet long, and it discharges the material over a 4- by 12-foot double-deck shaker screen. Material larger than 1½ inches drops into a 10- by 36-inch jaw crusher. Gravel over 1 inch in size slides into a set of 40- by 40-inch rolls. The undersize from both the jaw crusher and rolls is lifted by a wheel-type elevator 8 feet in diameter and discharged onto a conveyor belt 24 inches wide and 25 feet long which returns it to the shaking screen. All the material less than 1 inch in size slides to a conveyor belt stacker 30 inches wide and 50 feet long and is sent to the stock pile. None of the material is washed at this plant. It is all used for road base material for the new Highway 40 on the Fairfield by-pass. The contract calls for 35,000 tons of material. About 1,500 tons is dug per day. C. A. Farnquist is superintendent and 14 men are employed.

FIGURE 1. State of California, Division of Highways equipment loading gravel from Cache Creek southeast of Woodland.

Joe Schwarzgruber owns and operates a sand and gravel pit on the south side of Cache Creek in sec. 22, T. 10 N., R. 1 E., M. D. The gravel is about a quarter of a mile wide along the creek and lies in two broad terraces from five to ten feet above the water level in the dry season. There are no large boulders and few cobbles. The gravel is dug 8 feet deep to a clay formation with a P & H dragline fitted with a 30-foot boom and a $\frac{1}{2}$-cubic-yard bucket. Four dump trucks of four and five cubic-yards capacity haul the gravel to the screening plant, which is located near the road above the creek. The gravel is dumped into a hopper having a capacity of 20 cubic yards. It is drawn from the hopper by an apron feeder and dropped on a belt conveyor 18 inches wide and 125 feet long, which discharges it over a screen. The minus $1\frac{1}{2}$-inch material drops onto a shaking screen, which separates the material into the following sizes: minus $1\frac{1}{2}$, $+\frac{3}{4}$-inch; minus $\frac{3}{4}$, $+\frac{3}{8}$-inch; and minus $\frac{3}{8}$-inch. All material is washed with sprays on the screens and the minus $\frac{3}{8}$-inch material is dewatered in a drag-type classifier 20 inches wide and 15 feet long. Wash water is pumped from a well 6 inches in diameter and 70 feet deep with a Sterling pump driven by a $7\frac{1}{2}$-horsepower motor. Four bins, each of 30 cubic yards capacity are provided for the screened materials. They are built of 10- by 10-inch timber and have steel-lined floors. The material is drawn from the bins through horizontal sliding steel gates into trucks. The plant has a capacity of 300 cubic yards per day but production averages about 100 cubic yards in 8 hours. About 50 percent of the material is sold for roads and driveways, and 50 percent for concrete aggregate.

Joe Schwarzgruber and his son operate the plant and employ two men. The Sanders pit operated by Frank Goodwin and Yolo County is about a mile northeast. No plants are operating on Cache Creek west of the Schwarzgruber plant, except the Dudley Stephens pit north of Esparto.

Yolo County purchased 1,910 cubic yards of gravel at 35 cents per cubic yard from this plant in the six-month period from July to December, 1948.

The State of California is digging sand and gravel from the dry bed of Cache Creek in sec. 12, T. 10 N., R. 2 E., M. D., on land owned by Frank King. An International TD-14 bulldozer is used to push the material from the pit to feed a Michigan Model TMDT dragline. The dragline is equipped with a 30-foot boom and a $\frac{3}{8}$-cubic-yard clam-shell bucket. The gravel is dug in strips about 200 feet long across the creek bed and from 4 to 6 feet deep to a layer of clay. It is loaded onto dump trucks of 4 cubic yards capacity and used to build road shoulders. The material in this pit is mostly sand and small pebbles. Few pieces are over $\frac{3}{4}$-inch in size.

The Stephens sand and gravel plant is located on the south bank of Cache Creek $1\frac{1}{2}$ miles northeast of Esparto on land owned by C. L. Barr. The gravel is dug from a pit about 100 feet wide, which extends 200 feet northeast to the creek. The gravel is about 4 feet higher than the water level and it is dug about 6 feet below the water to a layer of cobbles. Digging is done with a $1\frac{1}{4}$-cubic-yard scraper pulled by a double-drum hoist driven by an International TD-18 diesel engine. The hoist and engine are mounted on a steel frame fitted with tractor treads. The scraper pulls the gravel into a 10- by 12-foot wooden hopper, which has an inverted pyramid-shaped bottom. Gravel is drawn through a gate

in the bottom onto a portable conveyor belt 20 inches wide and 80 feet long which is mounted on a steel frame. The sand and gravel are discharged from the conveyor into a steel trommel 3 feet in diameter and 6 feet long. The trommel is driven by a V-belt from an Allis-Chalmers, four-cylinder gasoline engine. Material less than 1½ inch in size drops into a 10- by 10- by 10-foot steel bin, from which it is drawn through a horizontal steel gate into trucks. Material over 1½ inches in size slides from the trommel into a wooden bin 10 feet square and 6 feet deep, from which it is drawn into trucks and dumped along the creek bank to prevent further stream erosion. A small amount of this coarse material is sold and used for drains. Stephens employs one man, and the plant has a capacity of 150 cubic yards per day. The material is used for road base and shoulders. Some of the pit run material is used for concrete aggregate to build driveways, sidewalks, and heavy slabs. Yolo County purchased 4,506 cubic yards from this pit in the six month period ending December 1948. It was used for road-base and shoulders.

Sutter County is digging sand and gravel from the bed of Cache Creek in sec. 11, T. 10 N., R. 2 E., M. D., on land owned by Mamie C. Ashley. The creek bed is about a quarter of a mile wide between the levee walls. Trucks are loaded with a P & H dragline equipped with a 20-foot boom and a ¾-cubic-yard bucket. The gravel is mostly fine, few pebbles being over ¾-inch in size, and it is dug about 5 feet deep to a layer of clay. Long strips of heavy hog wire fence material 30 inches wide are laid on the dry creek bed to enable the trucks to travel over it without bogging down.

Some shallow pits in Cache Creek on each side of Road 102 show that sand and gravel has been loaded there recently.

The Valley Gravel Company is operated by Robert Moran of Dixon. Sand and gravel is dug from a bar on Putah Creek just west of the Winters bridge on land owned by Jim Boyce of Winters. The bar is 150 feet wide, 300 feet long, and stands about 3 feet above the water. The gravel is dug with a scoopmobile loader equipped with a ¾-cubic-yard shovel. It is loaded into trucks and used locally for roads, corrals, and as a concrete aggregate for driveways and slabs. The Winters Gravel Service pit adjoins on the west.

Winters Gravel Service is operated by Roger G. Manas, Box 455, Winters, California. Sand and gravel is loaded from a bar on Putah Creek a quarter of a mile southwest of the Winters bridge on land owned by Mrs. Lucy Judy of Winters. The bar is about 100 feet wide, 1,200 feet in length, and stands 3 feet above the water. There are no boulders, and 85 percent of the material is less than 1 inch in size. The gravel is dug to a depth of 7 feet with an Austin-Western dragline equipped with a 30-foot boom and a ¾-cubic-yard bucket. Manas works alone and loads trucks on call. The pit material is used for building roads and driveways. A small amount is used as an aggregrate for concrete driveways and slabs. The property adjoining on the east is operated by Robert Moran of Dixon. The Parish Brothers pit is about half a mile southeast.

The Woodland Transit Concrete Company, a partnership composed of King Lindale, and Robert J. and Thomas W. McCoy, operates a Noble concrete batching plant on the north side of Woodland in SE¼ sec. 20, T. 10 N., R. 2 E., M. D. Washed and screened rock, sand, and gravel is dumped from trucks into a steel-lined concrete bin, which is divided into

four 30-cubic-yard compartments. The desired size of material is drawn from the compartments through steel gates onto an 18-inch by 250-foot conveyor belt which runs beneath the bins. It is delivered to four 25-cubic-yard bins at the Noble batching plant. The bins are filled with sand, ¾-inch gravel, 1½-inch rock, and a specified mixture of these sizes for concrete aggregate. The desired materials are weighed into a 2-cubic-yard hopper before they are drawn into the batching trucks. The cement is delivered to the plant in trucks which are emptied into a 3- by 5-foot inverted pyramid-shaped hopper beneath the batching plant. A 10-inch screw conveyor draws the cement from the hopper and feeds a bucket elevator, which delivers it to a 1,200-cubic-foot steel hopper at the same elevation as the aggregate bins. The required amount of cement is weighed into a canvas "sock" and is discharged into the transit-mix trucks with the aggregate. Water is pumped from a well 280 feet deep into a tank, from which it is drawn into the 200-gallon tanks mounted on the transit-mix trucks. There are three International trucks of 4½ cubic yards capacity each. They can deliver 150 cubic yards of concrete in an eight hour shift. Concrete made from materials mixed at this plant passed a 2,500 pound compression test in 28 days. Specifications for a recently built school building called for 1,440 pounds of sand, 325 pounds of 1½-inch rock, 1,762 pounds of ¾-inch gravel, 669 pounds of cement, and 0.5 pound of an admix per cubic yard of concrete. It required 26 gallons of water per cubic yard of concrete.

Yolo County is loading sand and gravel from a pit on the south side of Cache Creek in sec. 23, T. 10 N., R. 1 E., M. D., on land owned by E. E. Sanders.

The gravel is dug about 6 feet deep to a clay stratum. It is loaded into dump trucks of 4 cubic yards capacity and used to build roads. The trucks are loaded with a P & H dragline equipped with a 30-foot boom and a ½-cubic-yard bucket. A royalty of five cents per cubic yard was paid to the owner of the pit. In the six months period from July to December, 1948, Yolo County loaded 2,322 cubic yards of road material from this pit.

Yolo County also loads some gravel from pits east of Davis in sec. 24, T. 8 N., R. 2 E., M. D., on land owned by Lloyd Barnett and in sec. 6, T. 8 N., R. 4 E., M. D., on land owned by Fred Smith. The material is used for road base and shoulders in the vicinity of Davis. A small quantity of material is also taken from Cache Creek in sec. 12, T. 10 N., R. 1 E., and sec. 12, T. 10 N., R. 2 E., M. D., and used for road repairs. About 10,000 cubic yards of sand dredged from the Sacramento River in the Clarksburg district is also used by Yolo County for road building each year.

Natural Gas

The most active search for oil or gas in Yolo County has been in the Dunnigan Hills area about 12 miles northwest of Woodland, the Fairfield Knolls area northeast of Winters, and in the Rumsey Hills area east of Rumsey. The Texas Company drilled five wells in T. 11 N., R. 1 W., M. D., in 1947 and two of them were successfully completed. A well in sec. 22, T. 11 N., R. 1 W., struck gas between 2,400 and 2,620 feet in depth in a formation thought to be lower Eocene. The Fairfield Knolls gas field [10] is located in secs. 29 and 32, T. 9 N., R. 1 E., M. D., six miles

[10] Kirby, J. M., Fairfield Knolls gas field and Rumsey Hills area: California Div. Mines Bull. 118, pp. 599-605, 1943.

northeast of Winters. A series of small hills projecting a few feet above the valley alluvium and exposing the Red Bluff and Tehama sediments, is the only evidence of folding in the vicinity. Reflection seismograph work during 1935-36 and 1937 resulted in the definition of an anticlinal fold of low structural relief trending northwestward. The Standard Oil Company Hooper No. 1 well located in the NE¼ sec. 32, T. 9 N., R. 1 E., M. D., found gas in commercial quantities between 3,675 and 3,714 feet in August 1937. Drilling was continued to a depth of 5,181 feet without finding additional gas-bearing sands. The well was plugged to 3,400 feet, redrilled to 3,700 feet, and 6⅝-inch diameter casing cemented at 3,669 feet. A generalized stratigraphic sequence in the field based on the log of the well shows: upper Pliocene (Tehama formation), a few inches to 2,563 feet; upper and middle Eocene (includes recognized Markley, Domengine, and Capay formations), 2,563 to 4,170+ feet; upper Cretaceous (Chico series) 4,170+ to 5,181 feet. This well is now connected to the Rio Vista gas line. Analysis of gas from this well shows 0.14 percent hydrogen, 7.88 percent nitrogen, and 91.98 percent methane.

A second well drilled by the Standard Oil Company located in the SE¼ sec. 29, T. 9 N., R. 1 E., M. D., called the Corcoran No. 1 was completed September 19, 1939, at a depth of 3,682 feet. The top of the Hooper sand was logged at 3,682 feet and a 6⅝-inch diameter casing was cemented at 3,634 feet. This well is also connected to the Rio Vista gas line. The Shell Oil Company gas well in lot 7, sec. 18, T. 8 N., R. 1 E., M. D., drilled in 1947 is shut in.

The Rumsey Hills anticline[11] trends northwestward along the western foothill belt from Capay in T. 10 N., R. 2 W., M. D., to the northwest corner of T. 13 N., R. 3 W., M. D., in Colusa County, a distance of about 22 miles. The presence of natural gas in springs throughout the area called attention to the possibilities of developing commercial wells. Attempts to develop oil or gas through drilling dates back to the period from 1900 to 1903 when four wells were drilled in sec. 7, T. 12 N., R. 3 W., M. D., in Colusa County without favorable results. Several holes have been drilled in recent years along this anticline in T. 12, 13 N., R. 3 W., M. D., ranging from 570 to 6,764 feet in depth without developing commercial amounts of gas or oil.

A wildcat well drilled midway between Winters and Madison in sec. 28, T. 9 N., R. 1 W., M. D., was abandoned at a depth of 5,486 feet. Another wildcat well in the southeastern portion of the county in sec. 10, T. 6 N., R. 3 E., was abandoned at a depth of 4,912 feet.

There were 444 acres included in the proved acreage of Yolo County, December 31, 1947.[12]

Quicksilver

The quicksilver deposits of Yolo County are located in the northwestern corner of the county near the common border with Lake and Napa Counties. Cinnabar and metacinnabar occur in fractures and small seams and disseminated in hard, black, silicified Franciscan sediments in or near intrusive peridotite which has been altered to serpentine.[13]

[11] Kirby, J. M., Rumsey Hills area: California Div. Mines Bull. 118, pp. 601-605, 1943.

[12] Proved acreage by counties, December 31, 1947: California Div. Oil and Gas, Summary of Operations California Oil Fields, vol. 33, no. 2, p. 82, 1947.

[13] Jenkins, O. P., Economic mineral map of California, No. 1—Quicksilver: California Div. Mines, 1939.

The Harrison (New England, Ruby, and January) mine is located in secs. 26 and 35, T. 12 N., R. 5 W., M. D. It is owned by Madge J. Harrison and associates. It had a small production prior to 1900 but its period of greatest activity was during World War I. A concentrating plant consisting of a coarse crusher, ball mill, Wilfley, and Diester tables was built in 1918 to treat 150 tons of ore per day. Production statistics compiled by the U. S. Geological Survey in 1945 [14] credit the property with a production of 220 flasks in 1919 and a total production of 374 flasks to the end of 1945. The property was last operated by the Yo-Lake Mineral Company in 1943. It is described in an earlier report.[15]

The Reed (California) mine includes 370 acres of land in secs. 23, 24, 25, and 26, T. 12 N., R. 5 W., M. D., for which a patent was issued to the California Quicksilver Mining Company on October 2, 1875. The first production of 995 flasks was made in 1873. The mine was credited with a production of 9,648 flasks by 1880 and had a total production of 21,177 by the end of 1945.[16]

The Bradley Mining Company, 425 Crocker Building, San Francisco, acquired a grant of the mineral rights to the Reed mine from George A. Newhall and his wife on June 11, 1940, and a new period of activity commenced. During their operation Charles Boyd of Monticello was superintendent, and over 11,000 flasks of quicksilver were produced during the war years. Operations were suspended in November 1947, because of the increased cost of mining and the low price for quicksilver. A description of the property is given in an earlier publication.[17]

MINERAL COMMODITY SURVEY

The Spreckels Sugar Company at Woodland and the American Crystal Sugar Company at Clarksburg were the principal consumers of minerals in Yolo County in 1948. They used the following amounts of these minerals:

Diatomite—334,500 pounds. It was a processed product which was calcined and fluxed. The shape of the diatoms is important in the filtering process and not all types of California diatomite are suitable. It is used in a powdered form. The material was purchased from the Johns-Manville Products Corporation at Lompoc and from the Dictolite Company of Terrebonne, Oregon.

The sugar refining process using vertical kilns requires a dense, high-grade limestone which will not shatter and clog the kilns when it is burned. It is required in lumps from $1\frac{1}{2}$ to 6 inches in size. The suitability can be determined only by trial, but the chemical analysis must run over 98 percent $CaCO_3$ and less than 0.1 percent iron, 0.2 percent magnesium, and 0.5 percent silica. The limestone used in the sugar refineries of Yolo County amounted to 32,000 tons in 1948. It was purchased from the California Rock and Gravel Company at Auburn, and the El Dorado Limestone Company at Shingle Springs. In the refining processes the CO_2 is returned to the calcines, and the resulting chalklike product is used on the beet fields as a soil conditioner.

[14] Quicksilver production of Knoxville District: U. S. Geol. Survey Pamph., January 1947.

[15] Ransome, A. L., and Kellogg, J. L., Quicksilver resources of California: California Jour. Mines and Geology, vol. 35, p. 475, 1939.

[16] Quicksilver production of Knoxville district: U. S. Geol. Survey Pamph., January 1947.

[17] Averill, C. V., Reed mine: California Jour. Mines and Geol., vol. 39, p. 322, 1943.

*Tabulated list of mining properties in Yolo County, 1948.**

Number	Name of claim or mine	Owner (name and address)	Location				Mineral product	Remarks and references
			Sec.	T.	R.	B & M		
3	Ashley gravel pit	Mamie C. Ashley	11	10N	2E	M.D.	Sand and gravel	Sutter County operation, Cache Creek.
4	Barnett gravel pit	Lloyd Barnett	1	8N	3E	M.D.	Sand and gravel	East of Davis, Yolo County operations.
5	Cache Creek Sand and Gravel Company	Leroy Kerr, Box 34, Yolo, California	14	10N	1E	M.D.	Sand and gravel	
1	Harrison (New England, Ruby, and January) mine	Madge J. Harrison, et al	26, 35	12	5W	M.D.	Quicksilver	Idle. B. 27, p. 117; B. 78, p. 204; B. 78, p. 346; R. 12, p. 363; R. 13, p. 598; R. 14, p. 369; R. 35, p. 475.
6	King gravel pit	Frank King	12	10N	2E	M.D.	Sand and gravel	Pit is operated by California State Div. of Highways.
2	Reed (California) mine	Bradley Mining Co., 425 Crocker Bldg., San Francisco	23, 24, 25, 26	12N	5W	M.D.	Quicksilver	Idle. B. 27, p. 117; B. 78, p. 205; R. 13, p. 604; R. 14, p. 369; R. 28, pp. 318, 319, 326; R. 39, p. 322.
7	Rice gravel pit	R. W. Rice, Winters, California	28	8N	1W	M.D.	Sand and gravel	Pit is located on Putah Creek about ¾ mi. southeast of Winters bridge. Operated by Parish Brothers, Contractors, Benicia, California.
8	Sanders pit	E. E. Sanders	23	10N	1E	M.D.	Sand and gravel	Yolo County is digging gravel at this pit.

9	Sanders pit	E. E. Sanders	23	10N	1E	M.D.	Sand and gravel	South bank of Cache Creek. Frank B. Goodwin and Son also load gravel from Sanders pit a few hundred feet southwest of the Yolo County operation.
10	Schwarzgruber sand and gravel plant	Joe Schwarzgruber	22	10N	1E	M.D.	Sand and gravel	South side of Cache Creek.
11	Smith gravel pit	Fred Smith	6	8N	4E	M.D.	Sand and gravel	Yolo County operations near Davis.
12	Stephens sand and gravel plant	C. L. Barr					Sand and gravel	South bank of Cache Creek 1½ mi. northeast of Esparto Land, owned by C. L. Barr.
13	Valley Gravel Co. pit	Jim Boyce, Winters, California	22	8N	1W	M.D.	Sand and gravel	Operated by Robert Moran, Dixon, California; Putah Cr. near Winters Bridge.
14	Winters Gravel Service pit	Mrs. Lucy Judy, Winters, California	28	8N	1W	M.D.	Sand and gravel	On Putah Creek ¼ mi. S.W. of Winters bridge.
15	Woodland Transit Concrete Co.	(A partnership) King Lindale, Robert J. and Thomas W. McCoy	SE¼, 20	10N	2E	M.D.	Concrete, Concrete mix.	Batching concrete aggregate to specifications and delivering it in Transit-Mix trucks.

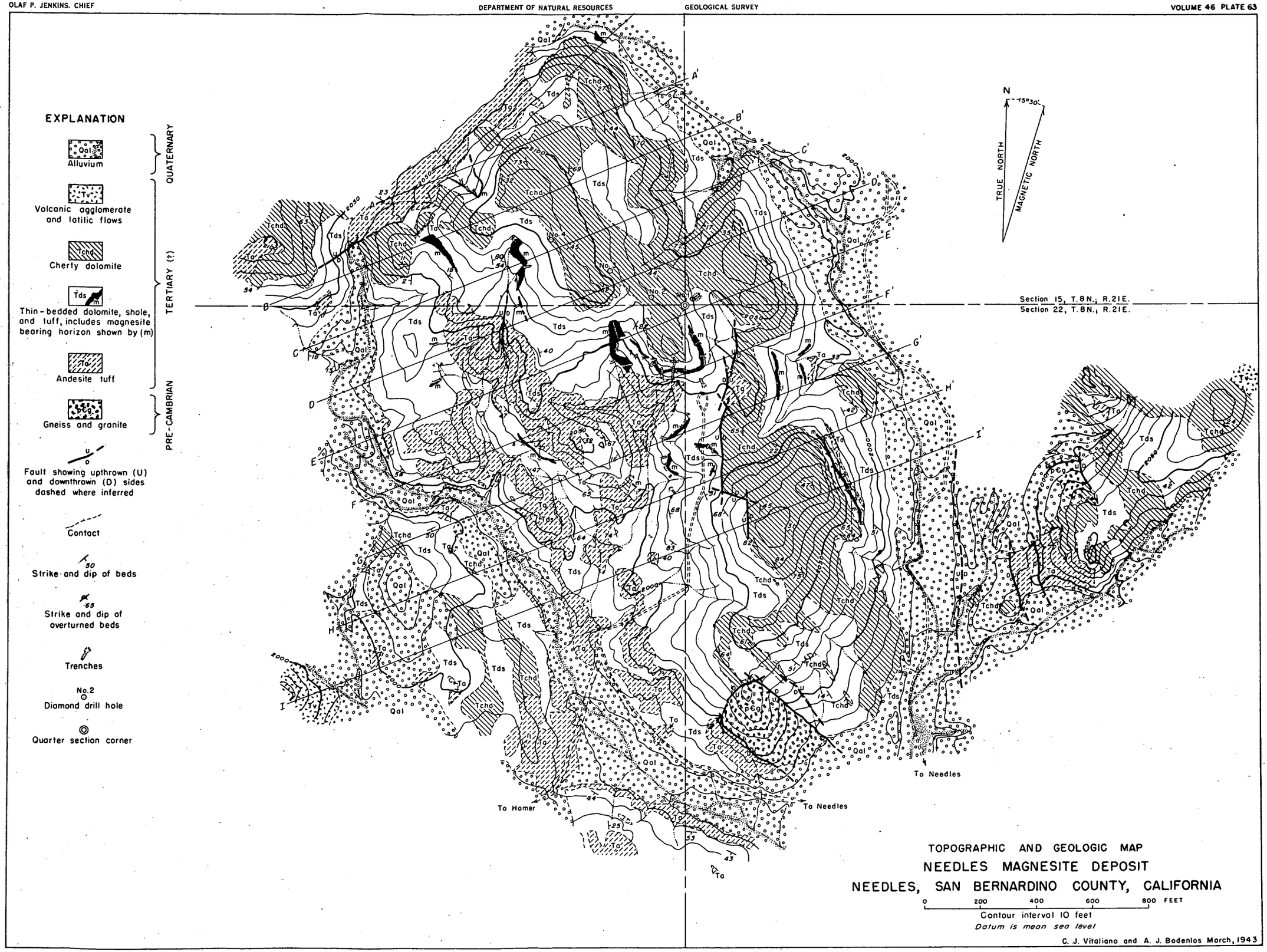
* References are to reports and bulletins published by the California State Division of Mines.

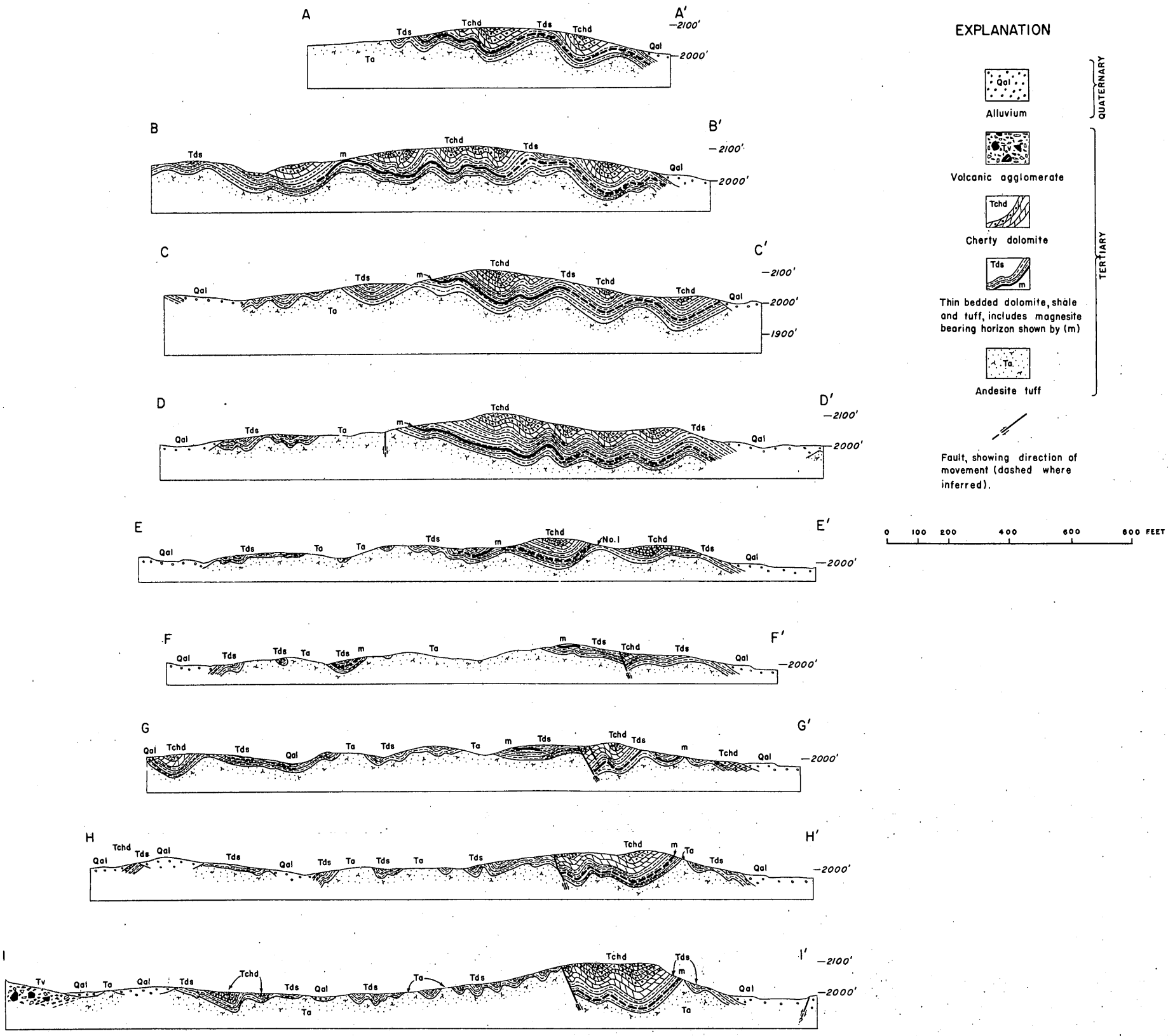
The sugar refineries used 266,400 pounds of commercial grade soda ash in 1948. It contained not less than 58 percent Na_2O and it was purchased in granular form, packed in 100 pound bags. The soda ash is used to precipitate the lime and it reduces the amount carried in solution. Some 26,650 pounds of caustic soda were used in the refineries in 1948. It was the ordinary commercial grade that is marketed in 400 pound metal drums.

One sugar refinery used 84,620 pounds of sulphur in 1948. It was purchased in crude lump form containing 99½ percent sulfur. Another company used 60,000 pounds of liquid sulphur dioxide in 1948. It was delivered in tank cars.

o

23300 3-50 2,500


EXPLANATION
QUATERNARY
Qal
Alluvium
TERTIARY (?)
Tv
Volcanic agglomerate and latitic flows
Tchd
Cherty dolomite
Tds
m
Thin-bedded dolomite, shale, and tuff, includes magnesite bearing horizon shown by (m)
Ta
Andesite tuff
PRE-CAMBRIAN
Gneiss and granite
U
D
Fault showing upthrown (U) and downthrown (D) sides dashed where inferred
Contact
50
Strike and dip of beds
65
Strike and dip of overturned beds
Trenches
No.2
Diamond drill hole
Quarter section corner
N
15°30'
TRUE NORTH
MAGNETIC NORTH
Section 15, T.8N., R.21E.
Section 22, T.8N., R.21E.
To Needles
To Needles
To Homer
TOPOGRAPHIC AND GEOLOGIC MAP
NEEDLES MAGNESITE DEPOSIT
NEEDLES, SAN BERNARDINO COUNTY, CALIFORNIA
0 200 400 600 800 FEET
Contour interval 10 feet
Datum is mean sea level
C. J. Vitaliano and A. J. Bodenlos March, 1943

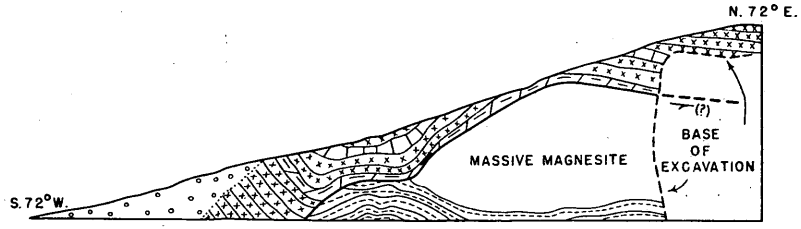


GEOLOGIC SECTIONS

OF THE

NEEDLES MAGNESITE DEPOSIT

C.J.Vitaliano & A.J.Bodenlos March, 1943



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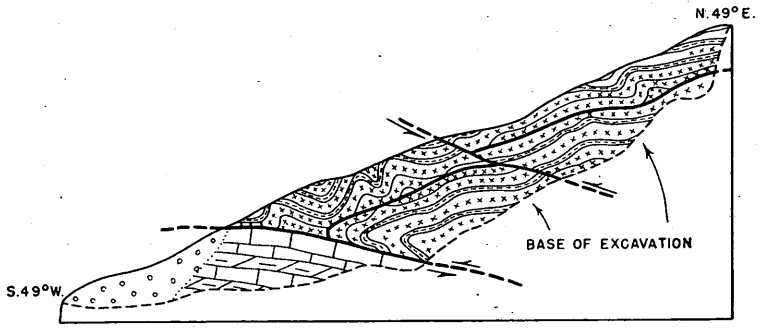

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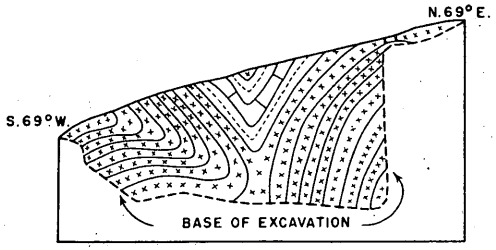

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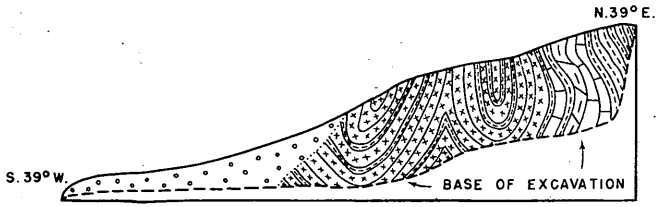

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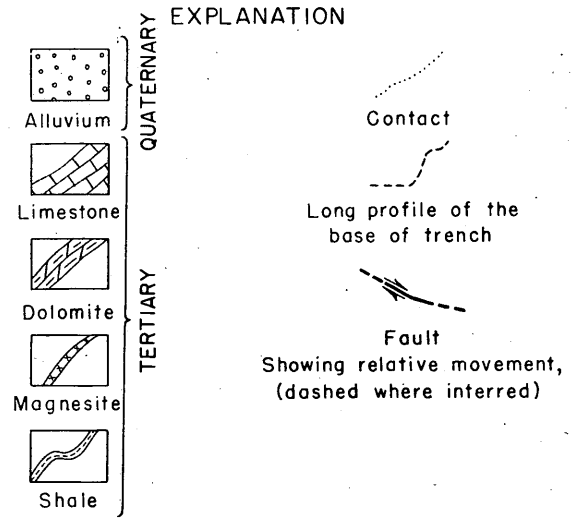


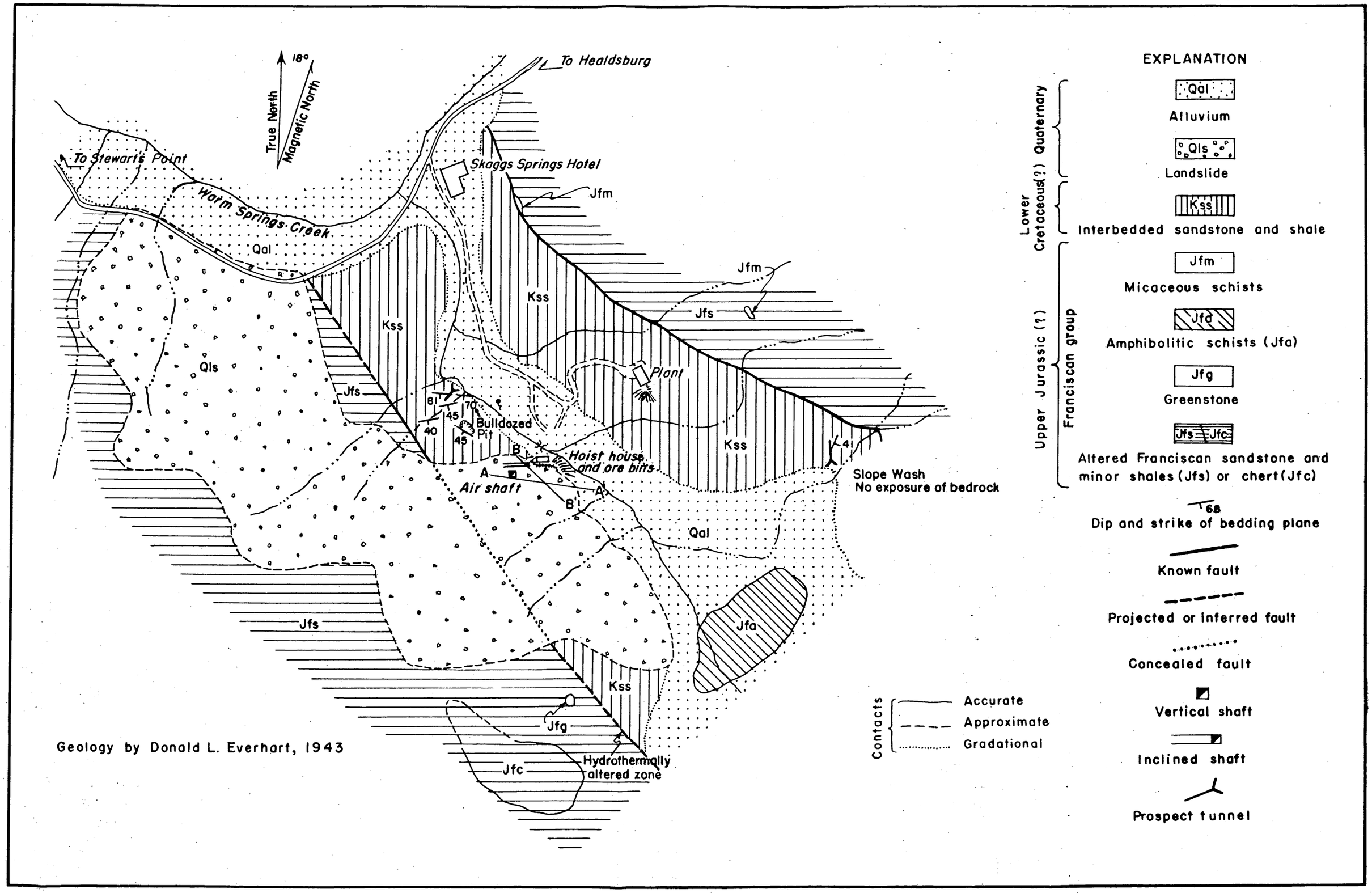
GEOLOGIC SECTION EXPOSED ALONG TRENCHES

NEEDLES MAGNESITE DEPOSIT

NEEDLES, SAN BERNARDINO COUNTY, CALIFORNIA.

0 5 10 20 FEET

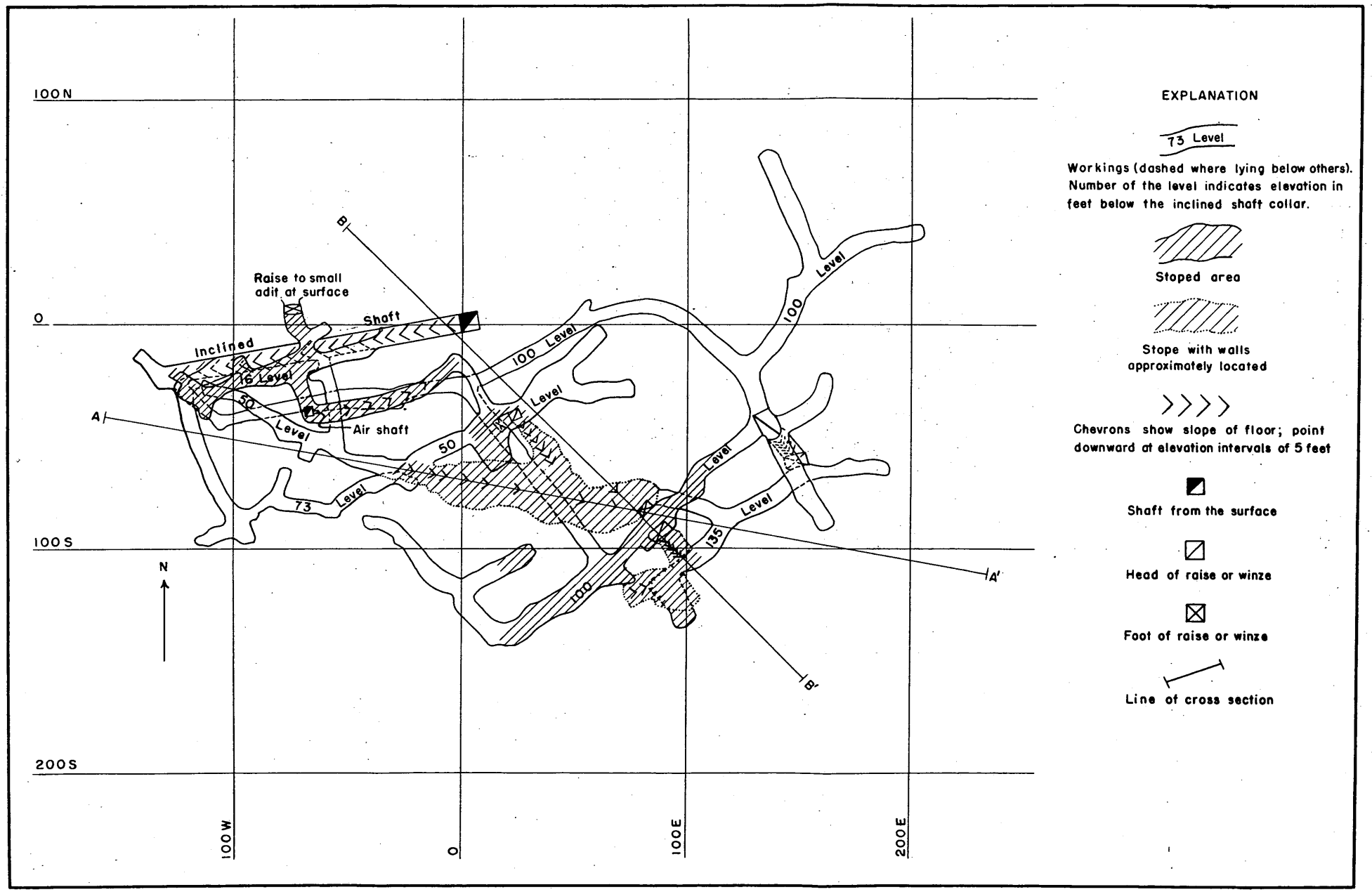
Geology by C. J. Vitaliano, March, 1943



GEOLOGIC SKETCH MAP OF THE VICINITY OF THE SKAGGS SPRINGS QUICKSILVER MINE, SONOMA COUNTY, CALIFORNIA

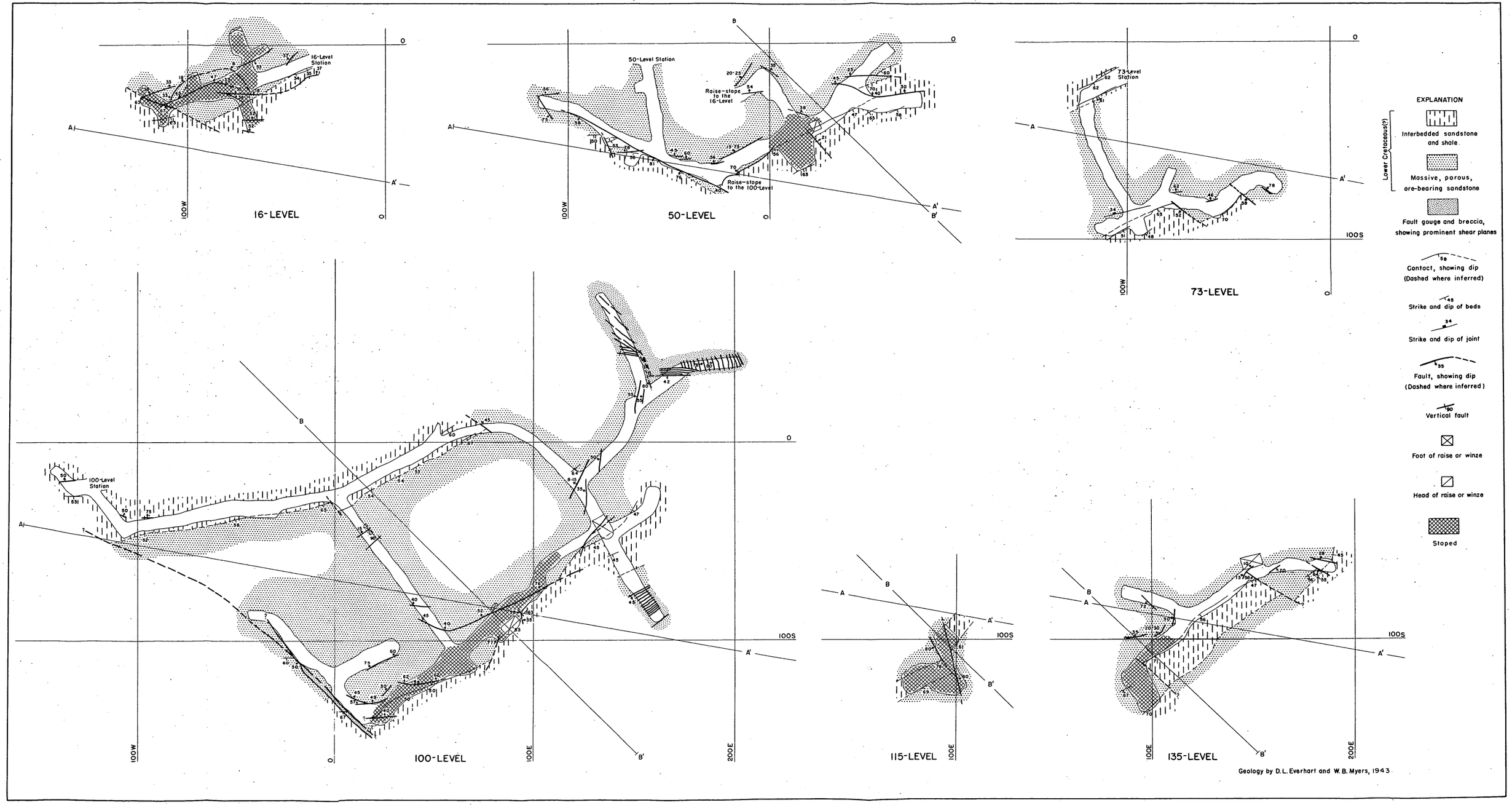
Approximate scale
0 400 800 1200 Feet

Enlarged 4X from geology plotted on aerial photographs (Scale: 1/20,000)



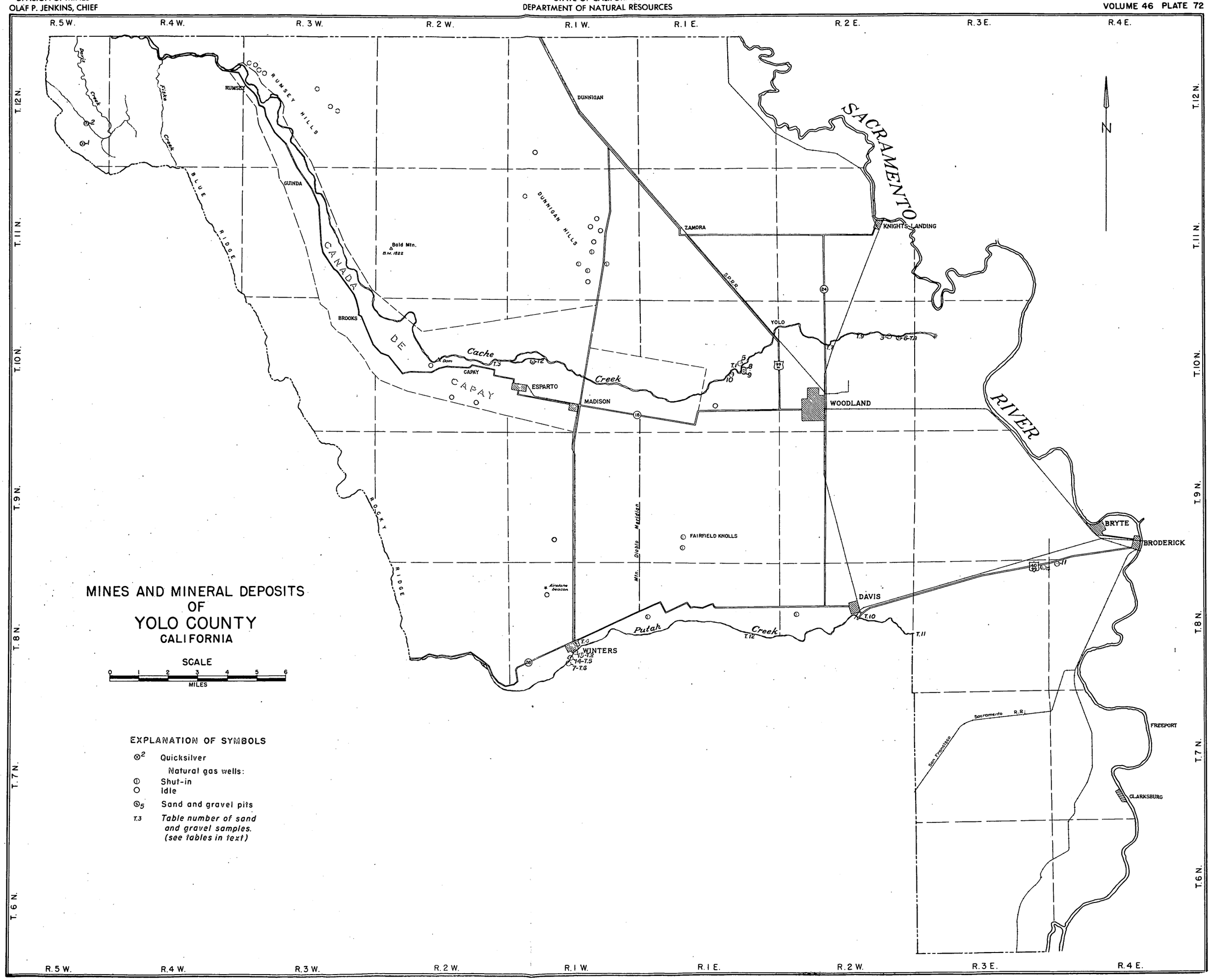
COMPOSITE MAP OF UNDERGROUND WORKINGS, SKAGGS SPRINGS QUICKSILVER MINE, SONOMA COUNTY, CALIFORNIA

50 0 50 100 150 Feet



GEOLOGIC MAPS OF THE UNDERGROUND LEVELS, SKAGGS SPRINGS QUICKSILVER MINE, SONOMA COUNTY, CALIFORNIA

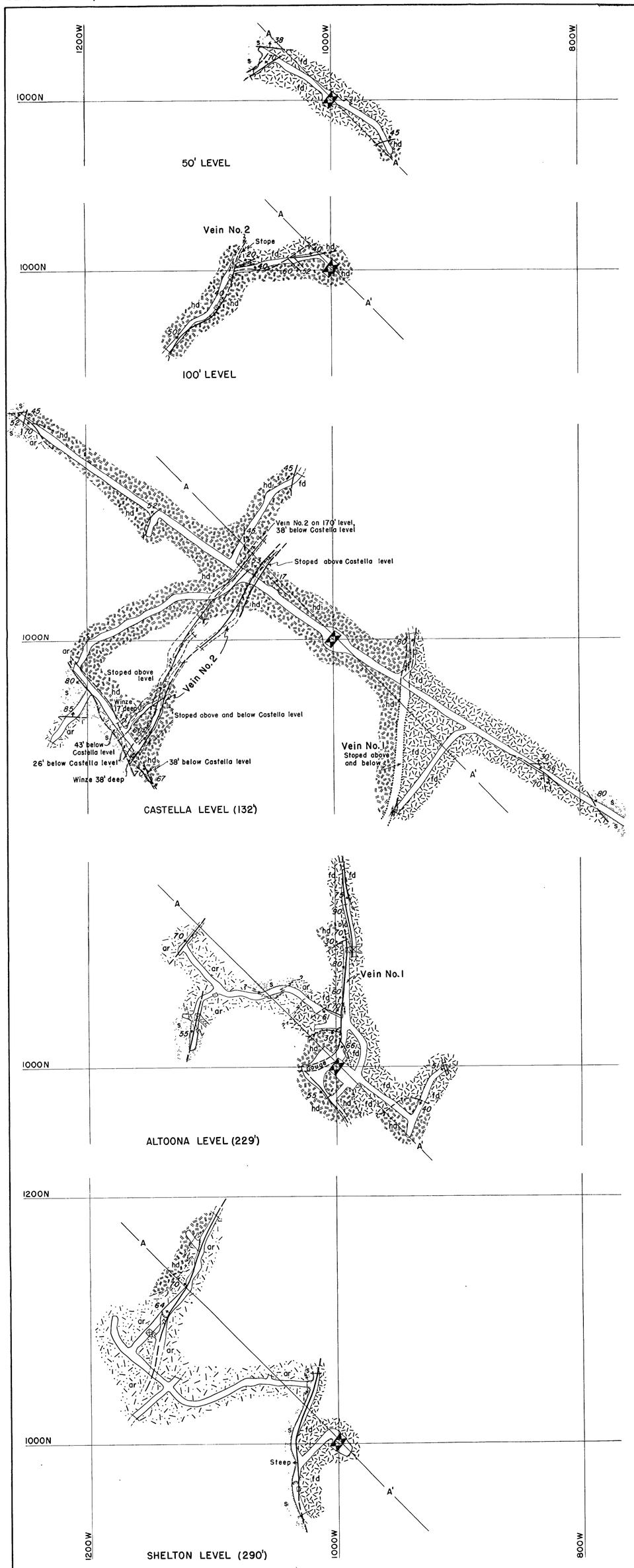
0 10 20 30 40 50 Feet


MINES AND MINERAL DEPOSITS
OF
YOLO COUNTY
CALIFORNIA
SCALE
0 1 2 3 4 5 6
MILES
EXPLANATION OF SYMBOLS
Quicksilver
Natural gas wells:
Shut-in
Idle
Sand and gravel pits
Table number of sand and gravel samples. (see tables in text)
R.5 W.
R.4 W.
R.3 W.
R.2 W.
R.1 W.
R.1 E.
R.2 E.
R.3 E.
R.4 E.
T.12 N.
T.11 N.
T.10 N.
T.9 N.
T.8 N.
T.7 N.
T.6 N.
N
SACRAMENTO
RIVER
RUMSEY
RUMSEY HILLS
GUINDA
BLUE RIDGE
CANADA DE CAPAY
BROOKS
Bald Mtn.
B.M. 1822
DUNNIGAN
DUNNIGAN HILLS
ZAMORA
KNIGHTS LANDING
S.P.R.R.
YOLO
Cache Creek
CAPAY
ESPARTO
MADISON
WOODLAND
ROCKY RIDGE
Mt. Diablo Meridian
FAIRFIELD KNOLLS
Airplane beacon
DAVIS
Putah Creek
WINTERS
BRYTE
BRODERICK
FREEPORT
CLARKSBURG
Sacramento R.R.
San Francisco

GEOLOGIC LEVEL MAPS AND CROSS SECTIONS OF THE ALTOONA QUICKSILVER MINE

TRINITY COUNTY, CALIFORNIA

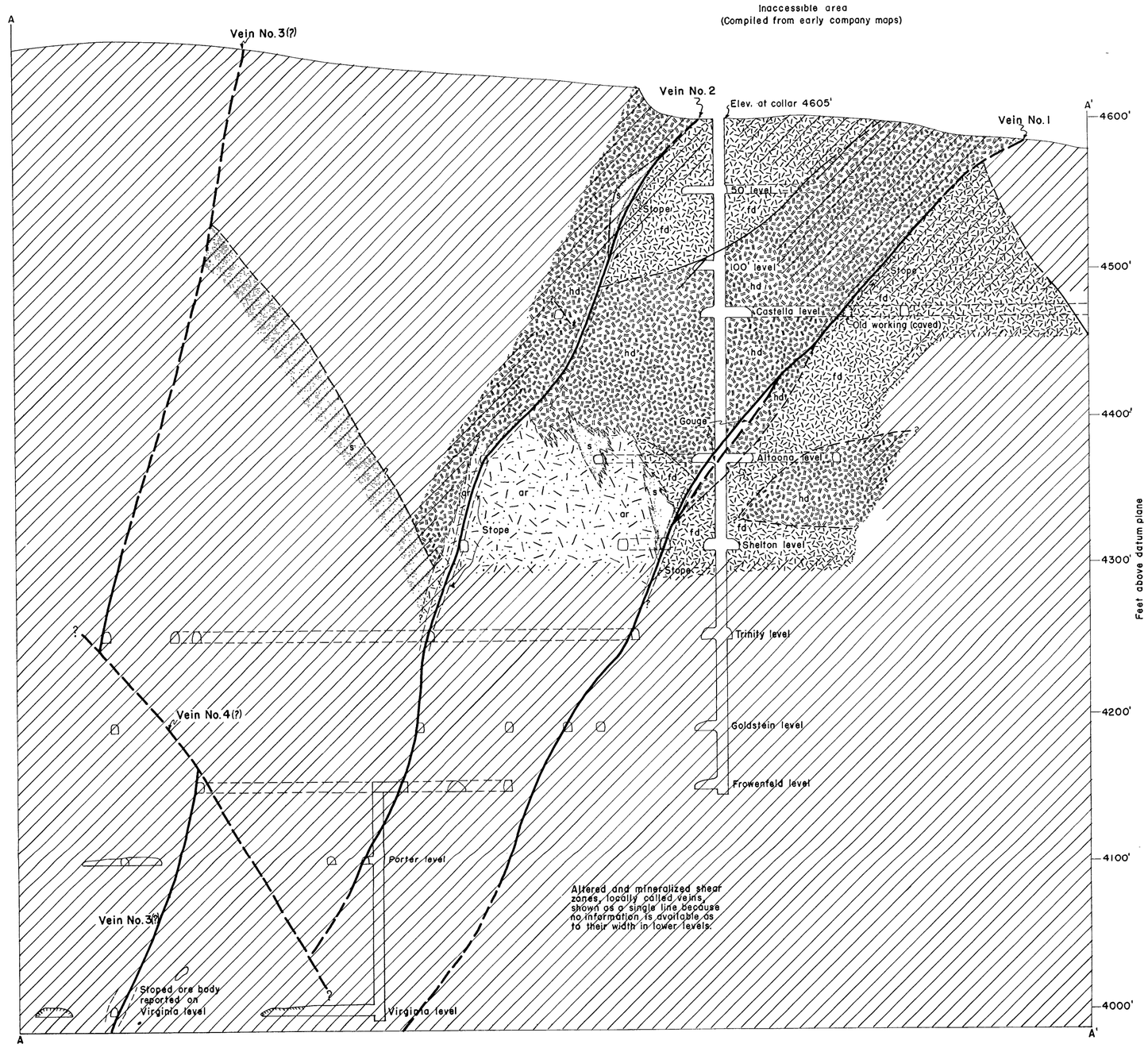
50 0 50 100 150 FEET
SCALE



LEVEL MAPS OF ACCESSIBLE AREAS

EXPLANATION

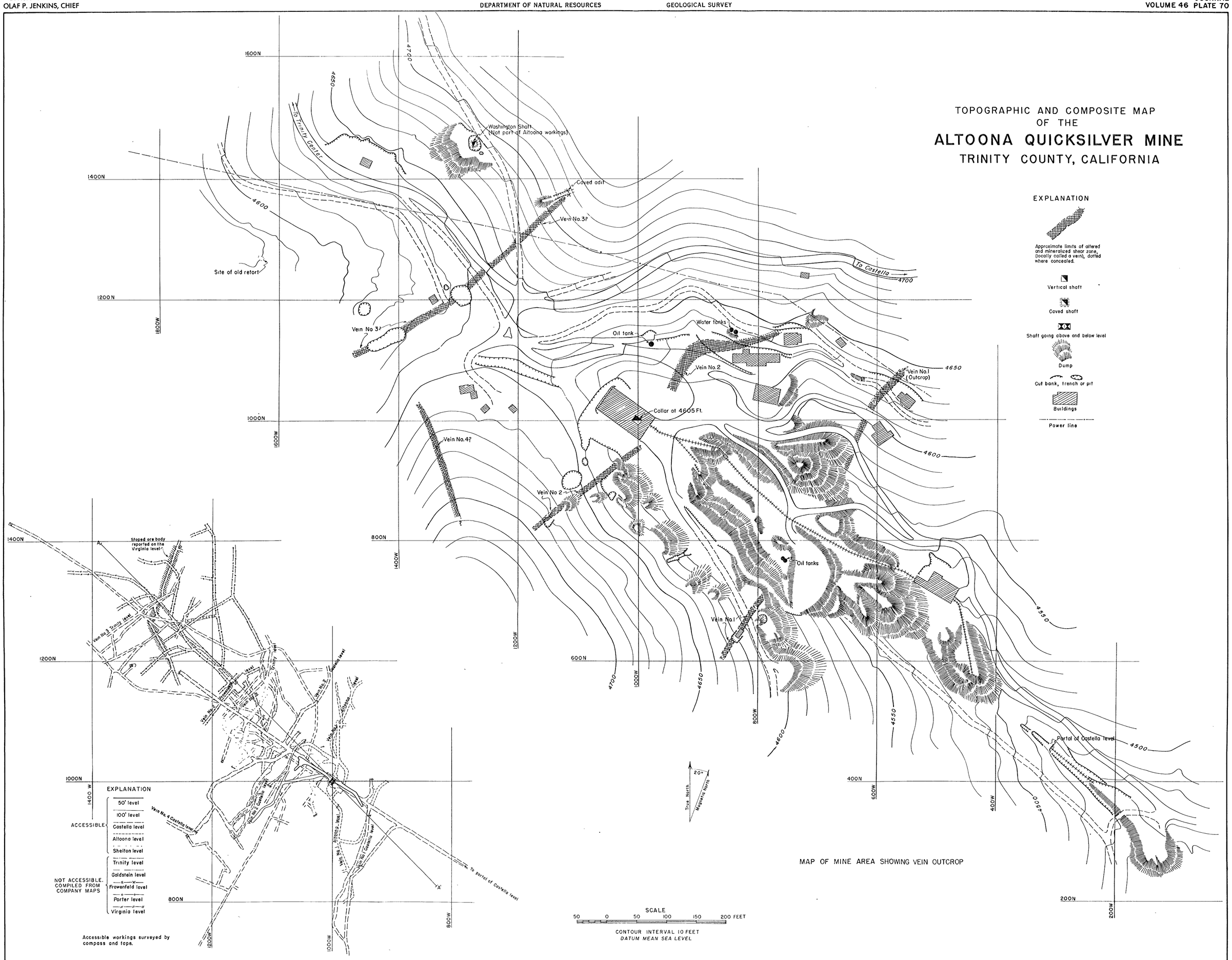
- hd — Porphyritic hornblende diorite
- fd — Porphyritic feldspathic diorite
- ar — Altered rock
- s — Serpentine
- Cinnabar veinlets
- Gradational contact
- 45 — Fault or shear, showing dip (Dashed where approximately located — dotted where concealed) U-upthrown side D-downthrown side
- 90 — Vertical fault or shear
- Shaft going above and below levels
- Inclined workings (Chevrons point down)
- Foot of raise or winze
- Head of raise or winze
- Ore chute
- Caved down area
- Caved workings
- Inaccessible area (Compiled from early company maps)



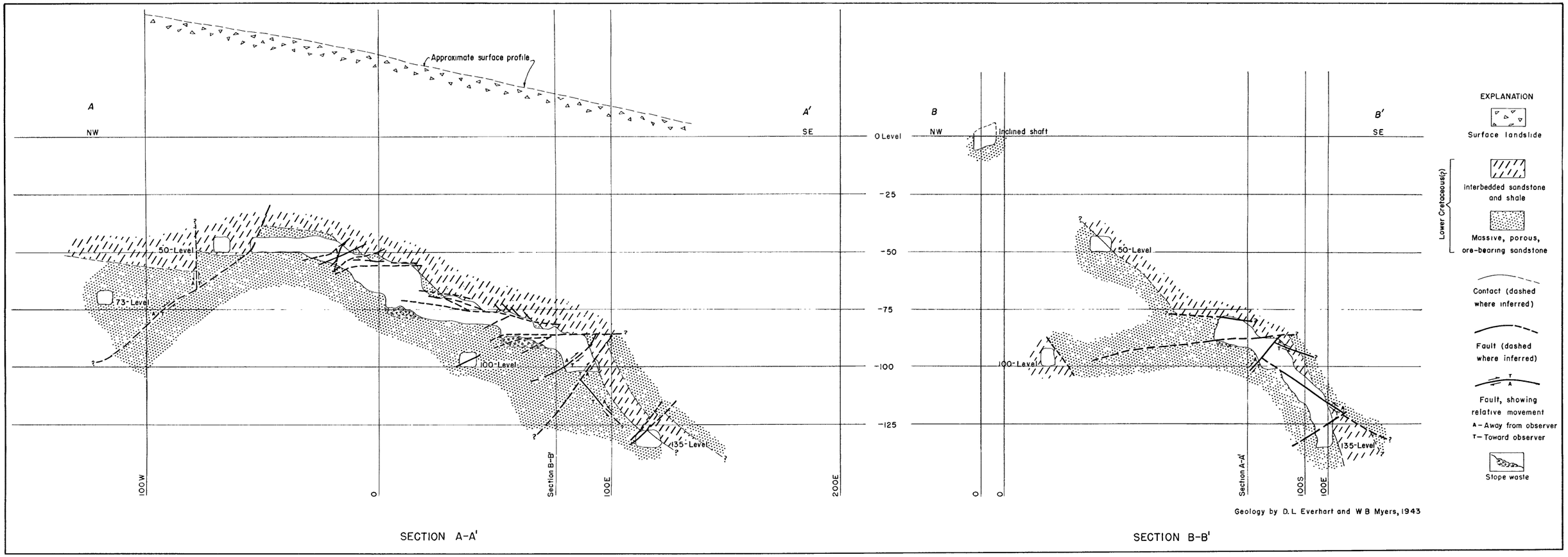
GEOLOGIC CROSS SECTION ALONG A–A'

Geology by: C. Melvin Swinney, 1944

TOPOGRAPHIC AND COMPOSITE MAP OF THE ALTOONA QUICKSILVER MINE TRINITY COUNTY, CALIFORNIA

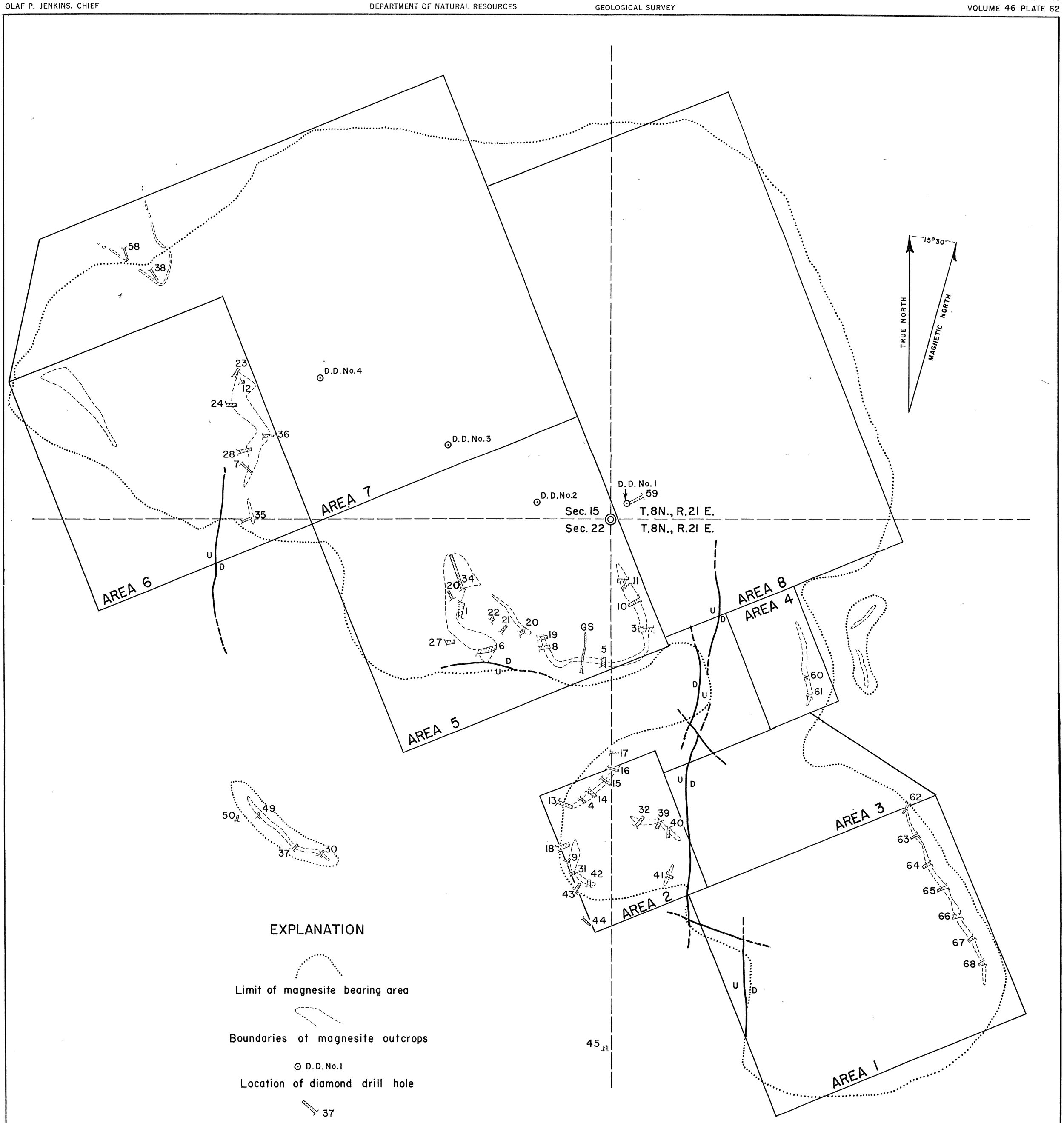


Topography by: Phillip F. Fix and G. Melvin Swinney, 1944



VERTICAL SECTIONS THROUGH SKAGGS SPRINGS QUICKSILVER MINE, SONOMA COUNTY, CALIFORNIA

0 10 20 30 40 50 Feet

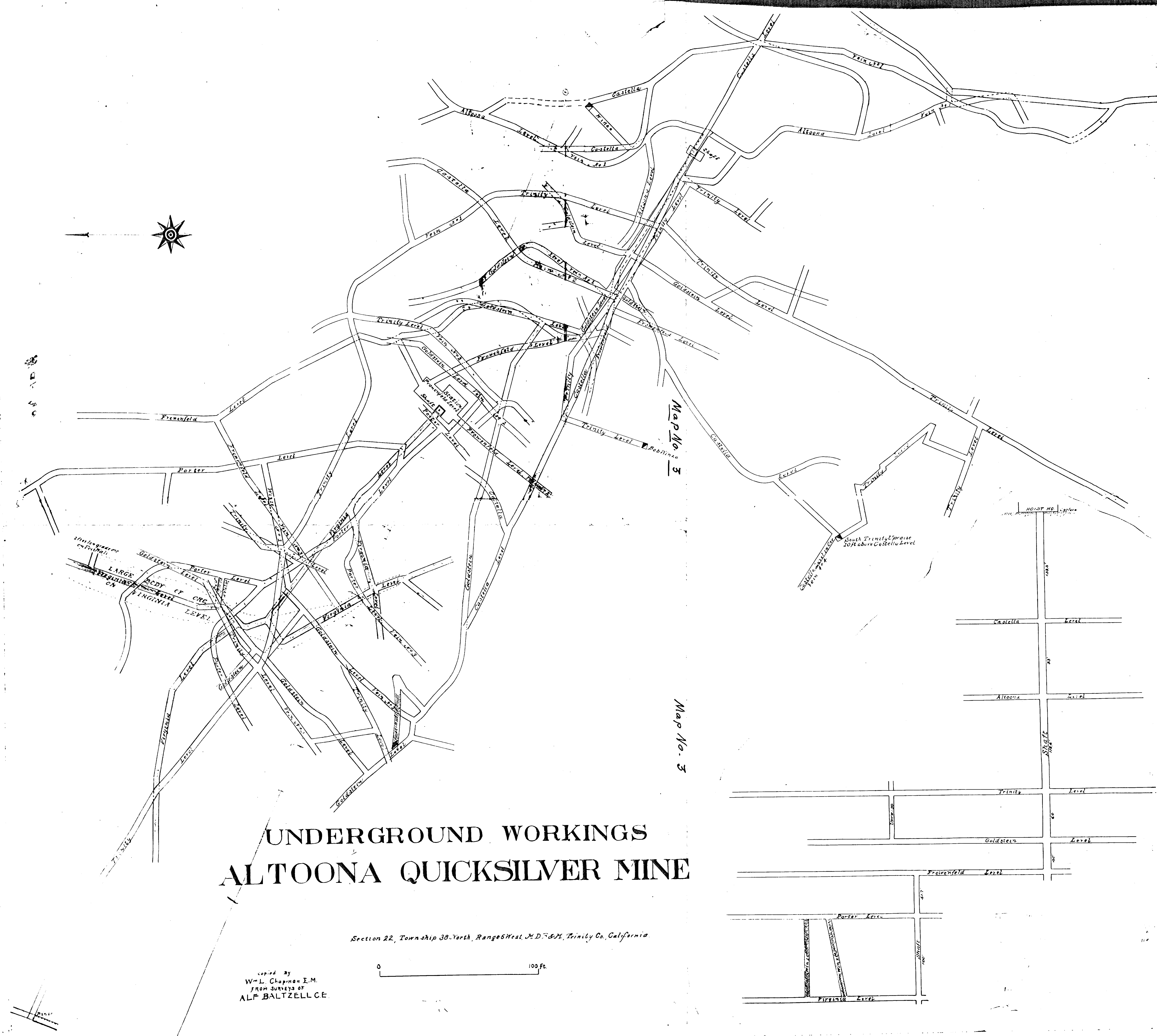


EXPLORATION MAP

NEEDLES MAGNESITE DEPOSIT

NEEDLES, CALIFORNIA

Geology by C.J.Vitaliano, March, 1943



UNDERGROUND WORKINGS ALTOONA QUICKSILVER MINE

Section 22, Township 38 North, Range 6 West, M.D.B.&M., Trinity Co., California.

copied by
Wm L. Chapman E.M.
FROM SURVEYS OF
ALF BALTZELL C.E.

SURFACE AND PROPERTY LINE MAP OF THE ALTOONA QUICKSILVER MINE

IN THE
S-W 1/4 OF SECTION 22
T-38-N R-6-W M.D.M.
IN
TRINITY COUNTY
CALIFORNIA

SURVEYED AT THE REQUEST OF
IRVING BALLARD, TRUSTEE
AUGUST 1938
SCALE 1" = 100'

R.U. THORNBURGH
REGISTERED ENGINEER
LICENSED SURVEYOR

LEGEND

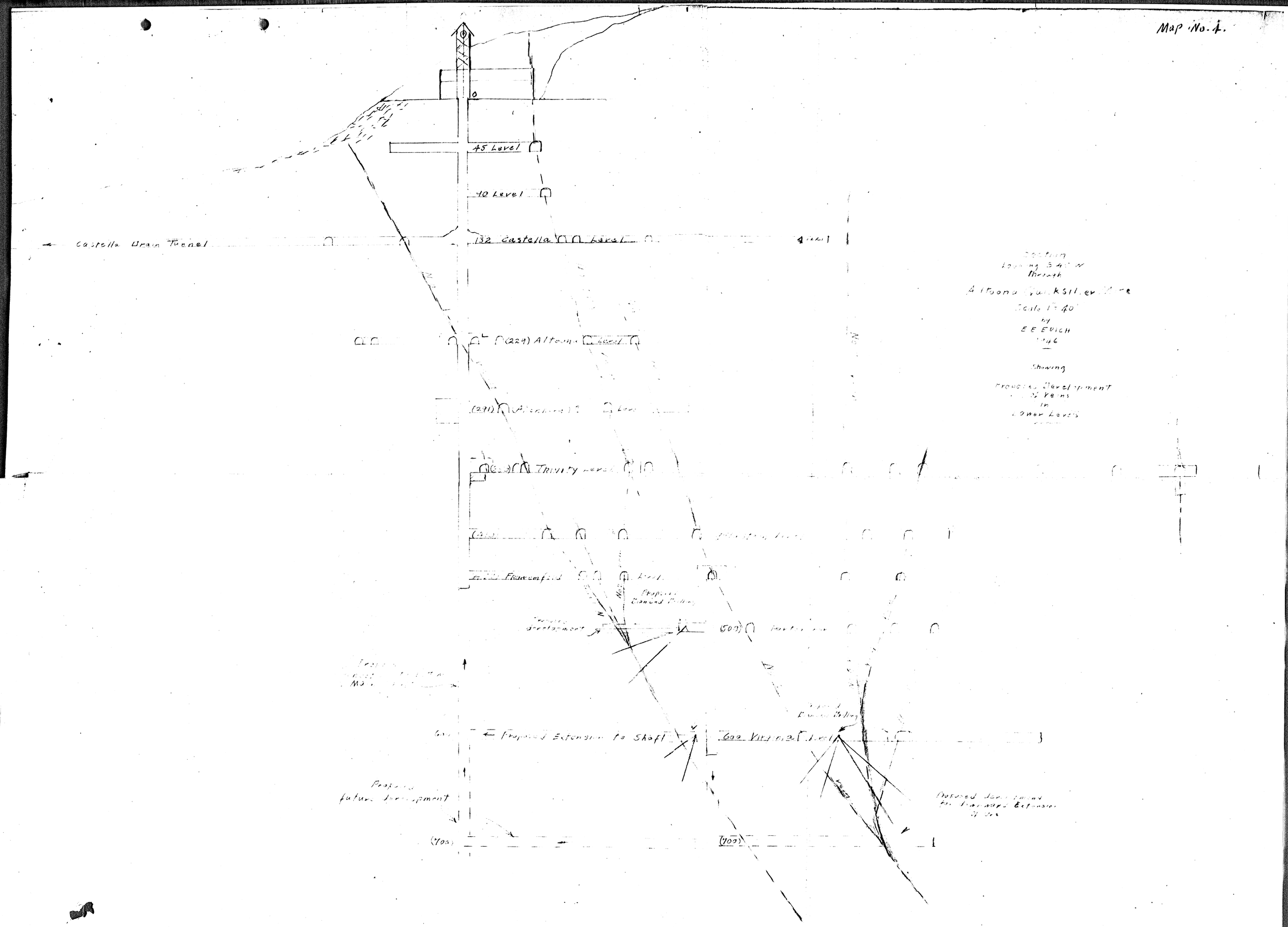
MAIN ROAD
SECONDARY ROAD
POSITIONED PROPERTY LINES
MAIN SURVEY TRAVERSE LINES
MAIN TUNNEL (MAP POSITION)

BEARINGS.

The bearings used on this survey are true bearings based on Solar Observation. Meridian determined Friday Aug. 26, 1938 at 8:07 A.M. and verified Friday Aug 26, 1938 at 3:57 P.M.

SURVEY NO. 2424-M. F.B. 62-15 "C.B. 73-1

Map No. 4.



Map No 4.