MINES AND MINERAL DEPOSITS IN DEATH VALLEY NATIONAL MONUMENT, CALIFORNIA

1976

CALIFORNIA DIVISION OF MINES AND GEOLOGY

SPECIAL REPORT 125

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MINES AND MINERAL DEPOSITS IN DEATH VALLEY NATIONAL MONUMENT, CALIFORNIA

By
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Geologists

1976

CALIFORNIA DIVISION OF MINES AND GEOLOGY
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Photo 1. Furnace Creek Wash area as viewed from the southeast. (B)Black Mountains, (G) Greenwater Range, (P) Panamint Range, (D) Death Valley, (F) Furnace Creek Wash, (C) Furnace Creek Ranch, (R) Ryan, (Bo) Boraxo mine area of Tenneco Mining, Inc. ***Photo by U.S. Air Force—U.S. Geological Survey, July 10, 1968.***

CONTENTS

MAPS

FIGURES

PHOTOGRAPHS

TABLES

PREFACE

Controversy erupted late in 1975 in the news media over the issue of mining in Death Valley National Monument.

Legislation was introduced in the U.S. Senate and the House of Representatives to regulate mining in the Monument. Hearings and public statements have brought out intense feelings on both sides. The hearings also disclosed that data on mineral production, ore reserves, and mineral uses were incomplete or out of date, as were descriptions of the relative role of the products mined from the Monument in the State's and the Nation's economy.

To provide answers to these questions, the California Division of Mines and Geology assigned a team of geologists to conduct a four-month investigation in the Monument. They visited the active mines, the mining companies, and the areas of mineral reserves and resources.

In preparing this report, the Division geologists depended on information received from all of the mining companies—data, maps, and confidential figures. Similarly, full cooperation was received from the National Park Service staff and from other citizens with information about Death Valley.

The intent of this report is to provide information useful to everyone concerned with the future of mining in Death Valley National Monument—voter, miner, conservationist, consumer, and legislator.

Thomas E. Gay Jr.
Thomas E. Gay Jr.
Acting State Geologist
February 19, 1976

Photo 2. Death Valley and the Panamint Range as viewed from the northeast. (P) Panamint Range, (D) Death Valley, (B) Black Mountains, (G) Galena Canyon, (W) Warm Spring Canyon. ***Photo by U.S. Air Force—U.S. Geological Survey, September 6, 1968.***

ABSTRACT

Death Valley National Monument, established in February 1933 by presidential proclamation, includes 2,067,793 acres (3211 sq. mi.). In June 1933, Congress opened the Monument to mineral location, subject to Federal regulations regarding the surface use.

In the Monument, 2,047,181 acres (3199 sq. mi.) are administered by the Federal government; 13,486 acres (21 sq. mi.) are administered by the State of California (State Lands Division); and 7,125 acres (11 sq. mi.) are privately owned. Of the private lands, mining companies (U.S. Borax & Chemical Corporation, Tenneco Mining, Pfizer, and others) own 4,412 acres (7 sq. mi.). In January 1976, about 1700 unpatented claims were reported to be active, encompassing about 34,000 acres (53 sq. mi.). Valid unpatented claims confer prospecting and mining rights but not title to the surface.

The most important minerals being produced from Death Valley National Monument are talc and the borate minerals colemanite and ulexite-probertite. Since 1910, the southern Death Valley area has been one of the principal sources of talc in the United States. In 1974, approximately 14 percent of the total national production of talc was from deposits in California, and about 86 percent of the California output was from deposits in the Monument. The total talc production in California in 1974 was 169,023 tons, of which about 145,719 tons, valued at $8,451,702, was from mines in the Monument. California ranked fifth in the nation in tons of talc produced in 1974, but because California talc commands premium prices, the state ranked first in the nation in total sales value. Since 1970 the annual talc production for the state has been in the range of 153,000 to 185,000 tons. Because of depletion of reserves and the cost of operating small underground mines, this production has been from a decreasing number of mines, with more dependence upon those mines in Death Valley National Monument.

Preliminary data for 1975 indicate that about 90 percent of California talc production came from the Galena Canyon-Warm Spring Canyon areas in the southwestern part of the Monument. This area has a large potential for white high-purity talc. About 7,000,000 tons of reserves and resources exist, of which about 4,000,000 tons appear to be recoverable—a 30- to 35-year supply at the present average rate of production. The total sales value of the recoverable reserves and resources, based upon a current average sales price of $60 a ton for ground talc would be $246 million.

Of the 169,023 tons of talc mined in California in 1974, about 45 percent was used as a ceramic raw material; 18 percent as a paint extender; and 11 percent as an insecticide carrier. The remainder was used as a rice-polishing medium, as paper filler and opacifiers, and as an adhesive filler. About 60 to 70 percent of the talc is consumed in California; the remainder is distributed nationally and internationally. Nearly 50 percent of the talc mined in California goes into the Los Angeles market area and about 20 percent into the San Francisco Bay Area.

Talc deposits from 8 to 30 feet thick and as much as 1200 feet long occur in the Monument in the Precambrian Crystal Spring Formation as replacements of dolomite in zones of silication adjacent to diabase sills. Commercial material is composed largely of the mineral talc, with minor proportions of carbonate minerals and chlorite, and with some admixed tremolite in the Warm Spring Canyon area. Compared to other U.S. talcs, Death Valley talc possesses a high whiteness or brightness factor and low tremolitic fiber content. Because of mineralogical and chemical differences, other talcs such as those produced in New York, Vermont, and Montana cannot be directly substituted for California talcs without consuming industries having to change their product formulations.

Eight talc mines were active in 1974-75 in the Monument, all in the Warm Spring-Galena Canyon area. Seven were open-pit operations and one was underground. The open-pit operations entail the removal of overlying waste rock by bulldozers and scrapers from the talc beds which mostly dip gently into the hillslopes. Once exposed, the talc is 80-90% recoverable. The downdip portions of the talc bodies have an increasing thickness of rock over them so surface mining becomes economically infeasible and underground methods must be used if mining is to proceed. The Grantham (Big Talc and #5) mine is an underground operation where room-and-pillar mining methods and diesel-powered haulage equipment is used.

Mining of the borate minerals colemanite and ulexite-probertite has been a significant part of the history of the Death Valley area. The borate deposits in the Monument owned by Tenneco Mining and United States Borax & Chemical Corporation are the largest known in the United States. About 79 percent of the nation's known colemanite reserves and resources, and about 84 percent of the known ulexite-probertite reserves, are in the Monument. The total potential sales value of these reserves and resources remaining in the Monument is estimated at $570 million at current prices.

Currently, only Tenneco Mining is actively mining borate in Death Valley, at the Boraxo and Sigma mines near Ryan in the Furnace Creek Wash area. All of the colemanite and ulexite-probertite presently produced in the United States comes from these mines. After mechanical beneficiation at the mine, the colemanite ore is hauled by truck to the calcining plant in Nevada. Calcine is then trucked to the grinding plant at Dunn Siding in San Bernardino County. Ulexite is hauled directly from the mine to the grinding plant. Calcined colemanite is used mainly for textile-grade glass fibers (fiberglass) used in reinforced plastics, fabrics, electrical insulation, and glass-belted tires. It is also used in the manufacture of heat-resistant glasses. Ulexite is used in construction fiberglass, fiberglass insulation, and the manufacture of fireproof paint. The combined value of calcined colemanite and processed ulexite-probertite at the railhead at Dunn Siding was about $3,300,000 in 1974 and $4,740,000 in 1975.

The deposits of both types of borate minerals occur interlayered with folded and faulted lacustrine sedimentary rocks of the Furnace Creek Formation, Pliocene in age, in the Furnace Creek Wash-Ryan area. The main known deposits are found within the lowermost 500 feet of the formation, commonly dipping 45 degrees or steeper. Many of the deposits are bounded and cut by steeply dipping faults. Detailed geologic mapping has shown that the northern Furnace Creek Wash area from the East Coleman Hills southeast to the Ryan area, most of which is in Death Valley National Monument, has strong potential for substantial borate deposits. Exploratory drilling to as much as a few thousand feet probably would be necessary to determine the borate potential of this area. Because of the great thickness of overburden, any deposits in this area would have to be mined by underground methods.

Approximately 10 million tons of material have been extracted from the Boraxo pit since 1971. The present stripping ratio of tons of overburden removed per ton of borate recovered is about 26 to one. The ratio will decrease before mining is complete. In January 1976, the pit was about 2200 feet long, ranging from 300 feet wide at the surface on the west to about 1000 feet on the east, and about 225 feet deep. The length and width are already at about maximum pit design, but the final depth will be 450 feet on the east. Benches are cut at 40-foot intervals with a slope face of about 38 in the north wall and 40 in the south wall. At the present mining rate, open-pit operations at the Boraxo pit will be complete in 1977, but at least 250,000 tons of colemanite and ulexite-probertite will still be left beneath the pit. At that stage, the stripping ratio will be too high for economic removal of ore by open-pit methods, so if the borates are to be removed, underground methods will be required.

Other mineral commodities that have been produced from Death Valley National Monument include gold, silver, antimony, copper, lead, zinc, and tungsten. The history of metallic mining in the Death Valley area extends back over a hundred years, and about 50 metal mines and prospects are known. However, no major mine was in production in 1975. Time limitations for this study did not permit geologic evaluation of the potential of the metallic deposits. Much work, including geologic mapping, sampling, and systematic drilling programs, would be needed to evaluate the metal mining potential of the Monument.

Photo 3. Gower Gulch (G), Death Valley (D), and the Panamint Range (P) as viewed west from Zabriskie Point observation station (Z), October 1975. Land south (left) of the center of the photo including Gower Gulch is patented placer mining claims owned by U.S. Borax prior to the establishment of Death Valley National Monument in 1933. Zabriskie Point was named in 1916 for C.B. Zabriskie, President of Pacific Coast Borax Company; and Gower Gulch was named for H.P. Gower, Company Superintendent and resident of Death Valley for over 50 years. Underground mines near the mouth of Gower Gulch have been worked for colemanite, but not for over 50 years.

MINES AND MINERAL DEPOSITS IN DEATH VALLEY NATIONAL MONUMENT, CALIFORNIA

By James R. Evans[1], Gary C. Taylor[1], and John S. Rapp[1]

INTRODUCTION

General Features

Herbert Hoover established Death Valley National Monument by Presidential Proclamation No. 2028 on February 11, 1933. The original monument was 1,601,800 acres (2,503 sq. mi.); but by 1975 the Monument had grown to 2,067,793 acres (3,211 sq. mi.).

Death Valley is in the Basin Ranges and Mojave Desert geomorphic provinces of eastern California and western Nevada (Map 1). It is bounded on the west by the Panamint Range—Last Chance, Cottonwood, and Panamint Mountains—and on the east by the Amargosa and Greenwater Ranges—Grapevine, Funeral, and Black Mountains.

Rocks found in the monument range in age from Precambrian to Holocene. The succession of Precambrian and Paleozoic rocks in Death Valley is moderately well exposed, complete, and similar to, although much thicker than, the rock section exposed in the Grand Canyon. These strata are intruded by Mesozoic rocks. Cenozoic sedimentary and volcanic rocks overlie the Precambrian, Paleozoic, and Mesozoic rocks. The total exposed section of sedimentary rocks in Death Valley exceeds 40,000 feet.

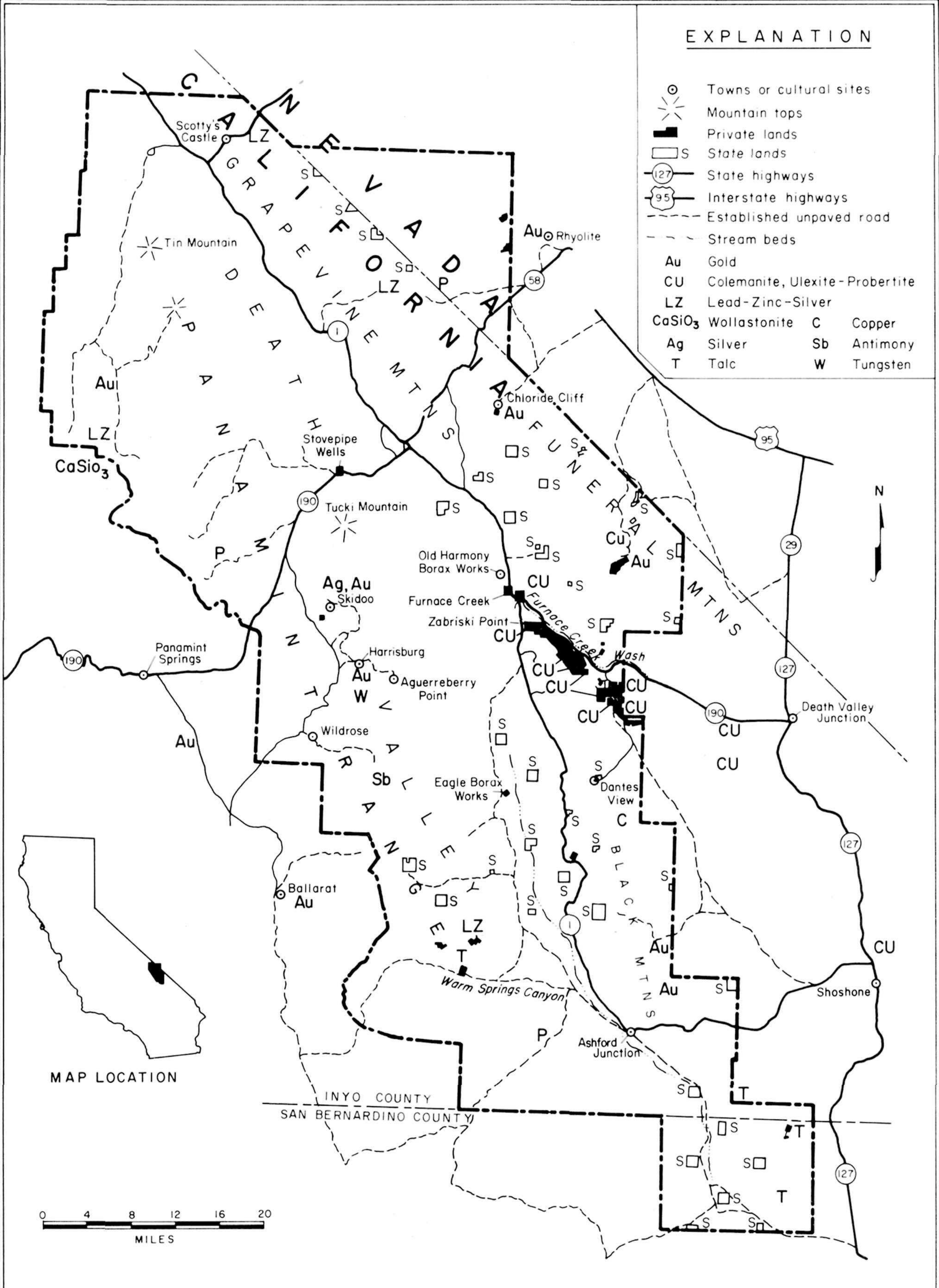
[1] Geologist, California Division of Mines and Geology

Mountains, valleys, and other spectacular land features, such as the playas and alluvial fans, are largely a result of uplift through Tertiary and Holocene faulting. Most faults are normal and trend north to northeast and are related to northwest-trending lateral-slip faults (Wright and Troxel, 1967, p. 948).

The Valley is one of the hottest places on earth. An air temperature of 134°F was recorded on July 10, 1913. In January temperatures drop to 15°F or even lower in the higher mountains. In 1949, 4 inches of snow stayed on the floor of Death Valley for several hours. Snow stays on the higher peaks of the Panamint Range through the winter months. Average annual rainfall is 2 to 3 inches, which may come in a torrential downpour.

Death Valley National Monument and the area surrounding it are distinguished by outstanding and colorful geological and mineralogical features. Among other things, the valley area is famed for richness in mining, scientific, and human interest. The 20-mule teams that hauled borates before the turn of the century are a well-known part of its history. A variety of minerals has been produced from the Monument, but the most important commodities are talc and the borate minerals colemanite and ulexite-probertite.

Other commodities that have been produced from Death Valley National Monument include gold, silver, antimony, copper, lead, zinc, and tungsten.



LAND OWNERSHIP AND MINERAL RESOURCE AREAS IN DEATH VALLEY NATIONAL MONUMENT

MAP 1

Mineral Entry and Land Status

Prior to establishment of the Monument, the public domain lands in the area were open to entry under the Federal mining law of 1872. National Monuments withdrawn by Presidential Proclamation are not open to mineral entry and location, but Congress passed an Act on June 13, 1933, (3348 Stat. 16, U.S.C. 447) specifically opening the withdrawn lands in Death Valley National Monument to mineral entry and location, subject to regulations regarding the surface use.

Of the 2,967,793 acres included in Death Valley National Monument, 2,047,181 acres (3,199 sq. mi.) are Federally administered; 13,486 acres (21 sq. mi.) are State administered (California State Lands Division); and 7,125 acres (11 sq. mi.) are privately owned. Of the 7,125 acres of private lands, 4,412 acres (7 sq. mi.) are held by U.S. Borax, Tenneco Mining, Pfizer, Inc., and others.

All but about 161,037 acres (252 sq. mi.) of the Federally administered lands in the Monument are open to mineral location and entry under Federal mining law. An active interest was maintained in January 1976 in about 1700 unpatented claims encompassing about 34,000 acres (53 sq. mi.). For purposes of administration, the National Park Service has divided the Monument into nine districts (Map 2). Records for unpatented and patented claims are filed under each district and kept in the Office of the Mining Engineer at Monument Headquarters. The following tabulation of unpatented and patented claims was prepared by Robert T. Mitcham, Monument mining engineer, as of January 5, 1976:

Furnace Creek District	338 claims
Ibex	274 claims
Ashford	154 claims
Butte	200 claims
Westside	7 claims
Wildrose	111 claims
Emigrant	214 claims
Cottonwood	292 claims
Grapevine-Funeral	266 claims
Total	1982 claims

On valid unpatented claims, the owner has prospecting and mining rights but not title to the surface.

Acknowledgments

The Abstract, the Introduction, the Mining Policy and Regulations, and the Borate Deposits sections were prepared by James R. Evans. The Talc Deposits section was prepared by Gary C. Taylor. The Metallic Mineral Deposits section and the References were prepared by John S. Rapp.

Many people contributed time and effort in preparation of this report. We thank each of them—particularly the staffs of the mining operations in Death Valley National Monument, who provided confidential information on production and reserves. We also thank the staff of the Minerals Office of the Death Valley National Monument for providing documents to us. The staff of the Mining and Minerals Section, National Park Service in San Francisco, was most helpful in providing information.

MINING POLICY AND REGULATIONS

Most of Death Valley National Monument is open to prospecting and mining under the Federal mining law of 1872. Use of the surface, however, is subject to Federal regulations (Code of Federal Regulations Title 36—Parks, Forest, and Memorials, Chapter 1—National Park Service, Section 7.26).

"(a) MINING. Mining in Death Valley National Monument is subject to the following regulations, which are prescribed to govern the surface use of claims therein:

"(1) The claim shall be occupied and used exclusively for mineral exploration and development and for no other purpose except that upon written permission of an authorized officer or employee of the National Park Service the surface of the claim may be used for other specified purposes, the use to be on such conditions and for such period as may be prescribed when permission is granted.

"(2) The owner of the claim and all persons holding under him shall conform to all rules and regulations governing occupancy of the lands within the National Monument.

"(3) The use and occupancy of the surface of mining claims as prescribed in subparagraphs (1) and (2) of this paragraph shall apply to all such claims located after the date of the act of June 13, 1933 (48 Stat. 139; 16 U.S.C. 447), within the limits of the National Monument as fixed by Proclamation No. 2028 of February 11, 1933, and enlarged by Proclamation No. 2228 of March 26, 1937, and to all mining claims on lands hereafter included in the National Monument, located after such inclusion, so long as such claims are within the boundaries of said Monument.

"(4) Prospectors or miners shall not open or construct roads or vehicle trails without first obtaining written permission from an authorized officer or employee of the National Park Service. Applications for permits shall be accompanied by a map or sketch showing the location of the mining property to be served and the location of the proposed road or vehicle trail. The permit may be conditioned upon the permittee's maintaining the road or trail in a passable condition as long as it is used by the permittee or his successors.

"(5) From and after the date of publication of this section, no construction, development, or dumping upon any location or entry, lying wholly or partly within the areas set forth in subdivisions (i) and (iii) of this subparagraph, shall be undertaken until the plans for such construction, development, and dumping, insofar as the surface is affected thereby, shall have been first submitted to and approved in writing by an authorized officer or employee of the National Park Service:

"(i) All land within 200 feet of the center-line of any public road.

"(ii) All land within the smallest legal subdivision of the public land surveys containing a spring or water hole, or within one quarter of a mile thereof on unsurveyed public land.

"(iii) All land within any site developed or approved for development by the National Park Service as a residential, administrative, or public campground site. Such sites shall include all land within the exterior boundaries thereof as conspicuously posted by the placing of an appropriate sign disclosing that the boundaries of the developed site are designated on a map of the site which will be available for inspection in the office of the Superintendent. If not so posted, such sites shall include all land within 1,000 feet of any Federally owned buildings, water and sewer systems, road loops, and camp tables and fireplaces set at designated camp sites.

"(b) USE OF WATER. No works or water system of any kind for the diversion, impoundment, appropriation, transmission, or other use of water shall be constructed on or across Monument lands, including mining claims, without a permit approved by an authorized officer or employee of the National Park Service. Application for such permit shall be accompanied by plans of the proposed construction. The permit shall contain the following conditions: (1) No diversion and use of the water shall conflict with the paramount general public need for such water; (2) such water systems shall include taps or spigots at points to be prescribed by the Superintendent, for the convenience of the public; and (3) all appropriations of water, in compliance with the State water laws, shall be made for public use in the name of the United States and in accordance with instructions to be supplied by an authorized officer or employee of the National Park Service.

"(c) PERMITS. Application for any permit required by this section shall be made through the Superintendent of the Monument.

"(d) FILING OF COPIES OF MINING LOCATIONS. From and after the publication of this paragraph, in order to facilitate the administration of the regulations in this part, copies of all mining locations filed in the Office of the County Recorder shall be furnished to the office of the Superintendent, Death Valley National Monument, by the person filing the mining location in his own behalf or on behalf of any other person."

Prospectors and miners are required to obtain special use permits from the Park Service for constructing roads or vehicle trails. Special use permits may be required for other activities related to mining—(Title 36, Parts 1-6) on claims filed after June 13, 1933.

"In addition to specific requirements under the special regulation on mining, 36 CFR 7.26, such as the permits required for opening a vehicle trail or constructing a road, prospectors and miners may be required to obtain permits that include activities that are requirements of, or a variance of, general regulations, 36 CFR Parts 1-6 apply on mining claims located after 6/13/33. Examples of such activities follows:

Permits required for:

2.1(b)	Leaving vehicle or personal property unattended over 24 hours
2.2	Air delivery of any person or thing, e.g., helicopter
2.5(a)	Camping in other than designated areas
2.5(e)	Digging or leveling ground for a campsite
2.9	Explosives use or possession
2.12	Kindling of fires
2.19	Operation of portable engines and generating plant
4.11(a)	Certain time period for using Monument roads
4.11(b)(c)	Overwidth or overlength vehicles on Monument roads
4.11(d)	Transporting of explosives over Monument roads
5.6	Use of Monument roads by commercial vehicles
5.7	Construction of a building, road trail, or private utility lines
5.15	Residence in the Monument

Permit required for variance with:

2.5(c)	Time limitation for camping
2.20	Destruction, injury, defacement in any manner of any building, sign, equipment, monument, marker or other structure; or artifact, relic, historic or prehistoric feature"

The current minerals management program for Death Valley National Monument as set forth by the Superintendent is designed to:

(1) "Minimize the impact of mineral exploration and development.

(2) "Halt any prospecting or mineral activities involving disturbance of the surface, unless it is related to valid mining claims or to a demonstrated mineral potential.

(3) "Resolve mining claims being illegally used and claims on which there are unsightly, dilapidated structures, broken-down equipment, etc."

Mineral investigation and management support for the program is provided by a mining engineer on the staff of the Monument Superintendent. Rangers watch for mining activity and enforce regulations and conditions of special use permits. Further information, or a clarification of mining regulations, can be obtained at the mining engineer's office at the Monument Administration Building, Death Valley, California 92328 (telephone 714-786-2331).

Form 10-114
(Rev. March 1971)

Page 1
This permit consists of .... pages including attachments.

UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

SPECIAL USE PERMIT

PERMIT NO.	EXPIRES
PREVIOUS PERMIT NO.	

....
(Area)

...., of .... is hereby authorized during the period from ...., 19......, through ...., 19......, to use the following-described land in the above-named area:

for the purpose of

subject to the conditions on the reverse hereof and attached pages and to the payment to the Government of the United States of the sum of .... Dollars ($......................), in advance .... (Monthly, semiannually, etc.), or as follows: ....

....

....

payment to be made to the Superintendent by Express or Postal Money Order, Certified Check, or Draft payable to the National Park Service, or Cash.

Issued at ...., this .... day of ...., 19.......
(City)

....
Superintendent.

The undersigned hereby accepts this permit subject to the terms, covenants, obligations, and reservations, expressed or implied, therein.

TWO WITNESSES TO SIGNATURES	* PERMITTEE (Signature)
NAME	NAME
ADDRESS	ADDRESS
NAME	NAME
ADDRESS	ADDRESS

APPROVED: *(If approval is required by higher authority)*

NAME	TITLE	DATE

*Sign name or names as written in body of permit; for copartnership, permittees should sign as "members of firm"; for corporation, the officer authorized to execute contracts, etc., should sign, with title, the sufficiency of such signature being attested by the Secretary, with corporate seal, in lieu of witnesses.

16—85968-8

Distribution—Field Finance Office.

Figure 1. Special Use Permit form, page 1.

Page 2*

CONDITIONS OF THIS PERMIT

1. **Regulations.**—The permittee shall exercise this privilege subject to the supervision of the Superintendent, and shall comply with the regulations of the Secretary of the Interior, or other authorized officer of the Government, governing the area.

2. **Definition.**—The term "Director, National Park Service" as used herein shall include the appropriate Regional Director or Superintendent as the representative of the Director.

3. **Rights of the Director.**—Use by the permittee of the land covered hereby is subject to the right of the Director, National Park Service, to establish trails, roads, and other improvements and betterments over, upon, or through said premises, and further to the use by travelers and others of such roads and trails as well as of those already existing. If it is necessary to exercise such right, every effort will be made by the National Park Service to refrain from unduly interfering or preventing use of the land by the permittee for the purpose intended under this permit.

4. **Nondiscrimination.**—See attachment A.

5. **Damages.**—The permittee shall pay the United States for any damage resulting from this use which would not reasonably be inherent in the use which the permittee is authorized to make of the land described in this permit.

6. **Construction.**—No building or other structure shall be erected under this permit except upon prior approval of plans and specifications by the Director, National Park Service, and the premises and all appurtenances thereto shall be kept in a safe, sanitary, and sightly condition.

7. **Removal of structures and improvements.**—Upon the expiration of this permit by limitation of time or its termination for any reason prior to its expiration date, the permittee, if all charges due the Government hereunder have been paid, shall remove within such reasonable period as is determinted by the Superintendent, but not to exceed 90 days unless otherwise stipulated in this permit, all structures and improvements placed on the premises by him, and shall restore the site to its former condition under the direction of the Superintendent. If the permittee fails to remove all such structures and improvements within the aforesaid period, they shall become the property of the United States, but that will not relieve the permittee of liability for the cost of their removal and the restoration of the site.

8. **Water rights.**—Water rights will be perfected, when necessary, by the United States in its own name for water developed or used in connection with this permit. The permittee will furnish to the United States such information as is necessary for perfection, including statutory fees, and for management and protection of the resource.

9. **Disposal of refuse.**—The permittee shall dispose of brush and other refuse as required by the Superintendent.

10. **Timber cutting.**—No timber may be cut or destroyed without first obtaining a permit therefor from the Director, National Park Service.

11. **Fire prevention and suppression.**—The permittee and his employees shall take all reasonable precautions to prevent forest, brush, grass, and structural fires and also shall assist the Superintendent in extinguishing such fires in the vicinity of any tract which may be used hereunder

12. **Soil erosion.**—The permittee shall take adequate measures, as directed and approved by the Superintendent to restrict and prevent soil erosion on the lands covered hereby and shall so utilize such lands as not to contribute to erosion on adjoining lands.

13. **Benefit.**—Neither Members of, nor Delegates to Congress, or Resident Commissioners shall be admitted to any share or part of this permit or derive, either directly or indirectly, any pecuniary benefit to arise therefrom: *Provided however,* That nothing herein contained shall be construed to extend to any incorporated company, if the permit be for the benefit of such corporation.

14. **Assignment.**—This permit may not be transferred or assigned without the consent of the Director, National Park Service, in writing.

15. **Revocation.**—This permit may be terminated upon breach of any of the conditions herein or at the discretion of the Director, National Park Service.

*Number all succeeding pages and attachments in consecutive order and identify each with the permit number.

U.S. GOVERNMENT PRINTING OFFICE 16—25053-6

Figure 1. (cont.). Special Use Permit form, page 2.

Form 10-114a (Dec. 1968)

UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

SPECIAL USE PERMIT CONTINUATION SHEET

AREA	PERMIT NO.	PAGE NO.
Death Valley National Monument		3

16. MOTORIZED EQUIPMENT LIMITATION. No motorized equipment may be brought into Death Valley National Monument under this permit, excepting for transportation use only. The automobile or truck to be used is described as follows:

    Make-Model-Color__________________________Year______State______Lic.No.____________

17. OFF ROAD DRIVING PROHIBITION. No vehicle may be driven off of existing roads and vehicle trails at any time.

18. RESTRICTION ON ROCK COLLECTION. "Rock Hounding" or gathering of common variety stones or rocks for landscaping, building stone, ornamental or lapidary purposes is prohibited. Rock samples may be taken for testing to determine if the rock contains minerals on which rights can be acquired by location of mining claims. Total weight of samples in possession at any time may not exceed 200 pounds, regardless of source.

19. SURFACE DISRUPTION LIMITATION. Disturbance of the surface is restricted to taking or cutting of samples and the excavation by hand tools necessary for taking samples.

20. RESTORATION REQUIRED. All excavations will be refilled and the surface restored as near as possible to its original configuration.

21. CONSTRUCTION PROHIBITED. No trails or roads may be constructed, nor structures built or erected. Mining claim corners may be erected if a valid discovery or minerals locatable under the mining laws is made.

22. EXPLOSIVES PROHIBITED. No explosives may be used, stored in or transported into Death Valley National Monument, under this permit.

23. MAINTENANCE. No equipment, parts, supplies or refuse are to be left in the Monument at any time. All discarded material and trash is to be contained at all times.

24. ADHERENCE TO REGULATIONS. Permittees are to otherwise conform to all the rules and regulations governing Death Valley National Monument, such as prohibition on possession and use of firearms, gathering wood, etc. Annual limitation on camping is a total of 30 days.

25. RIGHTS. This permit is issued subject to all valid existing rights, and does not authorize permittees to prospect on mining claims belonging to others, on Federal acquired or withdrawn lands, or on State of California lands. This permit is not a recognition or denial that the mining claims involved are valid under the mining laws of the United States.

26. ADDITIONAL PERMITS OR AMENDMENTS. Acceptance of this permit does not preclude issuance of other permits or amendments when mining claims involved are located or at any time prior to or after expiration of this permit.

27. COMMUNICATION. A report on activities under this permit is to be submitted to the Superintendent on the attached report forms by the end of each month. The permittee must have a copy of the permit in possession at all times during the permit period when in the permit area.

28. NEW CLAIMS. Permittee must within 15 days following the date of filing new claims in the Monument submit a copy of Notices of Location to the Superintendent, and within 60 days contact the Superintendent in regard to negotiating a permit to cover operations on the new claims.

★ U. S. GOVERNMENT PRINTING OFFICE: 1973—521-228

Figure 1. (cont.). Special Use Permit form, page 3.

METALLIC MINERAL DEPOSITS

A variety of metallic minerals has been prospected for and produced in the Death Valley area. Probably, the most famous are gold and silver. Others include antimony, lead, zinc, copper, and tungsten (Maps 1 and 2, and table 1). The search for gold and silver brought prospectors to the area as early as the 1850s. Undoubtedly, the tales of the richness of the gold at the Lost Breyfogle mine and masses of wire silver at the Lost Gunsight mine tempted some of the early prospectors to brave the hardships of the region. Many perished from the heat and other extremely harsh climatic conditions.

In 1874, rich silver deposits were discovered in the Panamint Range and a "rush" soon developed. Many other discoveries were made in the region during the 1880s, 1890s, and early 1900s. Numerous camps were established, but most were short-lived, and evidence of their existence has largely disappeared. Some of the better-known towns and camps were Skidoo, Greenwater, Chloride City, Panamint, Harrisburg, and Leadfield (Clark, 1970, p. 146-152). Furnace Creek was named for small furnaces used to smelt silver-rich ores.

Metallic mineral deposits that have been discovered and developed since the Monument was established in 1933 include tungsten deposits discovered about 1950 in the Trail Canyon area of the Panamint Range and the lead-silver deposits near Ashford Junction and in Wingate Wash.

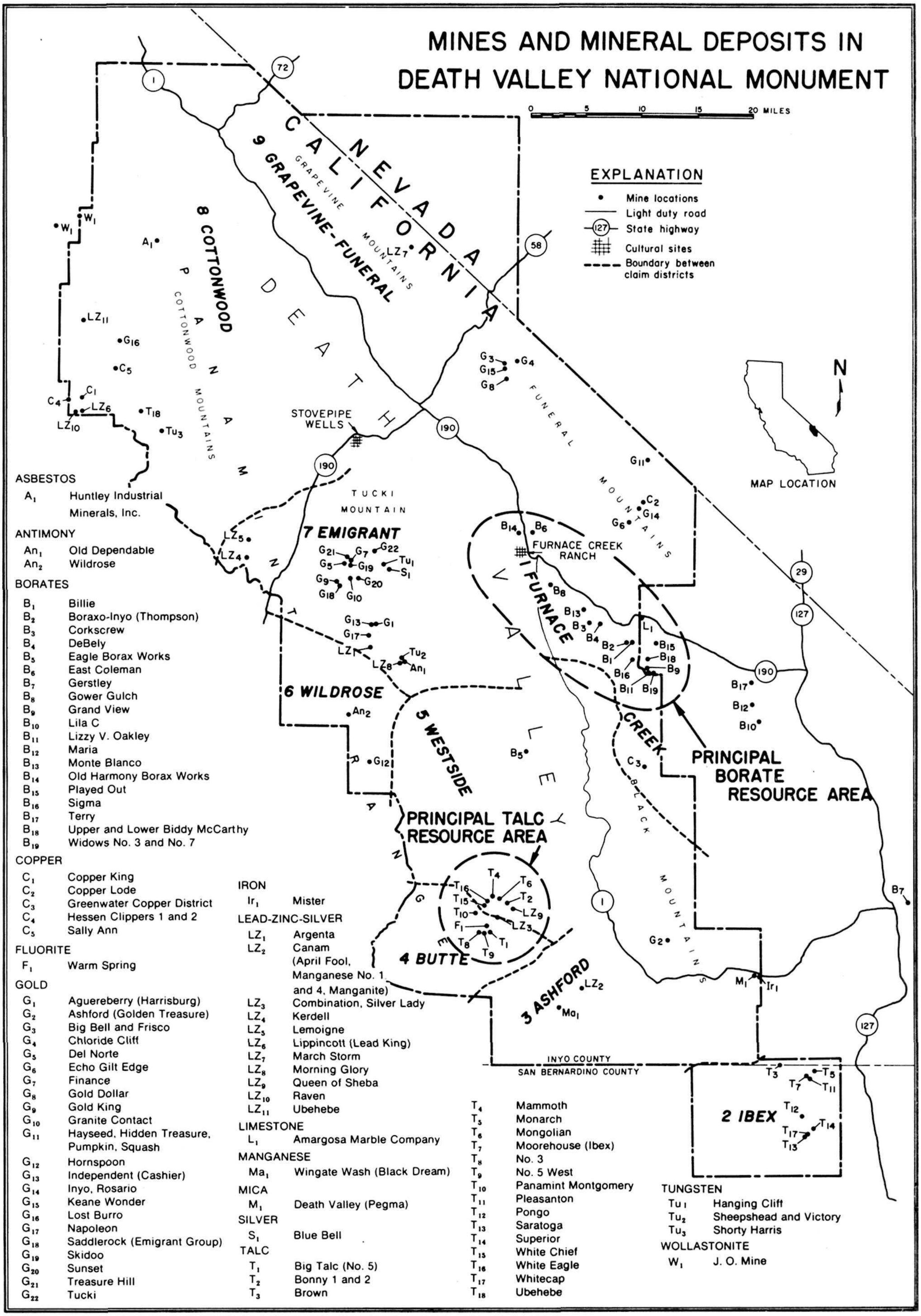
Mining and prospecting for metals in the National Monument has been sporadic and generally the direct result of a favorable change in the selling price of a commodity. Many of the deposits in the Monument have undergone several attempts at redevelopment. This section briefly describes some of the recent activity.

Tucki Mine

The Tucki mine is a few miles northeast of Skidoo on the southwest flank of Tucki Mountain. It is an underground mine and was first worked during the 1930s by the Journigan family. A minor amount of production was recorded in 1940 (Norman and Stewart,

Table 1. Metallic mineral deposits in Death Valley National Monument.

Mineral commodity	*Locations*	*Host rock description*	*Age of mineralization*	*Mode of mineralization and production (references coded by number to bibliography)*
Antimony	Wildrose Canyon, Panamint Range.	Tightly folded Precambrian(?) chlorite schist, amphibolite, and carbonate rock.	Tertiary(?)	Stibnite and pyrite-bearing quartz veins, ranging in thickness from less than 1 inch to 5 feet, contained 5 to 10% antimony. Brecciated amphibolite contained 1 to 2% antimony. About 1000 tons of metal were produced from the Wildrose deposit, mostly during World War I. (58)
Copper	Echo Canyon, Funeral Mountains, Greenwater District, Black Mountains.	Folded and metamorphosed beds of quartzite, siltstone and dolomite, mostly within the Stirling Quartzite.	Precambrian(?)	Azurite, malachite, and chrysocolla fill fractures, coat bedding surfaces, and are disseminated in host rocks in the Echo Canyon area. The average grade of 442,500 tons of rock in this area is about 0.447 % copper. (40) The Echo Canyon deposit lies at the west end of a mineralized belt that stretches into western Nevada. (48) No significant copper production from the Monument.
Gold	Skidoo and Ubehebe areas, Panamint Range. Chloride Cliff, Funeral Mountains. Ashford, Black Mountains.	A variety of stratified metasedimentary rocks, gneiss, and Mesozoic granitic rocks.	Tertiary(?)	Quartz veins with 1/10 to 1 ounce per ton gold, ranging in thickness from less than an inch to several feet. (39) According to production estimates made by early writers there has been 100,-000 to 200,000 ounces of gold produced in the Death Valley area. (39) (55)
Lead, zinc, silver	Ubehebe, Lemoigne Canyon, Galena Canyon, and Wingate Wash areas of Panamint Range	Folded and metamorphosed Precambrian and Paleozoic carbonate rocks, especially the Noonday Dolomite. Also, Tertiary andesite, fanglomerate and lake beds in the southern Panamint Range.	Tertiary(?)	Carbonate rocks have been replaced by galena, sphalerite, and other sulfide minerals. In some areas these minerals have been altered to oxide and carbonate minerals. Ore generally ran a few percent lead and zinc, minor copper and gold, and a maximum of about 20 ounces of silver per ton. Hand cobbed shipments ran as high as 50% metal content. Total value of production from the Queen of Sheba, Lippincott, and Lemoigne mines was about 2.4 million dollars, at January 1976 prices. (18) (35)(39) Lead, zinc, and silver occur in the Wingate Wash area in Tertiary rocks. (17)
Tungsten	Harrisburg-Trail Canyon area, Panamint Range.	Folded and faulted metasedimentary rocks of the Johnnie Formation and the Noonday Dolomite.	Tertiary(?)	Scheelite and calc-silicate minerals in skarn and in narrow quartz veins intruded along fractures. Silicification of Noonday Dolomite. Four samples taken by the National Park Service, one contained 3.43% WO_3, one 2.09%, and the others nil. (25)


MINES AND MINERAL DEPOSITS IN
DEATH VALLEY NATIONAL MONUMENT
0 5 10 15 20 MILES
EXPLANATION
Mine locations
Light duty road
State highway
Cultural sites
Boundary between claim districts
MAP LOCATION
N
NEVADA
CALIFORNIA
9 GRAPEVINE-FUNERAL
GRAPEVINE MOUNTAINS
8 COTTONWOOD
COTTONWOOD MOUNTAINS
PANAMINT
DEATH VALLEY
FUNERAL MOUNTAINS
STOVEPIPE WELLS
TUCKI MOUNTAIN
7 EMIGRANT
6 WILDROSE
5 WESTSIDE
FURNACE CREEK RANCH
1 FURNACE CREEK
PRINCIPAL BORATE RESOURCE AREA
PRINCIPAL TALC RESOURCE AREA
4 BUTTE
3 ASHFORD
2 IBEX
BLACK MOUNTAINS
INYO COUNTY
SAN BERNARDINO COUNTY
ASBESTOS
A1 Huntley Industrial Minerals, Inc.
ANTIMONY
An1 Old Dependable
An2 Wildrose
BORATES
B1 Billie
B2 Boraxo-Inyo (Thompson)
B3 Corkscrew
B4 DeBely
B5 Eagle Borax Works
B6 East Coleman
B7 Gerstley
B8 Gower Gulch
B9 Grand View
B10 Lila C
B11 Lizzy V. Oakley
B12 Maria
B13 Monte Blanco
B14 Old Harmony Borax Works
B15 Played Out
B16 Sigma
B17 Terry
B18 Upper and Lower Biddy McCarthy
B19 Widows No. 3 and No. 7
COPPER
C1 Copper King
C2 Copper Lode
C3 Greenwater Copper District
C4 Hessen Clippers 1 and 2
C5 Sally Ann
FLUORITE
F1 Warm Spring
GOLD
G1 Aguereberry (Harrisburg)
G2 Ashford (Golden Treasure)
G3 Big Bell and Frisco
G4 Chloride Cliff
G5 Del Norte
G6 Echo Gilt Edge
G7 Finance
G8 Gold Dollar
G9 Gold King
G10 Granite Contact
G11 Hayseed, Hidden Treasure, Pumpkin, Squash
G12 Hornspoon
G13 Independent (Cashier)
G14 Inyo, Rosario
G15 Keane Wonder
G16 Lost Burro
G17 Napoleon
G18 Saddlerock (Emigrant Group)
G19 Skidoo
G20 Sunset
G21 Treasure Hill
G22 Tucki
IRON
Ir1 Mister
LEAD-ZINC-SILVER
LZ1 Argenta
LZ2 Canam (April Fool, Manganese No. 1 and 4, Manganite)
LZ3 Combination, Silver Lady
LZ4 Kerdell
LZ5 Lemoigne
LZ6 Lippincott (Lead King)
LZ7 March Storm
LZ8 Morning Glory
LZ9 Queen of Sheba
LZ10 Raven
LZ11 Ubehebe
LIMESTONE
L1 Amargosa Marble Company
MANGANESE
Ma1 Wingate Wash (Black Dream)
MICA
M1 Death Valley (Pegma)
SILVER
S1 Blue Bell
TALC
T1 Big Talc (No. 5)
T2 Bonny 1 and 2
T3 Brown
T4 Mammoth
T5 Monarch
T6 Mongolian
T7 Moorehouse (Ibex)
T8 No. 3
T9 No. 5 West
T10 Panamint Montgomery
T11 Pleasanton
T12 Pongo
T13 Saratoga
T14 Superior
T15 White Chief
T16 White Eagle
T17 Whitecap
T18 Ubehebe
TUNGSTEN
Tu1 Hanging Cliff
Tu2 Sheepshead and Victory
Tu3 Shorty Harris
WOLLASTONITE
W1 J. O. Mine

MAP 2

1951), and then the property was idle for about 30 years. Thin quartz veins, containing minor amounts of gold, are found in fractures within Precambrian metasedimentary rocks, primarily metaquartzite. In 1974, Russ Journigan and Paul Barnett reopened the mine. Gold leaching apparatus and four steel-lined cyanidization tanks were constructed at the property. Old tailing dumps were leached and processed by the carbon filtration method, and a few dozen ounces of gold were recovered. Barnett and Journigan indicated in December 1975 that they intended to contract to local miners in an attempt to locate and mine gold-bearing rock on the property. Fifteen assay results obtained by the National Park Service averaged 0.06 ounces of gold and 0.4 ounces of silver per ton, or about $12 per ton. These samples were collected from the old workings and from existing tailings dumps.

Del Norte Mine

The Del Norte mine is at the northern end of the Skidoo gold mining district. It was probably first worked about 1900 when other mines in the District were active. Mining activity at Skidoo reached its peak in about 1920, although some gold production was reported at the Del Norte in the 1930s. The property apparently remained idle from 1942 until 1969, when 52 drill holes were drilled in an effort to redevelop the mine. The claims were leased by Bell Mountain Silver Mines, Inc., a New York company, in 1970; and Petro Mineral Projects, Inc., was contracted to do the development work. Since 1970, 1200 linear feet of outcrops of mineral-bearing rock have been sampled by near-surface blasting, and 30 shafts and 7 open cuts sampled, principally over a 4-acre area. The National Park Service and the U.S. Bureau of Mines collected and tested a one-ton sample in 1974. During the fall of 1975, Petro Mineral Projects initiated a 5,000-ton pilot leaching project but did not complete the experiment. Robin Hendrickson, the company vice-president, expects the project to resume in spring, 1976.

Gold occurs in a 25-foot-thick, massive metaquartzite bed that forms a 10° N dip slope on a ridge. Gold values are highest near the top of the bed. Small quartz veins intrude the metaquartzite, but it is uncertain whether gold values are contained in these small quartz veins, in the quartzite, or simply in near-surface joints that are filled with soil and rock fragments. The dominant joint and shear strike is N 45° W; they are nearly vertical.

More than 100 assay reports from samples taken in the 4-acre project area were obtained from Petro Minerals Projects and the Minerals Division of the National Park Service. These assays were divided into groups according to the vertical distribution of samples. All assay values of rocks collected within 6 feet of the ground surface were collectively averaged. The remaining assay reports from the 6-foot level to the base of the quartzite bed at 25 feet were also averaged. The uppermost 6 feet of rock averaged 0.13 ounces of gold and 0.33 ounces of silver per ton, or about $20 per ton at January 1976 metal prices. The lower assays, taken from rocks 6 feet to 25 feet in depth, averaged about 0.03 ounces of gold and 0.15 ounces of silver per ton, or about $5 per ton. There was a distinct vertical and lateral consistency of grades below the 6-foot horizon.

Lemoigne Mine

The Lemoigne mine is at about 5000 feet elevation in the Panamint Range west of Stovepipe Wells. The only access to this underground mine is by the narrow and steep Lemoigne Canyon road. This lead-zinc-silver deposit was discovered in 1918 by John Lemoigne. Ore was produced at the mine in 1925, 1927, and 1947 (Hall and Stephens, 1963). Total production from the mine consists of about 128 ounces of gold, 2,398 ounces of silver, 372,827 pounds of lead, and 52,246 pounds of zinc. The value of these metals at January 1976 prices would be about $116,000. Activity at the Lemoigne mine was renewed in 1974. In December 1975, the mine operator, Harold Pischel, was drifting into a previously unworked hillside, exploring for sulfide ore. Material, which was reported by Pischel to carry 14 ounces of silver per ton, was being stockpiled at the entrance to the adit.

The most common rock exposed in the Lemoigne mine area is gray, faulted and broken Paleozoic dolomite (Chapman, Healey, and Troxel, 1971). Base metal and silver mineralization consists of sulfide mineral replacement of carbonate rocks. Numerous shear zones are exposed in the workings, and iron stains and clay-rich slickensides are common. Some oxidized sulfide ore is present, but it occurs sporadically. The low-grade ore mined and stockpiled by Pischel was being removed from a 5-foot-wide hydrothermally altered zone between two parallel faults that trend N 25° E and dip about 45° NW. In December 1975, the stope was about 25 feet long, 7 feet high, and 7 feet wide. Reddish-brown oxidized silver-bearing carbonate rock was exposed in the face, back, and floor of the stope.

Canam Mine

The Canam lead-silver mine is in Wingate Wash at the southern end of the Panamint Range. Small deposits of manganese were mined in this locality during World War II, but it was not until 1964 that Canam Mines, Inc., discovered lead and silver minerals. Several small open pits were opened in 1969, and 15 tons of ore that averaged about 26% lead and 7 ounces of silver were shipped to a smelter at Selby, California. Since 1969, intensive geological and geophysical work has been done on the property, principally by R.J. Grabyan (1974). A few tons of high-grade ore are presently stockpiled at the mine and awaiting shipment.

Rocks exposed in the Wingate Wash area consist of Precambrian metasedimentary and igneous rocks, and Mesozoic granitic rocks, overlain by a sandy conglomerate, a lacustrine sequence of silty limestone, algal limestone and manganiferous sandstone, andesite porphyry, and Pleistocene conglomerate(?). Galena, chrysocolla, vanadinite, descloizite, anglesite, cerussite, linarite, wulfenite, chalcanthite, and coronadite have been identified in the ore zones (Grabyan, 1974). Small veins and irregular areas of chrysocolla, galena, and calcite are in brecciated andesite porphyry and in the lower conglomerate unit of Tertiary age. Veins range in thickness from mere coatings to about 8 inches. Mineralization occurred in Tertiary time.

Conclusions

The metallic mining history of the Death Valley area extends back more than a hundred years. About 50 mines and prospects are known to exist. In the early 1970s and particularly in 1975, there has been much exploration work; but no major mine is now in production. Time limitations for this study did not permit geologic evaluation of the potential of the metallic deposits. Much work, including geologic mapping, sampling, and systematic drilling programs would be needed for a complete evaluation.

Photo 4. Boraxo mine (Bo) of Tenneco Mining, Inc., January 14, 1976, as viewed from the southwest. (B) Black Mountains, (D) Death Valley, (F) Furnace Creek Wash, (C) Furnace Creek Ranch.

BORATE DEPOSITS (COLEMANITE AND ULEXITE-PROBERTITE)

Mining of borates has been a significant and integral part of the rich history of the Death Valley area. The colemanite and ulexite-probertite deposits owned by Tenneco Mining and United States Borax & Chemical Corporation are the largest in the United States (table 2). Currently, only Tenneco is actively mining in Death Valley, at the Boraxo and Sigma mines near Ryan. About 162 people are employed by Tenneco Mining, Inc., and the combined sales value of their borate products from Death Valley National Monument totaled about 4¾ million dollars in 1975. Colemanite and ulexite-probertite from their mines constituted the entire United States production of those ores in 1975.

Table 2. Borate minerals that occur in the Death Valley area.

Mineral	*Chemical composition*	*Specific gravity*	*B_2O_3 content, wt. %*
Borax	$Na_2B_4O_7 \cdot 10H_2O$ ($Na_2O \cdot 2B_2O_3 \cdot 10H_2O$)	1.7±	36.5
Colemanite	$Ca_2B_6O_{11} \cdot 5H_2O$ ($2CaO \cdot 3\ B_2O_3 \cdot 5H_2O$)	2.42	50.8
Howlite	$Ca_2SiB_5O_9(OH)_5$ ($4CaO \cdot 5B_2O_3 \cdot 2SiO_2 \cdot 5H_2O$)	2.58	44.5
Hydroboracite	$CaMgB_6O_{11} \cdot 6H_2O$ ($CaO \cdot MgO \cdot 3B_2O_3 \cdot 6H_2O$)	2.00	50.5
Inyoite	$Ca_2B_6O_{11} \cdot 13H_2O$ ($2CaO \cdot 3B_2O_3 \cdot 13H_2O$)	1.87	37.6
Kernite*	$Na_2B_4O_7 \cdot 4H_2O$ ($Na_2O \cdot 2B_2O_3 \cdot 4H_2O$)	1.95	51.0
Meyerhofferite	$Ca_2B_6O_{11} \cdot 7H_2O$ ($2CaO \cdot 3B_2O_3 \cdot 7H_2O$)	2.12	46.7
Priceite	$Ca_4B_{10}O_{19} \cdot 7H_2O$ ($4CaO \cdot 5B_2O_3 \cdot 7H_2O$)	2.43	49.8
Probertite	$NaCaB_5O_9 \cdot 5H_2O$ ($Na_2O \cdot 2CaO \cdot 5B_2O \cdot 10H_2O$)	2.14	49.6
Ulexite	$NaCaB_5O_9 \cdot 8H_2O$ ($Na_2O \cdot 2CaO \cdot 5B_2O_3 \cdot 16H_2O$)	1.96	43.0

*Kernite does not occur in Death Valley but is included in this table because it is mentioned frequently in the report.

History of Borate Mining

On October 12, 1872, Francis Marion ("Borax") Smith discovered borax at Teel's Marsh, Nevada, and until 1881 the marsh was the center of the United States borate industry. In 1881 Aaron and Rosie Winters of Ash Meadows, Nevada, identified borate material—"cottonball" or ulexite—in the playa at the mouth of Furnace Creek Wash in Death Valley. Winters sent samples to W.T. Coleman and Co., sales agents for "Borax" Smith, and eventually he sold his rights to Coleman for $20,000. In 1882, Coleman built the famous Harmony Borax Works near the discovery site of Winters and began processing "cottonball." That same year a new borate mineral called colemanite, after W.T. Coleman, was discovered by R. Neuschwander, in the hills adjacent to Furnace Creek Wash.

Isadore Daunet collected "cottonball" in 1875, and in the summer of 1881 he and his partners began mining borates in Death Valley when they built the Eagle Borax Works near Bennett's Well. However, their equipment was makeshift, ulexite was hard to process, their shipments were of poor quality, and the haul to a railhead at Mojave was arduous. The operation lasted only two years. Daunet killed himself in San Francisco, and his partners were unable to carry on.

The process used by Coleman to produce borax from "cottonball" was simple. He dissolved material in boiling water, allowed the solution to cool and the borax to precipitate out. It was so hot in the summer at the Harmony Borax Works that solutions would not cool and the plant had to close down. Fortunately another borate find was made at Amargosa between the present sites of Shoshone and Tecopa. Here summer temperatures reached a maximum of only about 110°F, and borax could be produced all summer long. In winter the richer deposits near the Harmony Borax Works were processed, and in summer operations were moved to Amargosa.

Coleman was thus in possession of two borax deposits and plants in a tough desert area, 165 trail miles from the railhead at Mojave. As his market would not support a railhead at the deposit, he decided that his transportation to market had to be built around mules, men, and wagons. The 20-mule teams and wagons are a legend of Death Valley and from 1883 to 1888, the teams made the Harmony Borax Works-Mojave run without a single breakdown. The round trip took about 20 days.

In 1883 colemanite was discovered by silver prospectors in the Calico Mountains near Barstow. Soon after the discovery, W. T. Coleman began buying claims around Borate 3 miles east of the silver camp of Calico. Colemanite had to be mined underground and was not as readily soluble in hot water as was "cottonball." Coleman purchased a plant at Alameda, California, and was beginning to process colemanite when he went into bankruptcy in May 1888. In 1890 the Harmony and Amargosa Borax Works, the Alameda refinery, and the borate mine were sold to "Borax" Smith, who already owned the largest known deposits of borax in the United States (Teel's Marsh, Columbus Marsh, Rhodes Marsh, and Fish Lake Marsh—all in Nevada). Smith consolidated all his holdings into the Pacific

Coast Borax Company, predecessor of United States Borax and Chemical Corporation. He closed the Harmony and Amargosa Works and obtained his ore from Borate, where colemanite was mined and moved by mule teams to the railhead at Daggett. In 1898 a narrow-gauge railroad was built from Daggett to Borate, and the 20-mule team haulage stopped.

In 1896 Smith went to England with the intent of developing an overseas market for borax. The result was the formation of the Pacific Borax and Redwood Chemical Works, Limited. In 1899 Borax Consolidated, Limited, was formed, of which Pacific Coast Borax Company was a part. The international organization eventually operated deposits and refineries in France, Chile, Turkey, England, and the United States.

After the colemanite ore body was depleted at Borate, Smith moved his operations to the Lila C mine (named for a daughter of W.T. Coleman), which was discovered in 1884 by the Kinsey Brothers in the Greenwater Range about 35 miles southeast of the Harmony Borax Works. Smith began development work at the Lila C in 1903 but could not begin production until transportation was provided.

In May 1905 the Pacific Coast Borax Company began building the Tonopah and Tidewater Railroad from Ludlow through Baker to Death Valley Junction to obtain colemanite from the Lila C mine. In 1907 the railroad reached Death Valley Junction, and a 7-mile spur put in from the Lila C mine to the Junction was used to haul the first rail shipment of colemanite. The spur was completed on August 16, 1907, and ore was shipped the same day, for the Lila C mine had been producing since June. From June to August the ore was hauled south about 30 miles to Zabriskie Station on the Tonopah and Tidewater Line, by the 20-mule-team wagons pressed back into service. Borate was then abandoned, and all equipment was moved to the Lila C mine. In 1912 a calcining plant to upgrade the B_2O_3 content of low-grade ore was installed at the mine. High-grade ore was hand sorted.

For seven years the Lila C mine yielded colemanite. High-grade ore was shipped to Alameda or Bayonne, New Jersey—a new company plant to serve the east coast. Lower grade ore was roasted before shipment in a calcining plant built in 1908.

As the Lila C mine became exhausted in 1914, the Pacific Coast Borax Company was already prepared to open new deposits near Ryan, using the just-completed narrow-gauge Death Valley Railroad from the new mine camp of Ryan to Death Valley Junction. A two rotary calcining plant for lower grade colemanite was built at Death Valley Junction. In January 1915 the Lila C was closed and the new group of mines was opened, including the Upper and Lower Biddy McCarty, the Played Out, the Grand View, the Lizzy V., the Oakley, and the Widow mines within a few miles of Ryan and the Monte Blanco mine about seven miles south. By 1915 about 150 men were working seven days a week to produce about 250 tons of colemanite a day. At first the mines were worked on the surface, but later work was underground by conventional mining methods.

In 1915 two more rotary calciners were brought over from the Lila C mine and installed at the Death Valley Junction plant. Gravity concentrating equipment was also added. Colemanite could be separated from the other borate minerals by gravity, but other borate minerals could not be separated from each other. The calciners operated at about 1300°F and caused the colemanite to break up into a powder. This powder was then screened from particles of rock and other impurities. Another important part of the Death Valley Junction plant was the analytical laboratory used to check on the quality of products and the efficiency of the beneficiation process.

Mining operations were suspended at Ryan in 1928 when the sodium borate (borax and kernite) mine of Pacific Coast Borax Company near Boron in Kern County came into production. Sodium borates were more economical to mine and process and were closer to the new processing plant in the port city of Wilmington. Currently, the Boron open pit is the largest sodium borate mine in the world.

The new Wilmington plant went on stream in 1924, and the Alameda plant was immediately closed; but the Bayonne plant was shut down gradually, closing in 1928. In 1928 the Death Valley Junction concentrating plant was shut down, closing an era of significant borate production and processing in the Death Valley area. In 1956 Pacific Coast Borax Company organized into the United States Borax & Chemical Corporation which in 1968 became a member of the Rio Tinto Zinc Corporation (RTZ), a worldwide group of companies.

Borate mining all but ceased in the Death Valley area in the period 1928-1956, but the borate mines were maintained on a stand-by basis. Small tonnages were shipped to fill special orders for colemanite or ulexite, such as for shielding around nuclear test sites and special pottery glazing mixtures. In 1956 the company increased ulexite production from their Gerstley mine near Shoshone. Ulexite was used at this time for borate slurry for fire depressants released from airplanes.

However, it was not until 1970, when Tenneco Oil Company began production of colemanite from the Boraxo mine, that borate mining again became significant in Death Valley. The classic uses of boron chemicals had not changed with time, but new uses were developed for calcium and sodium-calcium borate minerals. In 1974, Tenneco Mining was the largest producer of colemanite and ulexite-probertite in the United States.

General Geology

Borate deposits in the Death Valley area are of two distinct types: (1) accumulations of ulexite ("cottonball") and associated minor borate minerals in

Holocene playa lake beds that occupy the floor of Death Valley and (2) colemanite, ulexite, probertite, and associated minor borate minerals in bedded lake accumulations that occur interstratified in the Pliocene Furnace Creek Formation in the Furnace Creek Wash area. Current mining by Tenneco Mining is in the Furnace Creek Formation.

The Furnace Creek Formation lies between the Oligocene(?) to Pliocene Artist Drive Formation and the Pliocene and Pleistocene Funeral Formation (see McAllister, 1970, for a thorough description of these rock units). These formations have been folded into a broad syncline cut by steeply dipping faults with minor displacements. On the east, the formations are separated from Paleozoic rocks by the northwest-trending Furnace Creek fault zone and on the west by the frontal fault system that borders the east side of Death Valley.

The Furnace Creek Formation is composed of a maximum of about 7000 feet of interlayered and interfingered ancient lake beds, clastic sedimentary rocks, pyroclastic rocks, and flows of vitrophyric and basaltic rocks. Major known deposits of colemanite and ulexite-probertite are found within several tens of feet to about 500 feet above the base of the formation. The main borate deposits are interlayered with mudstone, shale, limestone, conglomerate, and gradational variations of these various rocks (McAllister, 1970, p. 8). Many borate deposits are bounded and cut by steeply dipping faults. Dips of beds (and deposits) are commonly as much as 45 degrees; steeper dips are known.

It appears that the borate minerals were deposited in a Pliocene playa lake near volcanic vents. Evidently thermal spring water enriched in boron fed into the calcium- and sodium-bearing lake and saturated the water with boron. The supersaturation of boron by evaporation ultimately led to the formation of the ulexite. Later, probertite formed as a result of ulexite dehydration, possibly after burial of the lake deposits by younger sediments. Eventually, colemanite and calcite mixtures were formed by addition of calcium to the ulexite-probertite mixtures by sodium leaching and alteration by migrating calcium-rich ground waters. Colemanite occurs as beds, as veinlets, as fracture fillings, and as a cementing agent in ulexite-probertite zones. It also lines and fills former solution cavities and channels. Much, if not all, of this alteration took place after folding and faulting because some colemanite occurs in fault zones and rock fractures, as well as in permeable zones in wall rocks that allowed ready passage of fluids.

Tenneco Mining, Inc.

BORAXO MINE

The Boraxo mine is about 2½ miles west and 1 mile southwest of the mining camp of Ryan (map 1). It is at an elevation of about 2400 feet just east of a small hill which rises above alluvial fan deposits shed off the northern flank of the Black Mountains.

History of the Boraxo mine begins in about 1915 when the Pacific Coast Borax Company filed the Clara lode claim. A discovery shaft sunk by Mr. Thompson led to the name—Thompson mine. A mineral patent was applied for but, for an undetermined reason, was not granted. On the assumption the claim was patented, Pacific Coast Borax Company ceased annual assessment work. Two new claims were filed over the area in 1921 by Messrs Russell, Monaghan, Barlow, and Hill. Subsequently these claims were patented as the Boraxo No. 1 and No. 2. A court battle over the issue was settled in favor of the new claimants, and Pacific Coast Borax bought the mine back in 1935. Kern County Land Company purchased the mine in 1960 for $200,000. Some underground development work was done, and a thousand or so tons of colemanite was produced during the early 1960s from the deposit, which later became known as the Boraxo deposit.

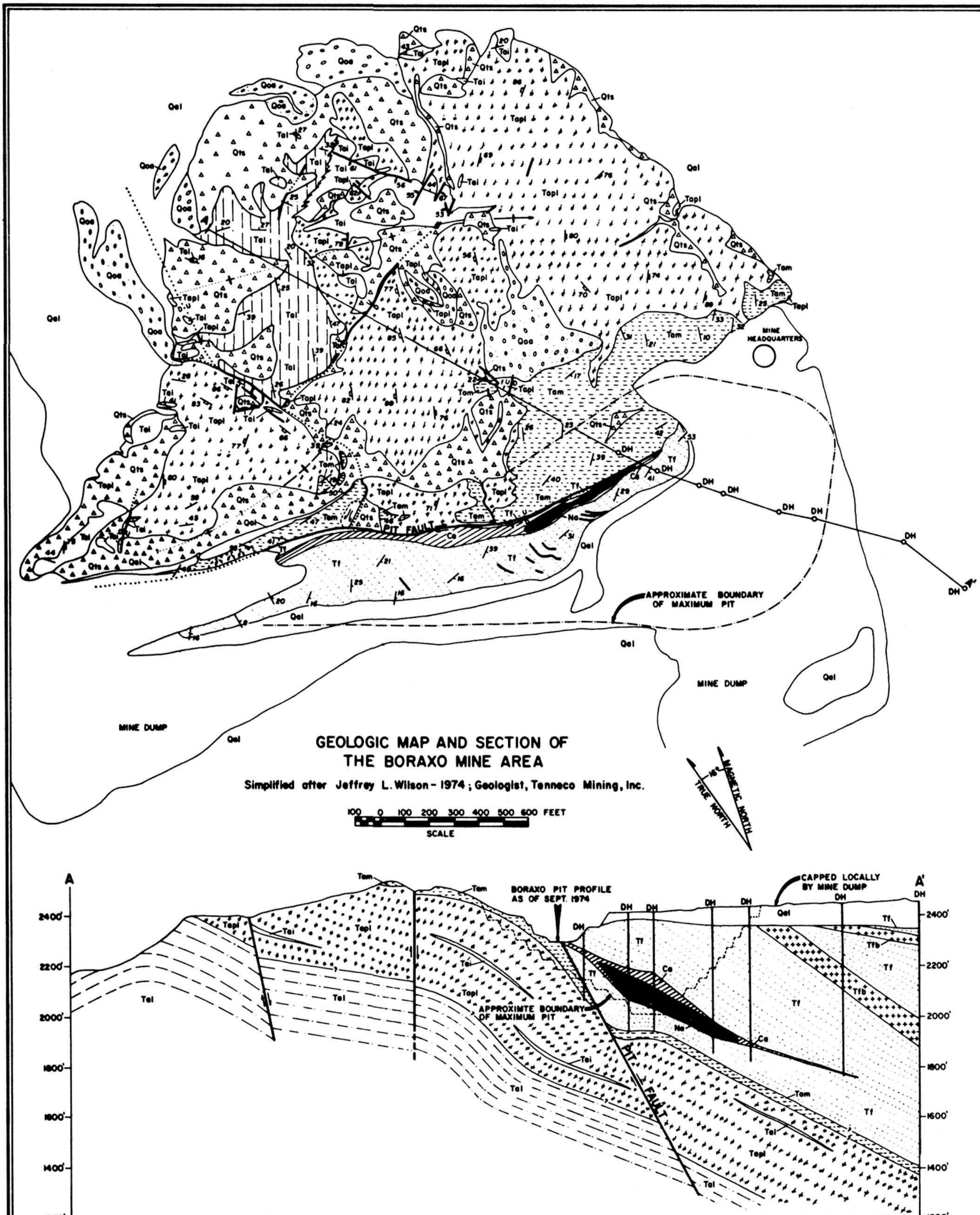
Kern County Land Company was purchased in 1967 by Tenneco, Inc., with their mineral activities assigned to Tenneco Oil Company. The mine was reopened from the surface in January 1970. Excavation was from west to east in a sequence of three adjoining pits—No. 1, No. 2, and No. 3. After extensive drilling, it was decided to develop the deposit by mining from a new pit—the Boraxo at No. 3 extension. In early 1974 overburden removal for the new pit was begun by Tenneco Mining (incorporated from the minerals department of Tenneco Oil Company). Removal was complete in late 1975. Drilling to insure that substrata beneath the mine dumps for the new pit was barren led to the discovery of a new deposit—the Inyo.

Geology and Mineralogy

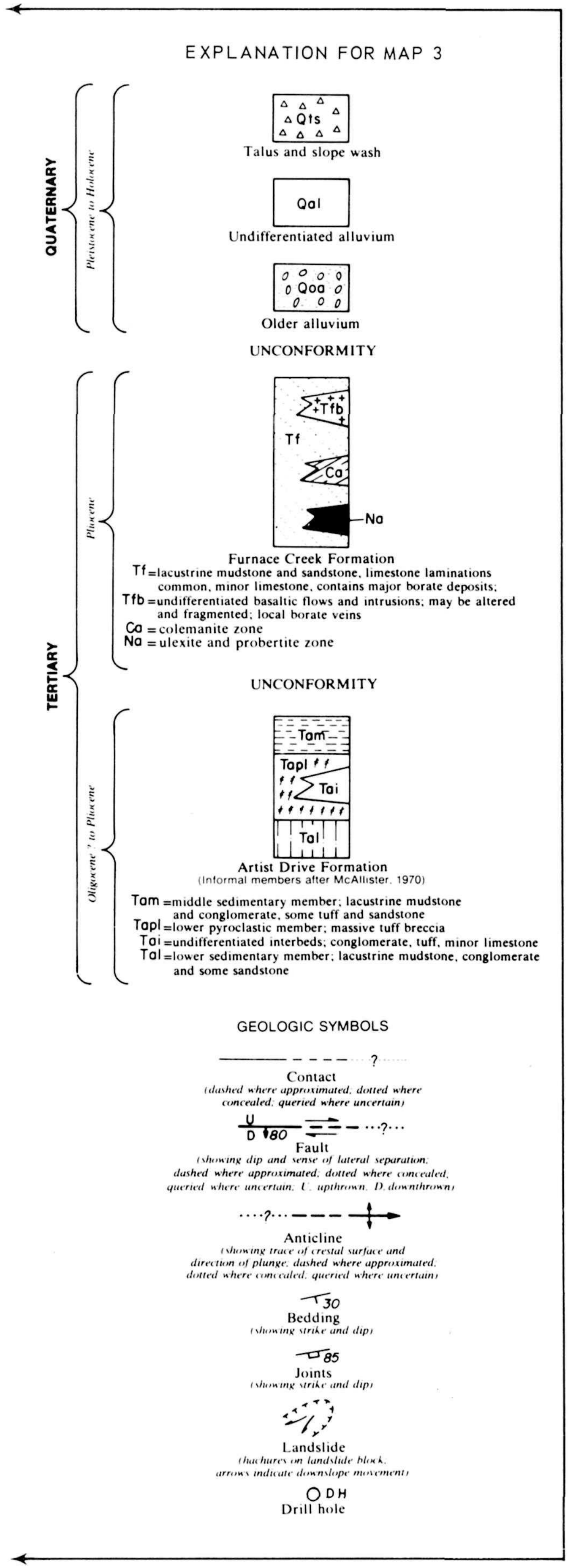
The Artist Drive and Furnace Creek Formations in the Boraxo mine area have been folded into an anticline, the axis of which trends and plunges easterly (Map 3). Several steeply dipping faults along which there is only a maximum of about 200 feet of displacement cut the folded rocks. In the mine area, the Furnace Creek Formation is composed of about a maximum 1200 feet of interlayered and interfingered gray to bluish tuffaceous lacustrine mudstone and shale and sandstone which contain abundant limy laminations. The rocks are yellow to greenish on weathered surfaces. Minor limestone does occur. Grayish basaltic flows and/or intrusions occur locally in a zone from 400 to 900 feet above the base of the formation.

The Boraxo deposit is lenticular and occurs on the south limb of the anticline within a few tens of feet to about 200 feet above the base of the Furnace Creek Formation. It is cut near ground surface on the north by the Pit fault and pinches out on the south at a depth of about 800 feet below the ground surface. The body is deformed locally by minor folds. It ranges in thickness from a feather edge to about 130 feet, with an average thickness of 40-45 feet. The deposit is about 2800 feet wide (along the strike) and was 300 to 700 feet long down dip prior to mining. It dips south from 5° to 60° with an average dip of about 40°. It is parallel to the dip of the enclosing beds, except for local variations.

The Boraxo deposit is composed of two zones of borate minerals with interstitial clay and interlayered


GEOLOGIC MAP AND SECTION OF
THE BORAXO MINE AREA
Simplified after Jeffrey L. Wilson - 1974 ; Geologist, Tenneco Mining, Inc.
100 0 100 200 300 400 500 600 FEET
SCALE
TRUE NORTH
MAGNETIC NORTH
MINE HEADQUARTERS
APPROXIMATE BOUNDARY OF MAXIMUM PIT
PIT FAULT
MINE DUMP
BORAXO PIT PROFILE AS OF SEPT. 1974
CAPPED LOCALLY BY MINE DUMP
APPROXIMTE BOUNDARY OF MAXIMUM PIT
A
A'
2400'
2200'
2000'
1800'
1600'
1400'
1200'

MAP 3



limy shale, mudstone, siltstone, and sandstone beds commonly 1 to 5 feet thick. Generally the outer zone of the deposit is calcite-bearing colemanite, and the core is a mixture of ulexite and probertite.

The approximate average grade of the colemanite and the ulexite-probertite mixtures in the Boraxo deposit, as determined from assays of drill cores and mill-run material is about 20 percent B_2O_3 (by weight) and 28 percent B_2O_3 (by weight), respectively. This indicates a mineral content of about 40 percent colemanite and 70 percent ulexite-probertite.

Mining

Approximately 10 million tons of material have been extracted since 1971 during development of the Boraxo pit. The stripping ratio of overburden to borate ore at present is about 26 to one. The ratio will decrease before mining is completed. In January 1976, the pit was about 2200 feet long, from 300 feet wide at the surface on the west to about 1000 feet on the east, and about 225 feet deep. The length and width are at about maximum pit design, but the maximum final depth will be 450 feet on the east. Benches are cut at 40-foot intervals with a slope face of about 38° in the north wall and 40° in the south wall. About 100 employees work at the mine.

Depth of weathering has been a key factor during pit development but was well defined through rotary drilling. Weathered material is mainly yellowish-gray mudstone and shale from 10 to as much as 150 feet thick. The contact between weathered material and fresh greenish or bluish-gray mudstone and shale is locally sharp, but generally a transition zone as much as 20 feet thick exists. Ground-water seeps and flows from roughly 14 to 30 gallons per minute were found in or near the transition zone, as well as adjacent to the Pit fault in the borate zone. Weathered material is readily ripped by D-9 Caterpillar bulldozers and removed to the dump by push-loaded scrapers of 18- and 24-yard capacity.

Fresh mudstone and shale in the Furnace Creek Formation on the south wall and area of the pit require blasting. They fracture well, however, with low powder factors of from 0.5 to 0.65 (lbs. powder/cu. yd. of broken rock). Pit benches are developed through drilling with two rotary blasthole rigs which drill 8-inch diameter shot holes to a depth of 20 feet on 11-by-22-foot staggered spacing. The pit floor is developed through drilling to a depth of 25 feet with a staggered 12-x-12-foot shot hole spacing. Fresh tuff breccia, conglomerate, and mudstone in the Artist Drive Formation on the north wall and area of the pit are more difficult to blast and have a powder factor of 0.8. Dry shot holes are loaded with ammonium nitrate and wet holes loaded with a slurry of nitro-carbo-nitrate.

The borate zones are blasted in 20-foot lifts, and the broken ore is selectively loaded into 35- and 50-ton rear-dump off-highway trucks by front-end loaders with 8-, 10-, and 15-yard-capacity buckets. At and near the margins of the colemanite and ulexite-probertite zones, the two types of borates are thin and interbedded. In these areas grade control is critical. Here as in other parts of the zones, borates are graded visually into three grades by grade technicians under supervision of mine geologists. Grades 1 and 2 (higher grades) are loaded into 50-ton dump trucks and hauled to a jaw crusher that reduces the material to less than 6 inches in diameter. After crushing, colemanite is moved by loader to a stockpile and later taken in 23-ton truck and trailer combinations to the calcining plant near Lathrop Wells, Nevada. Ulexite-probertite is hauled to the mill at Dunn Siding, California. Grade 3 (low-grade) material (about 10% B_2O_3) is upgraded by processing through a screening plant to remove the low-grade fines. A flotation plant is planned to further upgrade material.

At the present mining rate, Tenneco expects the Boraxo pit to be complete in 1977. It will be left as an open multiple benched pit. This is necessary because at least 250,000 tons of indicated resources of colemanite and ulexite-probertite will remain beneath the pit. It is not economic to remove these borates by open-pit methods, as the stripping ratio is too high. If the borates are to be removed, it must be by underground methods.

Processing, Production, Sales, and Uses

After the simple beneficiation at the mine, raw material containing an average about 40 percent by weight of colemanite (20% by wt. B_2O_3) is hauled by truck about 31 miles to the calcining plant in Nevada about 8 miles north of Death Valley Junction just off State Highway 127 near Lathrop Wells, Nye County. The plant has a work force of 37.

The first commercial shipment consisted of 90 tons of calcined colemanite made in August 1971, to Owens-Corning Fiberglass Corporation, Toledo, Ohio. The Lathrop Wells plant operates 24 hours a day, 7 days a week, and produces a calcined product that contains from 47 to 49 percent or more by weight B_2O_3. There is about a 2.7 to 1 reduction in weight from mine-run colemanite-bearing material to finished calcined colemanite.

Material trucked from the mine is dumped onto a 12-inch grizzly. It is then belt-fed to a hammer mill set at 1/4-inch, whence it is belt-fed to the wash plant to launder out clay particles. Rated capacity for material into the wash plant is 50 tons/hr. with a recovery of about 85 percent colemanite. Water for the plant comes from local wells. Material is then belt-fed to the wet stockpile. Tails go to the tailings pond, where about 75 percent of the water is reclaimed. Rubber-tired loaders move wet stockpile material onto slide plate feeders, where it is belt-fed to dryers at a maximum feed of 12 tons/hr. From here dried material goes to the gas-fired calciner. The calciner heats material and causes included shale and clay to expand and colemanite to decrepitate to a fine powder. Heated materials are then put into an air cyclone to separate colemanite from the impurities. Coarse material (about 5%) from the cyclone is moved to storage before shipment to the railhead at Las Vegas. Fines are fed to another cyclone for further upgrading and then to storage for shipment to the grinding plant at Dunn Siding.

The Dunn Siding facility is a converted talc grinding plant formerly owned by Vanderbilt Corp. about 30 miles west of Baker, San Bernardino County.

It is a modern facility with nine filter bag houses for dust control and employs 25 people. Calcined colemanite from the Lathrop Wells plant arrives at Dunn Siding in 25-ton tank trucks. Material is air blown off from the bottom of the trucks and pumped into four 120-ton-capacity storage silos or, depending on B_2O_3 content, into four 120-ton-capacity calcine-run-product silos. From the silos, material is pumped into a surge bin where it is blended before sending it on to the Raymond mill where it is ground to -70 mesh size. Ground material is pumped into five 120-ton finished product silos. Finished products are pumped into 85-ton capacity rail cars for Owens-Corning fiberglass and glass plants in Jackson, Tennessee, and Anderson, South Carolina.

Calcined colemanite is used mainly for textile-grade glass fibers used in reinforced plastics, fabrics, electrical insulation, and glass-belted tires. It is also used in the manufacture of heat-resistant glasses.

Ulexite and probertite raw material averaging about 70 percent by weight (28% by wt. B_2O_3) is hauled by truck about 100 miles from the mine to the Dunn Siding plant. Shipment of the -6 inch material is in 25-ton capacity semi-dump trucks. Material is belt-fed into the primary crusher, a double rotor impactor, that reduces it to -1 inch in size. The -1 inch can be belt-fed to a Raymond mill where a -70 and -200 mesh product is produced and then pumped into three storage silos—one of 600-ton capacity and two of 225-ton capacity. Material can be diverted to a screen plant where the -10 mesh fraction is pumped into nine blending and storage silos—two of 105-ton capacity and seven of 65-ton capacity. The +10 mesh fraction is fed to a hammer mill to reduce it to -10 mesh size.

Ground products containing from 25 to 30 percent by weight B_2O_3 are moved out in 90-ton capacity rail cars. The Raymond mill products (-70 and -200 mesh) are pumped into cars, and the -10 mesh fraction is belt and elevator fed into cars. Product is sold to Owens-Corning construction fiberglass plants at Santa Clara, California; Fairburn, Georgia; Barrington, New Jersey; and Waxahaxie, Texas. Product for use in fiberglass insulation is shipped to the Johns-Manville Corporation plant at Cleburne, Texas. Monotherm, at Riverbank, Merced County, California, uses the product in the manufacture of fire-proof paint.

The amount of material sold to different plants for different uses is confidential, but the total tonnage of ground calcined colemanite and ground ulexite-probertite and their respective total sales values for the years 1970-1975 is given in table 3. Total sales values for all products for these years is nearly $10,000,000, valued before loading for shipment at Dunn Siding.

Table 3. Total United States production of calcined colemanite and ulexite-probertite, 1970-1975—all from Tenneco's Boraxo and Sigma mines in Death Valley National Monument.

YEAR	BORATE MATERIAL AND SALES VALUE							YEAR
	Colemanite mined (short tons)	Calcined colemanite sold (short tons)	Sales value	Ulexite and probertite mined (short tons)	Ulexite and probertite sold (short tons)	Sales value	Total sales value	
1970	2,989	1,104	$ 66,824	——-	——-	——-	$ 66,824	1970
1971	1,342	497	19,349	6,604	4,623	$ 270,413	289,762	1971
1972	29,319	10,859	713,225	——-	——-	——-	713,225	1972
1973	35,753	13,242	888,300	——-	——-	——-	888,300	1973
1974	54,945	20,350	2,000,000	40,447	28,313	1,300,000	3,300,000	1974
1975	56,700*	21,000*	2,100,000*	94,286*	66,000*	2,640,000*	4,740,000*	1975
TOTAL	181,048*	67,052*	5,787,698*	141,337*	98,936*	4,210,413*	9,998,111*	TOTAL

*approximate

OTHER DEPOSITS

Tenneco Mining, Inc., owns 23 groups of unpatented and patented mining claims and millsites comprising roughly 1000 acres in Death Valley National Monument. Mining claims cover five major deposits: Boraxo (mine), White Monster-Sigma (mine), Inyo, Billie I and Hope-Fag End-Billie II. Ownership of the White Monster-Sigma, Billie I, and Hope-Fag End-Billie II deposits is shared by U.S. Borax and Chemical Corp. All of these deposits are near the base of the Pliocene Furnace Creek Formation near the central eastern boundary of the Monument. The location and description of these deposits is given in table 4.

U.S. Borax & Chemical Corporation

U.S. Borax & Chemical Corporation has a long history of mining borates in the Death Valley area, summarized above. Although little mining has been done since 1928, a significant amount of colemanite and ulexite still remains in most of U.S. Borax's mines and on their patented mining claims. They own 3,628 acres of patented mining claims (fee land) and claim about 955 acres of unpatented mining claims. All but 220 acres of the fee land was patented prior to 1907, well before the establishment of the Monument in 1933.

Principal deposits (mines) in the Monument held by U.S. Borax are—the White Monster part of the Billie I and (Hope-Fag End), DeBely, Corkscrew, Monte Blanco, Gower Gulch, and East Coleman. All these are in the Furnace Creek Wash area. The location and a description of the deposits is also given in table 4.

Reserves and Resources

Certain data and definitions are critical for an understanding of this section, and it seems best to discuss them at the start. The following definitions of reserves and resources and their various categories are used in this report.

MINERAL RESERVES: Measurable amounts of mineral-bearing materials that can be produced with current technology under existing economic and political conditions.

MINERAL RESOURCES: Mineral-bearing materials that could become mineral reserves either through future technological developments, improved economic conditions, different political conditions, or a combination of developments and conditions.

Measured: Reserves or resources for which tonnage is computed from dimensions revealed in outcrops, trenches, workings, and drill holes and for which the grade is computed from the results of detailed sampling. The sites for inspection, sampling, and measurement are spaced so closely and the geologic character is so well defined that size, shape, and mineral content are well established. The computed tonnage and grade are judged to be accurate within limits which are stated, and no such limit is judged to be different from the computed tonnage or grade by more than 20 percent.

Indicated: Reserves or resources for which tonnage and grade are computed partly from specific measurements, samples, or production data and partly from projection for a reasonable distance on geologic evidence. The sites available for inspection, measurement, and sampling are too widely or otherwise inappropriately spaced to permit the mineral bodies to be outlined completely or the grade established throughout.

Inferred: Reserves or resources for which quantitative estimates are based largely on broad knowledge of the geologic character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on an assumed continuity or repetition, of which there is geologic evidence; this

Table 4. Colemanite and ulexite-probertite deposits in the Death Valley area. All deposits occur in the Pliocene Furnace Creek Formation, most near the base of the Formation.

DEATH VALLEY NATIONAL MONUMENT

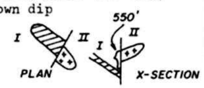
NAME AND OWNERSHIP	LOCATION	DESCRIPTION	THICKNESS IN FEET	MINERALOGY (C=colemanite; Ca=calcite; U=ulexite; P=probertite)	RESERVES (Rs) AND RESOURCES (Ro) IN SHORT TONS (M=measured; Id=indicated; In=inferred)	APPROXIMATE AVERAGE GRADE (wt. %)	APPROXIMATE AVERAGE B_2O_3 (wt. %)	MOST PROBABLE MINING METHOD FOR EXTRACTION	ESTIMATED RESERVES AND RESOURCES RECOVERABLE (%)
BORAXO (MINE) Tenneco Mining, Inc.	SE¼ S25, NE¼ S36, T26N, R2E; S of Hill 2562 about 3½ mi. NW of Ryan	W-E strike; S dip, 5°-60°, about 40° av.; on S limb of W trending anticline, cut on N by Pit fault; about 2800' wide, about 300'-700' long down dip; portion left after surface mining about 2800' wide, from about 20'-280' long down dip	0-130 about 40 av. about 9-22	C+Ca enclosing U+P; in limy shale, mudstone, siltstone, sandstone	MRs 170,000 C MRs 445,000 U+P IdRo 100,000 C IdRo 150,000 U+P (may be several times these figures)	40 C 70 U+P 40 C 70 U+P	20 C 28 U+P 20 C 23 U+P	Surface-benched pit--about 271,000 C and 141,000 U+P mined out (1/76) Underground--cut and fill? room and pillar?	85 50
SIGMA (MINE) Tenneco Mining, Inc. and WHITE MONSTER U.S. Borax & Chemical Corp.	T25N, R3E; about 1¼ mi. W of Ryan	NW strike; NE dip, 5°-15°; about 1100' av. width, about 1900' long down dip	0-270 200 av.	C+Ca enclosing U+P; in limy shale and mudstone	MRs 102,000 C MRs 198,000 U+P IdRo 4,420,000 C IdRo 8,580,000 U+P	40 C 58 U+P	20 C 23 U+P	Surface-benched pit about 100,000 C and about 100,000 U+P mined as of 1/76; Present pit 500' x 500' and a few to 60' deep	85
INYO Tenneco Mining, Inc.	SW¼ S25, T26N, R2E; NW of Hill 2562 about 4 mi. NW of Ryan	NW strike; NE dip about 45°; on NE limb of NW trending anticline; deposit blind; 1200' wide from about 150' below grd. surface to 800' below grd. surface, about 900' long down dip	0-100 50-60 av.	C+Ca enclosing U+P; as matrix in sndy. congl. w/mudstone interbeds	IdRo 1,320,000 C IdRo 680,000 U+P	44 C 60 U+P	22 C 24 U+P	Underground--shaft, drifts, stopes	50
BILLIE I Tenneco Mining, Inc. and U.S. Borax & Chemical Corp.	S½ S31, T26N, R2E, and NW¼ S6, T25N, R2E; adjacent to Dantes View Rd. about 1½ mi. NNW of Ryan	NE strike; SE dip 2°-40°, about 25° av.; N of NNE trending and steeply dipping fault; 200'-800'; wide, about 700' av.; about 3700' long down dip 	0-250 150 av.	C+Ca enclosing U+P; in limy shale, mudstone, siltstone, sandstone	IdRo 9,750,000 C IdRo 3,250,000 U+P	44 C 68 U+P	22 C 27 U+P	Underground--cut and fill, through vertical access shaft outside Monument	50-75 max.
BILLIE II Tenneco Mining, Inc. and HOPE-FAG END U.S. Borax & Chemical Corp.	S½ S31, T26N, R2E and NW¼ S6, T25N, R2E, adjacent to Dantes View Rd. about 1½ mi. NNW of Ryan	NE strike; NW dip about 25°; S of NNE trending and steeply dipping fault; 200'-900' wide, about 750' av.; about 1000' av. long down dip; fault has offset deposits and top of Billie II is about 550' above top of Billie I deposit	75-300 175 av.	C+Ca enclosing U+P; in limy shale, mudstone, siltstone, and sandstone	IdRo 3,000,000 C IdRo 1,000,000 U+P	44 C 68 U+P	22 C 27 U+P	Surface-benched pit	85
DeBELY (MINE) U.S. Borax & Chemical Corp.	S22, T26N, R2E, Black Mts., adjacent to Furnace Creek Wash	Deposit exposed at surface and in underground workings, not blocked for mining; complexly folded and faulted*		C+Ca; in shaly limestone interb. w/shale	IdRs 45,000 C*	32 C*	16 C*	Underground--modif. room and pillar w/subl. haulage and slushers	50
CORKSCREW (MINE) U.S. Borax & Chemical Corp.	S21, T26N, R2E, Black Mts., adjacent to Furnace Creek Wash in Corkscrew Canyon	Borate-bearing zone, about 1800' long down dips NE about 50°; basaltic flows in footwall, tuffaceous mudstone and sandstone in hanging wall; well exposed at surface*		C+Ca+U; C massive and cavernous; in shaly limestone w/interb. shale	IdRs 170,000 C* IdRs 80,000 C* InRs 380,000 C* InRs 120,000 U+P*	54 C 78 U+P 52 C 63 U+P	27 C* 31 U+P* 26 C* 25 U+P*	Underground--adits, shafts, drifts, stopes	50
MONTE BLANCO (MINE) U.S. Borax & Chemical Corp.	S16, 17, T26N, R2E, Black Mts., adjacent to Furnace Creek Wash	Interlayered in steeply dipping beds; faulted off at one end, grades into shale at other, well exposed at surface*		C+Ca+U; in shaly limestone w/interb. shale	InRs 949,000 C* InRs 1,990,000 U+P*	44 C 45 U+P	22 C* 18 U+P*	Surface benched pit	70
GOWER GULCH (MINE) U.S. Borax & Chemical Corp.	S36, T27N, R1E, Black Mts., adjacent to Furnace Creek Wash in Gower Gulch	Some borates occur in gypsiferous member of Fm. that dips N 40°-45°; other borates occur in basal conglomerate that dips N 55°-60°		C+Ca+U	Undetermined			Underground--adits, shafts, drifts, stopes	
EAST COLEMAN (MINE) U.S. Borax & Chemical Corp.	S14, T27N, R1E, East Coleman Hills near Furnace Creek	Borate-bearing zone about 2000' long in a NNW direction occurs between two faults that also trend NNW. Beds of tuffaceous mudstone and sandstone are probably steeply dipping		C+Ca	Undetermined			Surface-benched pit Underground?	

Table 4 (cont.). Colemanite and ulexite-probertite deposits in the Death Valley area. All deposits occur in the Pliocene Furnace Creek Formation, most near the base of the Formation.

AREA	NAME AND OWNERSHIP	LOCATION	DESCRIPTION	THICKNESS IN FEET	MINERALOGY (C=colemanite; Ca=calcite; U=ulexite; P=probertite)	RESERVES (Rs) AND RESOURCES (Ro) IN SHORT TONS (M=measured; Id=indicated; In=inferred)	APPROXIMATE AVERAGE GRADE (wt. %)	APPROXIMATE AVERAGE B_2O_3 (wt. %)	MOST PROBABLE MINING METHOD FOR EXTRACTION	ESTIMATED RESERVES AND RESOURCES RECOVERABLE (%)
RYAN AREA	WIDOW NO. 3 (New Widow) (MINE) U.S. Borax & Chemical Corp.	S16, T25N, R3E, about 2 mi. SSE of Ryan, Greenwater Range	Deposit limited on one side by fault; deposit may extend to WIDOW NO. 7 MINE IdRs blocked out and ready to mine; InRs extend down and laterally in one direction from IdRs*		C+Ca enclosing U+P; in shaly limestone w/interb. shale	IdR[illegible] [illegible]30,000 C* IdR[illegible] [illegible]05,000 U+P* InR[illegible] 750,000 C InRs 1,250,000 U+P	40 C* [illegible] U+P* 36 C* 57 U+P*	20 C* 22 U+P* 18 C* 23 U+P*	Underground--room and pillar w/slusher drifts	50
	WIDOW NO. 7 (Old Widow) (MINE) U.S. Borax & Chemical Corp.	S17, T25N, R3E, about 2 mi. S of Ryan, Greenwater Range	Deposit wedge-shaped, opening down dip; 700' wide, 700' long, upper contact dips about 20° parallel to beds, lower contact dips 30°-40°, steeper than beds, deposit pinches out abruptly; shale layers in deposit thicken down dip*	150 max.*	C+Ca+U about 2% in shaly limestone w/interb. shale	IdRs 896,600 C* InRs 780,000 C*	36 C* 32 C*	18 C* 16 C*	Underground--room and pillar	50
	LIZZIE V. OAKLEY (MINE) U.S. Borax & Chemical Corp.	S17, T25N, R3E, about 1½ mi. S of Ryan, Greenwater Range	Deposit faulted on one side; extension possible in down faulted block*		C+Ca; in shale	IdRs 15,500 C* InRs 16[illegible],300 C*	28 C* 30 C*	14 C* 15 C*	Surface-cuts; underground--adits, shaft, drifts, stopes	60
	GRAND VIEW (MINE) U.S. Borax & Chemical Corp.	S17, T25N, R3E, about 1 mi. S of Ryan, Greenwater Range	IdRs is all in pillars; deposit extends from surface to flat fault 300' down dip*	Few to 50*	C+Ca; in shaly limestone, w/interb. shale	IdRs 86,000 C*	28 C*	14 C*	Underground--pillar removal	50
	UPPER BIDDY McCARTHY (MINE) U.S. Borax & Chemical Corp.	S8, T25N, R3E, Ryan, Greenwater Range	IdRs ready for mining; lower part of highest grade already stoped---some left as pillars; deposit is near Lower Biddy McCarthy but is not connected*		C+Ca+U; replaces limestone breccia interst. in limy flat pebble congl.; thin shale beds interst. thru deposit	IdRs 285,500 C* IdRs 5,000 U+P* InRs 87,000 C*	36 C* 80 U+P* 22 C*	18 C* 32 U+P* 11 C*	Underground--room and pillar, drifts, and stopes	60
	LOWER BIDDY McCARTHY (MINE) U.S. Borax & Chemical Corp.	S8, T25N, R3E, Ryan, Greenwater Range	Deposit has moderate dip, pinches and swells beneath undulating hanging wall fault*		C+Ca; in limestone interb. w/shale and congl.	IdRs 45,500 C* InRs 30,000 C*	44 C* 50 C*	22 C* 25 C*	Underground--room and pillar, drifts, stopes; some near surface work caved	50
	PLAYED OUT (MINE) U.S. Borax & Chemical Corp.	S4 proj. T25N, R3E, about 1½ mi. NNE of Ryan, Greenwater Range	Small blocks and pillars left, generally less than 1000 tons; in moderately steep dipping beds*		C+Ca enclosing U; in limy shale which is interb. w/shale and sandstone	IdRs 25,000 C* some U+P* InRs 15,000 C some U+P	28 C* 34 C*	14 C* 17 C*	Underground--pillar and block removal	50
DEATH VALLEY JUNCTION WEST AREA	LILA C (MINE) U.S. Borax & Chemical Corp.	T24N, R4E, about 7 mi. SW of Death Valley Junction, Greenwater Range	Borate-bearing zone in tuffaceous mudstone and sandstone about 1800' long; dips E about 38°-45°, bounded on W by NNW trending & steeply dipping fault		C+Ca	Mined out			Underground--modified room and pillar w/subl. haulage and slushers; workings caved	0
	TERRY (MINE) Tenneco Mining, Inc.	T25N, R4E, about 5 mi. W of Death Valley Junction Greenwater Range	Deposit at depth of 15'-20'		C+Ca	IdRs 2000 C	50 C	25 C	Surface--pit; several thousand tons mined in 1974-1975	90
	MARIA (MINE) Tenneco Mining, Inc.	T24N, R4E, about 5 mi. SW of Death Valley Junction, Greenwater Range	NW strike; NE dip, 10°-15°; about 600' wide; 1600' long; deposit is blind, occurs at depth of about 700'-900'	0-38 20 av.	C+Ca	IdRo 700,000 C	48 C	24 C	Underground--room and pillar or cut and fill thru access shaft	50-60
SHOSHONE AREA	GERSTLEY I (MINE) U.S. Borax & Chemical Corp.	S16, State Land section, T22N, R7E, about 5 mi. NE of Shoshone	Deposit in lake beds of Pliocene? age; borate beds about 30' thick interlayered in mudstone and conglomerate; NE strike; 10°-30° SW dip; bounded on NE and SW by steeply dipping SW trending faults	about 250 zone	C+Ca+U; in mudstone and congl.	MRs 82,700 U some C IdRs 141,300 U some C	70 U 68 U	28 U 27 U	Underground--room and pillar w/slusher drifts; about 24,000 tons produced intermittently since 1960	50
	GERSTLEY II Tenneco Mining, Inc. and U.S. Borax & Chemical Corp.	S8, 17, T22N, R7E, about 6 mi. NE of Shoshone	Deposit in faulted and fractured lake beds of Pliocene? age; borate beds about 10'-35' thick interlayered in limestone breccia zone, above congl. and below shale; NE strike, dip 25° SE; zone about 400' wide, 1000' long; blind; from about 120' to 700' below grd. surface	about 150 zone	C+Ca+U; in limestone breccia	IdRo 850,000 C IdRo 150,000 U	44 C 80 U	22 C 28 U	Underground--room and pillar	50

*Data from Smith & Associates, unpublished U.S. Geological Survey report, 1954.

evidence may include comparison with deposits of similar type. Bodies that are completely concealed may be included if there is specific geologic evidence of their presence. Estimates of inferred reserves or resources should include a statement of the specific limits within which the inferred material may lie.

All tonnages given in this report are in short tons, and a tonnage factor of 15 cubic feet of borates per ton was used in calculating tonnage from volume measurement. Factors used for mineral grade computation from chemically determined B_2O_3 content were 50 percent B_2O_3 in colemanite and 40 percent B_2O_3 in ulexite and probertite. For example, a 20 percent by weight of B_2O_3 in colemanite would represent a mineral content of about 40 percent by weight. A 28 percent by weight of B_2O_3 in ulexite or colemanite would represent a mineral content of about 70 percent by weight (table 2).

CALIFORNIA AND THE UNITED STATES

Pertinent data on known borate deposits in the Death Valley area are tabulated in table 5. A summary of data regarding reserves and resources from table 5 and some additional data on the Boron area, California, and the Lake Mead Recreational area, Nevada, are given in table 6. Colemanite and ulexite have been mined in San Bernardino County near Borate, in Los Angeles County near Lang, and in Ventura County about 5 miles west of Frazier Mountain. Little is known about the potential for further deposits in these areas, but all available information indicates that deposits are small or have been nearly mined out. Therefore, they were not considered in this analysis. No deposits in other playa lakes in California are known to be large enough for commercial exploitation.

Reserves, resources, and approximate average grades for about half of the deposits in table 4 were determined through consultation with staff members of both Tenneco Mining, Inc., and U.S. Borax and Chemical Corp. Surface and underground geologic maps, grade maps, and geologic cross-sections prepared from drill logs were examined. A model for the Billie I and Hope-Fag End-Billie II deposits was examined. Data in table 4 marked with an asterisk was taken from an unpublished report on borate reserves in the Death Valley area by Ward C. Smith and Associates, U.S. Geological Survey, July 24, 1954. The same tonnage factor, and percentage factors for conversion of contained B_2O_3 to colemanite, ulexite, and probertite used by the U.S. Geological Survey were used for this report (see above).

Data in table 5 show that the bulk of the known reserves and resources of colemanite and ulexite-probertite in the United States are in California, mainly in Death Valley National Monument. The tonnages given in table 5 are "in-the-ground tonnages" at different grades and do not reflect the tonnage which can be recovered by mining. The mining method used to extract the deposits is critical to the amount that can be recovered. Perhaps as much as 90 percent of a deposit can be recovered through surface mining methods; whereas, only 50 to 75 percent could be recovered by underground mining methods since material must be left to provide roof support. An estimated percentage of material that can be recovered is given in the last column on table 5.

An estimated current sales value of reserves and resources of colemanite and ulexite-probertite can be obtained by reducing the tonnages in table 5 through consideration of the appropriate grades, mining methods, and processing techniques. The Anniversary mine was not considered in this analysis. Table 5 shows a national total of 25,871,400 tons of all categories of colemanite, known or inferred, remaining to be mined from known deposits. Of which about 79 percent is within Death Valley National Monument, about 15 percent of this is in the Ryan area, and about 3 percent each in the Death Valley Junction and Shoshone areas. There is a total of 19,977,070 tons of all categories of ulexite-probertite known but not mined, of which about 84 percent is in Death Valley National Monument, 10 percent is in the Ryan area, about 5 percent is in the Boron area, and less than 1 percent is in the Shoshone area.

More than half of the 20,406,000 tons of colemanite that remain unmined in deposits in Death Valley National Monument is recoverable. However, to be on the conservative side the tonnage of recoverable colemanite is assumed to be 10,000,000 tons to account for the loss in recovery through mining. At about 40 percent (20% B_2O_3) grade there is about a 2.7 to 1 reduction on calcining. This leaves 3,700,000 tons of calcine presently valued at about \$100 per ton, or \$370,000,000. Similarly the 16,493,000 tons of unmined ulexite-probertite is reduced to 8,225,000 tons to allow for mining losses. At about 60 percent (24% B_2O_3) grade there is about 5,000,000 tons recoverable, presently valued at about \$40 per ton or about \$200,000,000. Thus the total current sales value of colemanite and ulexite-probertite known in the Monument is about \$570,000,000. Similarly calculated, a current sales value for deposits in the Ryan area is about \$122,000,000; for the Boron area about \$42,000,000; for the Shoshone area, \$35,000,000; for the Death Valley Junction area, \$13,000,000. These dollar values indicate the relative importance of colemanite and ulexite-probertite in California and the different areas; they do not indicate that these large tonnages could be sold immediately in the current market if they were mined and ready to be sold. Underground mining is generally more costly than surface mining, and the recovery of material is only about half that of surface mining. For these reasons, plus inflation and price increases, it would seem reasonable to expect the sales value of these reserves and resources to rise every year.

WORLD

World borate production from 1970 to 1974 and crude estimates of world reserves and resources of all borates is given in table 10. The United States (California) and Turkey are the number one and number two world leaders in production, reserves, and resources. Turkey's role may become even more significant in a few years, as attempts are made to develop borax deposits and new beneficiation and refinery plants to complement its large current production of colemanite.

Table 5. Reserves and resources of colemanite and ulexite-probertite in California and the United States. See also table 4.

Area and category	*Colemanite* (*short tons*)	*Ulexite-probertite* (*short tons*)	*Totals* (*short tons*)
DEATH VALLEY NATIONAL MONUMENT, INYO COUNTY, CALIFORNIA			
Measured reserves	272,000	643,000	
Indicated reserves	215,000	80,000	
Inferred reserves	1,329,000	2,110,000	
Indicated resources	18,590,000	13,660,000	
	20,406,000	16,493,000	36,899,000
RYAN AREA, INYO COUNTY, CALIFORNIA			
Indicated reserves	2,084,100	810,000	
Inferred reserves	1,829,300	1,250,000	
	3,913,400	2,060,000	5,973,400
DEATH VALLEY JUNCTION AREA, INYO COUNTY, CALIFORNIA			
Indicated reserves	2,000		
Indicated resources	700,000		
	702,000		702,000
SHOSHONE AREA, INYO COUNTY, CALIFORNIA			
Measured reserves		82,700	
Indicated reserves		141,300	
Indicated resources	850,000	150,000	
	850,000	374,070	1,224,070

BORON AREA,
KERN COUNTY, CALIFORNIA

There is a stockpile of about 7,000,000 tons of an indicated resource of ulexite- and colemanite-bearing shale containing as much as 10% B_2O_3 at the U.S. Borax sodium borate mine at Boron. Ulexite makes up the majority of the two borate minerals, approximately 15% or 1,050,000 short tons. There is no known way to economically separate and produce these two minerals, which are stockpiled during mining of the sodium borates.

LAKE MEAD RECREATION AREA,
CLARK COUNTY, NEVADA

Drilling in the early 1970s by Tenneco Mining showed an indicated resource of about 1,125,000 tons containing about 28% colemanite (14 wt. % B_2O_3) or about 315,000 short tons. The colemanite body occurs at a depth of about 600 feet in a tightly folded syncline at Stauffer Chemical Corporation's Anniversary mine, which has not produced since the early 1930s.

Borate production and marketing data reported by Turkey are generally inconclusive because the industrial processes and end products are largely undetermined, and the relationship of the increasingly powerful Government-owned company, Etibank, to the six private producers (Wang, 1975, p. 4). Extensive deposits of both borax and colemanite are already under Etibank's control, and possibly the whole industry will be nationalized in the near future. In 1974 Etibank operated one surface mine and one underground mine in the Emet Tertiary borate district about 125 air miles south-southeast of the port city of Bandirma in northwest Turkey. Wang reports that roughly 255,000 tons of colemanite upgraded to about 40 percent B_2O_3 were exported by Etibank in 1974. Also, the six private companies who operate mines in the Bigadic Tertiary borate district about 75 miles south of Bandirma exported about 340,000 tons of colemanite, upgraded to about 38-42 percent B_2O_3. About 21,214 tons of hand-sorted colemanite, valued at $852,000 f.o.b. Turkey, produced by the private companies was imported into the United States. Imports remained fairly constant from 1970 through 1974 (table 6). During the first nine months of 1975, 20,800 tons of colemanite were imported. Hand sorting is apparently necessary to keep the arsenic content below 100 parts per million. Colemanite used to manufacture glass products in the United States must have a low arsenic con-

Table 6. World borate production 1970-1974 and estimated reserves and resources of all borates (data in thousand short tons - from U.S. Bureau of Mines, and Kistler and Ward, 1975).

	PRODUCTION					*ESTIMATED RESERVES AND RESOURCES*	
COUNTRY	*1970*	*1971*	*1972*	*1973*	*1974**	*Millions of short tons*	± *grade, wt. % B_2O_3*
United States (imports of colemanite from Turkey)	1,041 (27)	1,047 (7)	1,121 (20)	1,225 (18)	1,185 (21)	200-255	25 borax, kernite, colemanite, ulexite, probertite
Argentina	35	38	50-60	50-60	50-60	8-15	20 borax, ulexite
Turkey	334?	629?	680?	700?	700?	150-525?	30 borax, colemanite, ulexite
U.S.S.R.	155	158	200	200	350	7-20?	20 szaibelyite
Mainland China	34?	35?	35?	not available	not available	5-10?	20 ulexite, ?

About 96% of this value represents boron minerals and compounds made from sodium borates produced at either U.S. Borax's Boron mine (the world's largest mine) in Kern County or from Kerr-McGee's Searles Lake mine at Trona, San Bernardino County. Principal products are borax decahydrate ($Na_2B_4O_7 \bullet 10H_2O$), borax pentahydrate ($Na_2B_4O_7 \bullet 5H_2O$), borax anhydrous ($Na_2B_4O_7$), and boric acid ($H_3BO_3$). The remainder was calcined colemanite and ulexite-probertite produced at Tenneco's Boraxo and Sigma mines in Death Valley National Monument.

tent. Apparently some of Etibank's colemanite runs as high as 1200 parts per million arsenic (from realgar, AsS).

Etibank has a Tertiary deposit of borax at Kirka about 175 air miles southeast of Bandirma which probably had production in 1975. It is apparently similar in size to the mine at Boron. A refinery with an annual capacity of 180,000 tons of product was under construction in 1975, and a plant of similar size is planned for construction in 1976. The borax is mined in an open pit (Wang, 1975, p. 5).

The following information on Argentina, the U.S.S.R., and mainland China was taken from Wang (1974 and 1975) and Kistler and Smith (1975). In Argentina the only important producer is the Tincalayo mine (at 13,000 feet elevation) of Boroquimica Limitada. Borates from Tertiary rocks are shipped 250 miles to the processing plant at Camp Quijano in the foothills of the Andes. The borate industry in the U.S.S.R. is about 40 years old. A fracture zone in a Permian salt dome in the Inder district north of the Caspian Sea was the site of the first discovery of the magnesium borate szaibelyite. Later other deposits of sodium borates were found in Kazakhstan, the Caucasus, and several places in Siberia, including the Lake Baikal area. In 1974 about 50,000 to 60,000 tons of borates were shipped to Japan. In China ulexite deposits occur in the Iksaydam Lake-Tsaidam area in Tsinghai Province. The textile fiberglass industry has expanded sharply in recent years and apparently uses all but a few thousand tons which are exported annually to Japan.

Photo 5. Boraxo mine of Tenneco Mining, Inc., January 14, 1976.

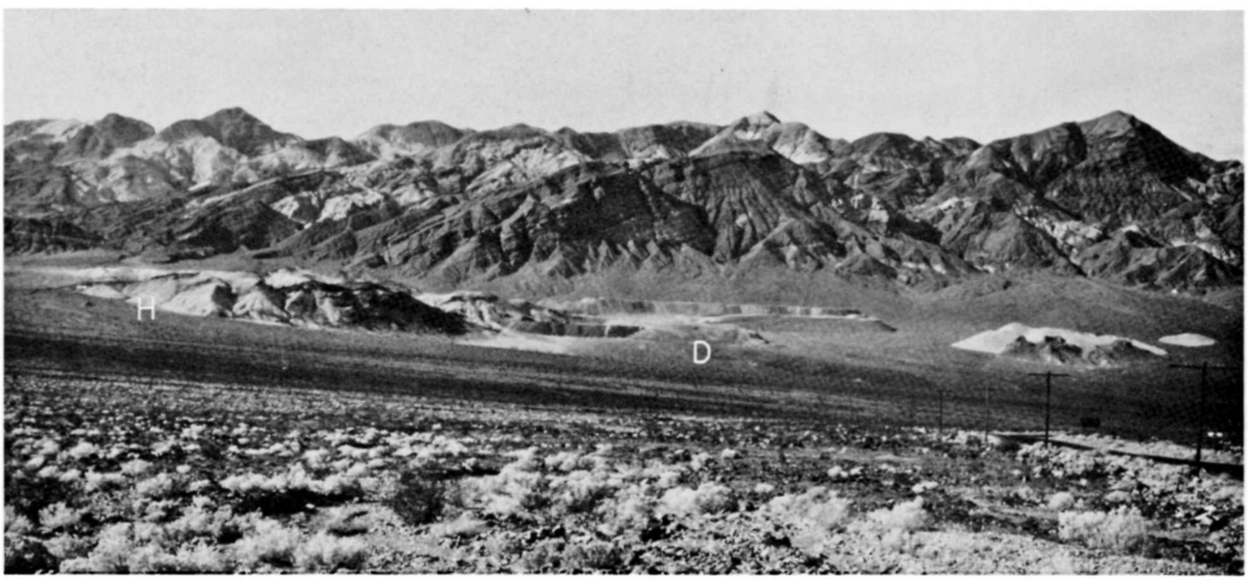


Photo 6. Boraxo mine of Tenneco Mining, Inc., as seen from the Furnace Creek road (State Highway 190) in October 1975. The Black Mountains are in the background.

Photo 7. Sigma mine (S) of Tenneco Mining, Inc., January 14, 1976, as viewed from the northeast. Black Mountains are in the background; Furnace Creek Wash is in the foreground.

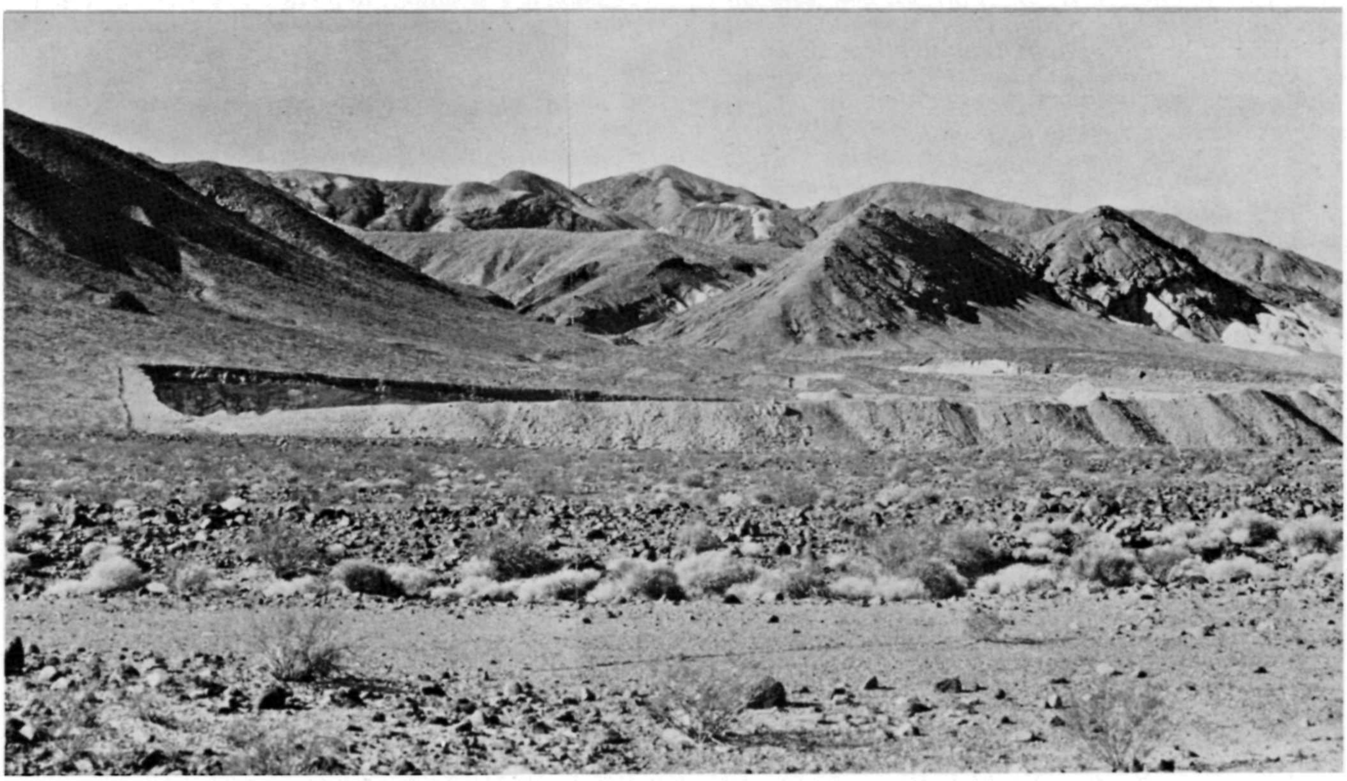


Photo 8. Sigma mine of Tenneco Mining, Inc., January 14, 1976, as viewed from the east along the Dantes View Road.

TALC DEPOSITS

Mining of talc deposits of the Death Valley area began about 1910, although much of the area had been intensely prospected for precious and base metals and borates since the mid-1800s. Since that time, the southern Death Valley area has been one of the significant sources of commercial talc in the United States. In 1974, approximately 14 percent of the total national production of talc was from deposits in California, 12 percent of which was from deposits in Death Valley National Monument (table 11). In 1975, California ranked fifth in the nation in tonnage of talc produced; but, because California talcs command premium prices, the state ranked first in the nation in total sales value.

Talc deposits occur in a single geologic unit—the Crystal Spring Formation of later Precambrian age—the known exposures of which are confined to the southern Death Valley area and eastward to the Kingston Range region. Approximately 50 talc mines and prospects are known in this region. Many have been mined, but as of January 1976 talc mining in Death Valley National Monument was solely in deposits in the Warm Spring-Galena Canyon area in the southwest portion of the Monument.

History of Talc Mining

Talc was first mined in California by Indians, who carved it into utensils and ornaments. As early as the mid-1800s, California settlers were mining soapstone from deposits along the western foothills of the Sierra Nevada and were using the material in linings and foundations of furnaces and for building and ornamental stone. Talc-bearing areas in the Mojave Desert area that are now major domestic sources were opened in the period 1912 to 1918. Especially important was the Talc City mine near Darwin, Inyo County (Page, 1951; Gay and Wright, 1954), which for many years was the nation's principal source of steatite-grade talc. (Steatite was originally a mineralogical name applied to pure talc, but today it refers to a massive variety of blocky talc suitable for electrical insulator manufacture.)

From 1916 to the mid-1930s, the Talc City mine, together with the Western mine in southern Inyo County and the Silver Lake mine in northern San Bernardino County, were the principal sources of talc in California. During this period, the total production of talc in the state rose from about 9,000 to about 20,000 tons per year. This output was used mainly in the paint, cosmetic, and insulator industries.

Between 1933 and 1943, the use of talc as a major ingredient in the manufacture of wall tile became widespread. In this period also, steatite-grade talc was found to be a necessary ingredient in the manufacture of high-frequency electrical insulators for certain types of electronic equipment. Because this grade of talc was then again in short supply, it was classified as a critical mineral for several months in the war years 1942 and 1943. Spurred by these two uses and by the growth of industry and population on the Pacific Coast, talc production in California had reached 65,000 tons per year in 1943. This output was obtained mainly from mines in the region that extends from the Inyo Mountains southeastward through the Death Valley area to Nevada. The Talc City, Western, and Silver Lake mines continued in operation after the war, and numerous other mines were expanded or placed in production. Of these others, the White Mountain mine in the Inyo Mountains; the Death Valley, Grantham (Warm Spring), Eclipse, Monarch, Superior, Tecopa, Acme, and Excelsior mines in the southern Death Valley-Kingston Range region; and the Yucca Grove mine north of Baker, San Bernardino County, were the most productive and continuously worked (Wright, 1966).

The post-war building boom, and the resulting demand for paint and wall tile, caused a continued increase in talc production in California. Annual production of about 120,000 tons was reached in 1951. Since 1970, the annual production rate has been in the general range of 153,000 to 185,000 tons. Because of depletion of reserves and the cost of operating small underground mines, this production has been from a decreasing number of mines, with more dependence upon those mines in Death Valley National Monument. Preliminary data for California talc production in 1975 indicate that over 90 percent of total statewide production for that year came from the area of Galena and Warm Spring Canyons in the southwestern part of Death Valley National Monument.

Mineralogy and Uses of Talc

Talc is a distinct mineral species, a hydrous magnesium silicate. Pure talc has a chemical composition of $Mg_3(Si_4O_{12})OH_2$ and contains 63.5 percent SiO_2, 31.7 percent MgO, and 4.8 percent H_2O; but it is seldom found in nature in large quantities. In common commercial usage, most rocks that are called talc contain such minerals as tremolite, dolomite, antigorite, calcite, and chlorite. These minerals compose as much as, or more than, 50 percent of some deposits; and, because of this mineralogical variation, the chemical compositions of many commercial talcs differ markedly from the composition of pure talc. For many uses, these other minerals are beneficial. Tremolite, for instance, is useful for ceramic tile manufacture, as it acts as a bonding agent and prevents excessive shrinking during firing. Others, such as chlorite or calcite, are harmless when used in stucco or plaster products or when blended with other talc and used in paint products; but, for such uses as in the manufacture of pharmaceuticals, cosmetics, and electrical insulators, they are detrimental impurities and are not acceptable.

Commercial talc can be classified into four major categories:

Steatite: Compact, massive, cryptocrystalline; can be sawed, drilled or machined to required shapes. Steatite converts to interlocking crystals of clinoenstatite upon firing at 1800 F for 6 hours, resulting in a product that has excellent insulating properties.

Soft platy talc: An alteration product of magnesium carbonate rocks. Chlorite is a common accessory mineral. This is probably the most important type of talc, as it is used in more products than any other talcose material.

Tremolite talc: Massive or laminated rock composed of varying percentages of tremolite, anthophyllite, calcite, dolomite, serpentine, and "soft talc." It is characterized by calcium oxide contents of from 6 to 10 percent.

Mixed talc: Various types of talc; includes the so-called "soft talc," a friable, white schistose rock largely composed of platy talc, dolomite, calcite, serpentine, and other trace minerals.

Table 7 lists the various properties of talc which are important in specific markets or industries. The cosmetic industry has been omitted because very little, if any, California talc is marketed to this industry.

Table 7. Talc properties important to specific industries.

PAINT INDUSTRY
Color (whiteness)
Particle shape
Packing quality
Oil absorption
Fine particle size (Hegman gage rating)
Opacity
PAPER INDUSTRY
Free of grit (low abrasion value)
Color (with MgO as 100, prefer 90 or higher)
Opacity
Particle size (less than 5u)
Low alkali content
Effective in controlling pitch, oil, or other oleoresinous substances
Talc pigment gives lower wax pick values than clay pigments
Talc gives lower ink receptivity than clay
CERAMIC INDUSTRY
Uniform chemical composition
Constant amount of shrinkage on firing
Fired color
Particle size distribution
PLASTIC INDUSTRY
Low iron content
Particle shape
Reinforcing ability
Compatibility with resins and other components (Talc is inert)
Superfine particles
Resistivity
ROOFING INDUSTRY Asphalt Backing and Surfacing
Minimum oil absorption
Color
Particle size consistancy
Brightness
Particle shape
PETROLEUM AND AUTOMOTIVE INDUSTRIES Lubricants, Body Putty, Undercoating
Free from grit (pure platy talc for lubricants)
Chemically inert
Nonwicking (undercoating)
RUBBER INDUSTRY
Good lubricity
Free of grit
Color (only in white rubber and latex)
Resistivity
Chemically compatible with latex

Most commercial talc products are a blend of two or more types of talc formulated to provide distinctive chemical and/or physical properties for consuming industries. For example, one type would be hard, massive, gray-white talc mined for its ceramic properties; another would be the soft foliated type mined for use in paint and plastics. With the exception of pure steatite grades, hand-picked platy cosmetic talc, and a few products from flotation mills, the industrial product "talc" is a mixture of several minerals. Chemical analyses of typical California talcs and products from talc-producing areas in the United States are listed in table 8.

General Geology

Talc in the southern Death Valley region occurs only in the Crystal Spring Formation, the lowest and most extensively exposed of three formations that comprise the Pahrump group of later Precambrian age. The Crystal Spring Formation is from 3000 to 4200 feet thick and consists characteristically of: (1) a lower part, a few hundred to 1000 feet thick, composed of quartzite and shale; (2) a middle part, a few tens of feet to a few hundred feet thick, composed of dolomite and/or limestone, and a higher layer of massive chert; (3) an upper part, a few hundred feet thick, composed of interlayered and thinly bedded quartzite, shale and dolomite; and (4) intrusive sills and sill-like bodies of diabase, a few hundred to 1000 or more feet in thickness. The most persistent of the diabase bodies lies immediately below the carbonate unit in the middle part of the Crystal Spring Formation (Wright, 1954).

Contact metamorphism of the carbonate member in the middle of the Crystal Spring Formation by the intrusion of diabase has resulted in the formation of pronounced and widespread zones of silicate minerals. These silicate zones range in thickness from a few inches to 200 feet or more and are in contact with, or close to, the diabase. The strata at or near the base of the carbonate member, which are close to the lowest of the large diabase sills, are the most persistently altered and show some degree of silication wherever the contact zone is observed. Almost all commercial bodies of talc occur within these silicated zones at this stratigraphic position (Wright, 1968).

Talc Mines in the Warm Spring-Galena Canyon Area

LOCATION AND ACCESSIBILITY

The Warm Spring-Galena Canyon area is in the southern part of the Panamint Range on the west side of Death Valley (Map 1). Topography of the area consists of rugged northwest-trending mountains deeply incised by eastward draining canyons. Relief is considerable, with elevations of the talc deposits ranging from 1200 feet to 4400 feet. The gravel access roads up Warm Spring Canyon and Galena Canyon are unpaved but generally well graded, as they serve as main haulage

Table 8. Typical chemical analyses of commercial talc.

	Pure talc (theoretical)	*Average Vermont carbonate ore*[1]	*Flotation talc, Johnson mine, Vermont*[1]	*Roofing granules, Cohutta Talc Co., Georgia*[1]	*Steatite, Yellowstone mine, Montana*[1]	*Average talc ore, Talcville, Gouverneur District, New York*[1]	*Texas talc*[2]	*Massive talc rock, Grantham mine*[3]	*Massive talc rock, Grantham mine*[3]	*Massive talc rock, Mammoth mine*[3]	*Talc schist, Monarch mine*[3]	*Massive talc rock, Montgomery mine*[3]	*Talc schist, Pleasanton mine*[3]	*Mistron F-128 and 139, Panamint mine*[4]	*Furnace Creek and Furnace Creek Coarse, Panamint mine*[5]	*C-400 and C-500, Panamint mine*[6]
SiO_2	63.36	35.98	59.15	47.92	62.65	59.80	57.92	57.35	56.66	55.80	54.80	56.42	46.38	56	58	57
MgO	31.89	32.95	31.34	26.00	30.23	27.45	27.20	27.95	23.35	26.83	26.82	28.11	23.80	26	26	26
Fe_2O_3	- -	0.65	3.36	6.82	1.51	0.05	0.46	0.35	0.18	0.09	0.18	0.28	0.34	$>1/2$	$>1/2$	$>1/2$
TiO_2	- -	0.02	- -	0.15	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	trace
Al_2O_3	-	0.43	0.26	7.35	0.31	0.57	-	0.75	1.14	2.23	1.15	0.58	1.87	1	1	1
CaO	-	0.00	0.15	4.14	trace	6.80	5.76	5.70	5.91	5.45	6.24	5.63	10.76	7	6	6
K_2O	-	0.00	-	0.00	0.05	- -	- -	0.58	0.44	- -	0.18	0.02	0.97	1	1	1
Na_2O	- -	0.00	- -	0.00	0.15	- -	- -	1.81	1.13	- -	0.72	0.12	1.28			
CO_2	- -	20.45	1.76	- -	0.27	1.18	- -	3.05	4.40	- -	4.75	4.46	8.17	6	$4\frac{1}{2}$	$5\frac{1}{2}$
H_2O	4.75	2.73	4.30	0.05	4.87	- -	- -	3.22	3.94	8.20	3.63	4.12	2.22	3	3	3
MnO	- -	0.41	- -	0.00	- -	0.39	- -	- -	- -	- -	- -					
S	- -	0.06	- -	0.09	- -	(SO_3)0.07	- -	- -	- -	- -	- -					
NiO	- -	0.21	- -	- -	- -	- -	- -	- -	- -	- -	- -					
Cr_2O_3	- -	0.18	- -	- -	- -	- -	- -	- -	- -	- -	- -					
CoO	- -	0.01	- -	- -	- -	- -	- -	- -	- -	- -	- -					
FeO	- -	5.96	- -	- -	- -	0.15	- -	- -	- -	- -	- -					
Less O for S	- -	0.05	- -	- -	- -	- -	- -	- -	- -	- -	- -					
P_2O_3	- -	0.01	- -	0.00	- -	- -	- -	- -	- -	- -	- -					
Ign. loss	- -	- -	- -	7.51	- -	4.75	10.76									
	100.00	100.10	100.32	100.03	100.04	101.21	99.10	100.76	101.51	98.62	98.47					

[1]Chidester (1964).

[2]Pence (1955).

[3]Wright (1968).

[4]Paint and general purpose: brightness %, GE 91+, L. 92+; SG. 2.8. % acid sol., 9; tremolite free.

[5]High-loading filler for plastics: brightness %, GE. 88+ and 87+, L. 90+ and 89+; SG. 2.8. % acid sol. 7; tremolite free.

[6]Extenders in paint, rubber, plastics, etc.: brightness %, GE 89+, 90+, L. 91+; SG. 2.8. % acid sol. 8, tremolite free.

roads for hauling talc by truck to talc mills at Dunn Siding, Los Angeles, and Victorville.

GEOLOGY

The most westerly talc deposits in the southern Death Valley region are exposed in the Warm Spring-Galena Canyon area. In Warm Spring Canyon are the Grantham (Big Talc and #5), Panamint (Montgomery), Warm Spring West, Warm Spring, and #2 and #3 deposits. In Galena Canyon are the Bonny, Mammoth, Mongolian, White Chief, White Eagle, and Panamint deposits. The Panamint (Montgomery) deposit is on a ridge between Warm Spring and Galena Canyons (Map 4).

In this area, the Crystal Spring Formation rests unconformably upon gneiss and schist of earlier Precambrian age (Wright, 1966). The Crystal Spring Formation here is about 4,000 feet thick and contains all of the three typical members. The largest and most productive bodies of talc—the principal bodies at the Grantham and Mammoth mines—have altered from siliceous dolomite at the base of the carbonate member and lie along the upper margin of a diabase sill. Part of the talc at the Panamint mine also occurs in this setting. Other talc bodies at the Panamint (Montgomery) and Grantham (Big Talc and #5) mines, as well as the bodies at the Bonny mine, form parts of septa within the sill.

The rocks of the southeastern slope of the Panamint Range are cut by numerous high-angle faults, most of which trend northward to northwestward. These faults separate the Crystal Spring Formation into blocks that are several thousand feet long and several hundred feet wide. Within these blocks, beds of the Crystal Spring Formation dip gently to moderately eastward to southeastward. Talc bodies, which ordinarily are terminated by faults, range in length from a few tens of feet to 3,000 feet or more and are from a few feet to as much as 20 feet thick.

JOHNS-MANVILLE PRODUCTS CORPORATION'S MINES

Geology and Mineralization

The Grantham (Big Talc and #5) mine in the lower part of Warm Spring Canyon has yielded more talc than any other mine in California. It has been in operation almost continuously since 1942, with a total production of nearly 90,000 short tons in 1974 (table 10). Most of this production came from removing (pulling) and reducing (robbing) pillars from the underground works.

The lower part of Warm Spring Canyon is bordered mainly by metasedimentary rocks and diabase of the Crystal Spring Formation. The strata and diabase bodies in the mine area strike northeastward and dip gently to moderately southeastward. The Grantham (Big Talc and #5) mine is underground on discontinuous exposures of talc on the gently dipping south limb of an anticlinal structure. The talc-bearing zone in the mine is uniform in thickness, composition, attitude, and internal structure (Map 5).

The Warm Spring mine is about 4,000 feet west of the Grantham (Big Talc-#5) mine. Here, two talc-bearing zones strike northeastward, dip about 25° southeastward, and are exposed along strike for about 750 feet. This deposit closely resembles the deposit in the Grantham (Big Talc-#5) mine area. Talc zones are truncated on the south by a northwest-trending fault (Map 4). Most of the zones have been removed through surface mining. Part of the deposit extends to the fault but would have to be mined by underground methods.

Lying between this fault and the #2 deposit is the Warm Spring West deposit, a commercial body of talc 22 feet thick that has been intersected at a depth of 127 feet by four drill holes (Don Anderson, personal communication, 1975). The Warm Spring West deposit appears to dip gently southeastward, but more drilling is needed to outline it (Map 4 and table 9).

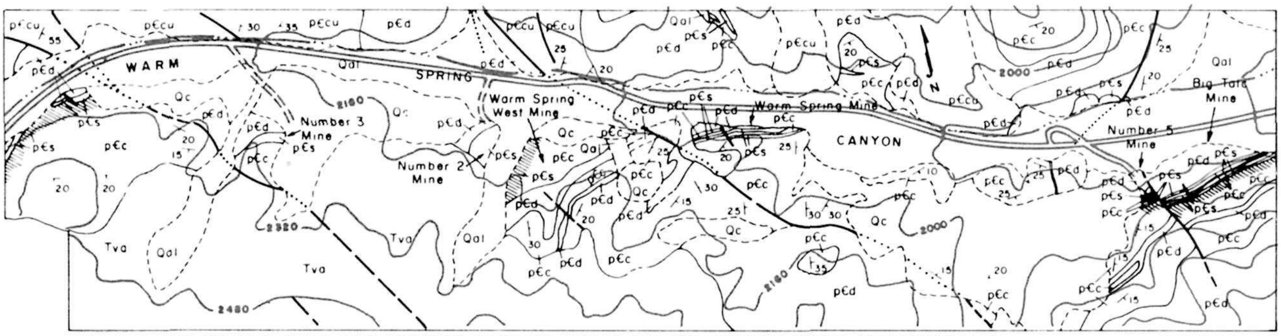
On the #2 and #3 deposits, which are approximately 1700 and 3600 feet, respectively, west of the Warm Spring mine, the exposed talc bodies strike northeastward and dip gently southeastward. These are relatively small bodies, both well exposed at the surface through recent exploration work.

Mining

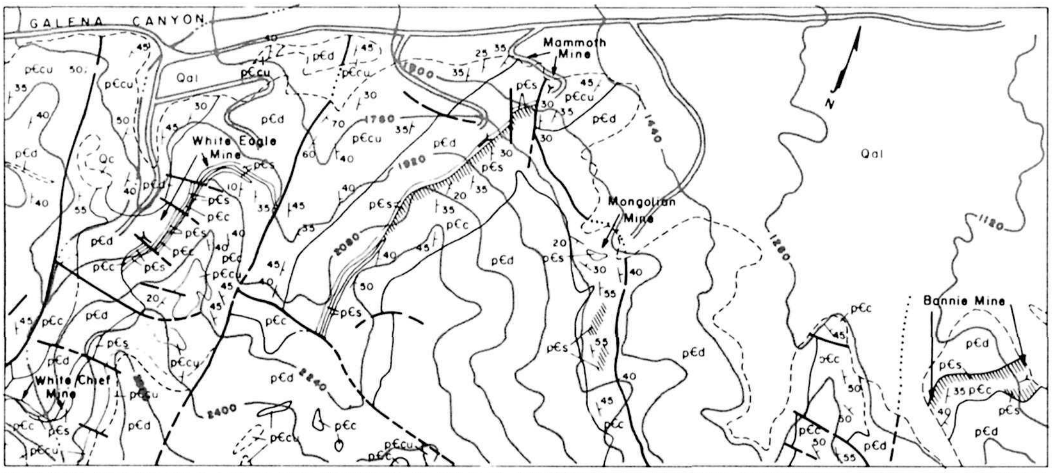
The talc bodies dip gently southeastward into the hills on the south side of Warm Spring Canyon. As a consequence, downdip portions of the talc body have an increasing thickness of rocks over them. These conditions have locally precluded the use of surface mining techniques.

The underground workings of Grantham (Big Talc and #5) have been developed by inclined haulageways (15°) (Map 5) designed to accommodate rubber-tired diesel haulers and front-end loaders. The talc zones have been developed by levels driven at various elevations off of these haulageways. Ground support can be a major problem in the underground talc mines in Death Valley, so extensive timbering in conjunction with roof bolting is commonly required to hold the blocky, caving ground that is prevalent in talc horizons. This problem and expense has been circumvented in the Grantham (Big Talc and #5) workings by employing a room-and-pillar mining method. Although initial recovery is only about 50 percent with this method, the large talc zones make this method economically feasible, and eventually recovery may be as much as 75 percent because pillars can be pulled and robbed.

The Warm Spring mine consists of an open benched pit about 80 feet in maximum depth. In plan, the longest dimension is about 800 feet in a westerly direction. It's about 400 feet wide. The open pit operation was discontinued because of excessive overburden and truncation of the talc beds on the west by the northwest-trending fault. In addition to the Warm Spring mine, the #2 and #3 deposits will be developed by open pits,



GEOLOGIC MAP OF TALC MINES AND DEPOSITS IN WARM SPRING CANYON, SOUTHEASTERN PANAMINT RANGE GEOLOGY BY L A WRIGHT (1955-1960)



GEOLOGIC MAP OF TALC MINES AND DEPOSITS IN GALENA CANYON, SOUTHEASTERN PANAMINT RANGE GEOLOGY BY L A WRIGHT (1955-1960)

EXPLANATION

SYMBOLS

Contact
Dashed where approximately located

Fault
Dashed where approximately located, dotted where concealed

Strike and dip of bed

Adit

0 1000 2000 3000 FEET

CONTOUR INTERVAL 160 FEET

QUATERNARY

Qal — Younger alluvium, fanglomerate and landslide material (undifferentiated)

TERTIARY

Qc — Older alluvium and fanglomerate

Tva — Volcanic rocks

PRECAMBRIAN

p€d — Diabase

p€cu / p€c / p€cu — Crystal Spring Formation

p€cu – shale, quartzite, dolomite, chert and conglomerate undifferentiated

p€c – massive carbonate member, mosty dolomite, lower strata cherty

p€s — Silicated rocks

Silicated rock containing abundant talc and/or tremolite composed largely of material of commercial interest; shaded where undivided or mixed with abundant waste rock

GEOLOGIC MAPS SHOWING TALC-RICH SILICATED ROCKS IN THE WARM SPRING – GALENA CANYON AREA

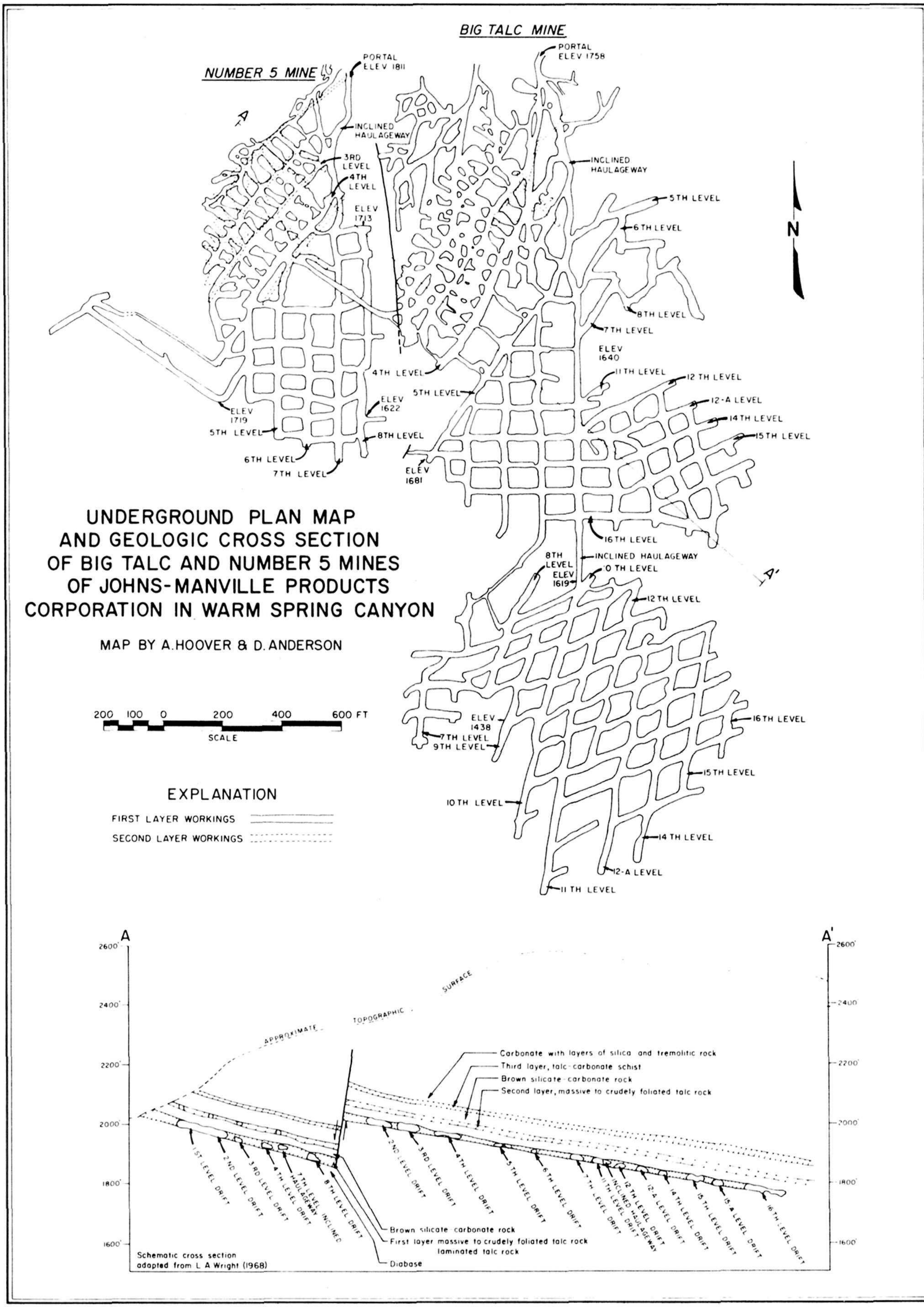
MAP 4

Table 9. Talc reserves and resources of Cyprus Industrial Minerals, Johns-Manville Products Corporation, and Pfizer, Inc., in Death Valley National Monument (see Maps 1, 2, and 4 for locations).

Company and mine names	*Type of operation*	*Reserves and resources*	*Percentage recoverable (estimated)*	*Comments*
CYPRUS INDUSTRIAL MINERALS COMPANY Ibex	Open pit	Indicated reserves 10,000 (dumps)	90	Underground workings have caved and are inaccessible; reserve would be dependent upon recovery by flotation methods of existing dump material.
Monarch-Pleasanton	Underground	Measured reserves 78,000 75,000 Indicated reserves	60	Ore body dips at near vertical; recovery would be dependent upon development of a block-caving mining technique in conjunction with a flotation plant; talc has 1-5% tremolite.
Panamint (Montgomery)	Open pit	Measured reserves 225,000	85	Channel assays on footwall vein where accessible and grid drill hole data on both the hanging wall and footwall vein; tremolite content averages less than 0.1%.
Ubehebe	Underground (shrinkage stope)	Unknown	50	Accessibility to the mine is a problem; road width violates current safety regulations and park service will not allow any increase in road width; deposit contains some cosmetic-grade talc; last mined in 1950s.
JOHNS-MANVILLE PRODUCTS CORP-ORATION Grantham (Big Talc and No.5)	Underground	Measured reserves 500,000	65	Talc available as pillars left as roof support in the old workings; tremolite content ranges from 5-15%. Pillars estimated at being 65% recoverable.
Warm Spring West		Indicated resources Underground	50 2,000,000	Tonnage indicated from continuation of silicated zone at depth; intersected by four drill holes; talc bed 22′ thick, 1200′ long, and 800′ wide. Depth to deposit 127′. More drilling needed to better define body.
Warm Spring	Open pit and underground	Indicated resources 60,000 8,000 under dumps	50	Remaining two talc beds occur in triangular shaped block about 400′ x 400′ x 400′. Truncated by NW trending fault. Upper bed 4′, lower bed about 6′ thick 4′-6′ of silicated rock between. Some talc in place under dump, questionably recoverable. Tremolite content ranges from 5-15%
No.2	Open pit	Measured reserves 66,000	80	Tonnage indication by surface cuts on strike length; some drilling done. Talc bed is 400′ long, 220′ wide, and 10′ thick; fractured and stained by secondary iron oxides.
No. 3	Open pit	Measured reserves 120,000	80	Deposit has been explored underground along strike. Some downdip drilling done. One commercial talc bed 8′ thick, 400′ long, and 500′ wide.
PFIZER, INC. Bonny deposit	Open pit Underground	Measured reserves 143,000 280,000 Measured reserves	90 80	These deposits have been evaluated on the basis of air-trac drilling; results were indicative of a commercial deposit and patent application has been filed on these claims. Commercial beds appear to pinch and roll within the siliceous septa and dip at 35° to 45°. Hanging wall bed is 10′-12′ thick, and the footwall bed is 12′-16′ thick; separated by 12′-15′ of dolomite.

Mammoth	Open pit Underground	Indicated resources 875,000	90 75	Deposit has a visible strike length of 2500' and locally has been developed by underground workings and surface cuts; downdip extension has not been drilled but indicated for 500'. Commercial thickness 6' to 30'; average 20'.
Mongolian	Open pit	Measured reserves 69,000	90	Talc body is on a dip slope. Present exposed strike length is 400'; width is 230'. Commercial talc zone averages 10' thick and dips north 30°.
White Chief	Underground	Indicated resources 825,000	50	Deposit undeveloped, appears to be one layer of talc; thickness 10'-30', average 20'; dips SE 30°. Two talc bodies (1) 800' x 500' x 20' 92) 500' x 300' x 20'. No drilling has been done.
White Eagle	Open pit Underground	Indicated resources 675,000	90 75	Deposit has an exposed strike length of 1200' and contains two commercial talc beds in a zone about 30' thick that dips 35° SE; upper bed is 5' thick, lower bed 12' thick; 20,000 tons has been produced by a small stripping operation but stripping ratio will soon preclude this type of mining. No drilling has been done. Deposit was indicated down dip for 500'.
Panamint	Open pit	Indicated resources 120,000	90	Deposit dips gently NE, is about 400' x 400' and about 10' thick; developed by a production of less than 2000 tons, but property has not been evaluated downdip or along strike by a drilling program. Deposit appears to be a dip slope deposit.
Saratoga	Open pit Underground	Indicated resources 186,000	90 75	Three deposits discontinuously exposed along a N strike for 4500'. Three shallow shafts on the property but no drilling done. Commercial zone 8' to 30' thick and dip is almost vertical. Northernmost two bodies, if extended under alluvium, are 2100' long. Southernmost body about 1000' long. Body about 1000' long. Bodies indicated down dip for 100'.

All categories of talc	In-the ground tonnage	Recoverable tonnage
Measured reserves	1.36.000	1.030.000
Indicated reserves	85.000	54.000
Indicated resources	5.749.000	3.009.000
Totals	7.195.000	4.093.000


BIG TALC MINE
NUMBER 5 MINE
PORTAL ELEV 1811
PORTAL ELEV 1758
INCLINED HAULAGEWAY
3RD LEVEL
4TH LEVEL
ELEV 1713
5TH LEVEL
6TH LEVEL
8TH LEVEL
7TH LEVEL
ELEV 1640
11TH LEVEL
12TH LEVEL
12-A LEVEL
14TH LEVEL
15TH LEVEL
4TH LEVEL
5TH LEVEL
ELEV 1622
ELEV 1719
5TH LEVEL
8TH LEVEL
6TH LEVEL
7TH LEVEL
ELEV 1681
16TH LEVEL
8TH LEVEL ELEV 1619
INCLINED HAULAGEWAY
12TH LEVEL
ELEV 1438
7TH LEVEL
9TH LEVEL
16TH LEVEL
15TH LEVEL
10TH LEVEL
14TH LEVEL
12-A LEVEL
11TH LEVEL
N
A
A'
UNDERGROUND PLAN MAP AND GEOLOGIC CROSS SECTION OF BIG TALC AND NUMBER 5 MINES OF JOHNS-MANVILLE PRODUCTS CORPORATION IN WARM SPRING CANYON
MAP BY A. HOOVER & D. ANDERSON
SCALE
EXPLANATION
FIRST LAYER WORKINGS
SECOND LAYER WORKINGS
APPROXIMATE TOPOGRAPHIC SURFACE
Carbonate with layers of silica and tremolitic rock
Third layer, talc-carbonate schist
Brown silicate-carbonate rock
Second layer, massive to crudely foliated talc rock
Brown silicate carbonate rock
First layer massive to crudely foliated talc rock
laminated talc rock
Diabase
Schematic cross section adapted from L. A. Wright (1968)
2600'
2400'
2200'
2000'
1800'
1600'

MAP 5

at least during their initial development phase. The final pit dimensions should be about 400 feet by 500 feet wide and from a few feet to several tens of feet deep. However, the Warm Spring West deposit will be mined underground by room-and-pillar methods after sufficient surface work is done to provide adequate entry.

CYPRUS INDUSTRIAL MINERALS COMPANY'S MINES

Geology and Mineralization

The Montgomery mine, the most westerly of the talc mines in the Death Valley region, is high on the ridge that separates Warm Spring and Galena Canyons. This deposit is in one of the rare occurrences of silicated rock that is associated with a cross-cutting body of diabase rather than a sill. Because most of the diabase bodies crosscut dolomite of the Crystal Spring Formation, the talc occurs in displaced blocks within a fairly uniform zone.

The margin of the diabase dike strikes eastward and is bordered on the north by carbonate rocks of the Crystal Spring Formation. Here, as elsewhere, the zone of silication that contains the bodies of commercial talc is altered lower strata of the carbonate member, but it forms a lens that strikes northwest at an angle of about 30° with the diabase contact and thins and daylights to the north.

At this locality, the zone of silicated rock averages a few tens of feet in thickness and is about 500 feet in exposed length, strikes northwest and dips about 20° to 30° southwest. The talc of commercial interest occurs in two layers, the lowest of which has been the most extensively mined. The layers are separated by beds of darker-colored silicate-carbonate rock. Also bordering the margin of the diabase body, but higher in the carbonate member, are layers of green tremolite rock oriented parallel with the strata. The two principal layers of talc are from about 10 to 15 feet in thickness and are separated by 8 to 12 or more feet of the darker rock. The talc is generally blocky but crudely foliated and tinted gray to green.

Mining

The lower layer was mined underground prior to 1972, primarily during the 1940s; but work in the fractured, caving ground had to be discontinued. Hazardous mining conditions requiring extensive timbering, coupled with a recovery rate of 35 percent, required development of the talc through surface mining.

Since 1973, a pit has been in development. Overlying waste rock from the southeast-dipping talc beds was being removed according to plan. Stripping ratio is 13 to 1. About 688,000 tons of overburden were removed in 1974, about 281,000 in 1975. The company plans to remove between 200,000 and 300,000 tons during 1976. Depth of the final pit will be approximatly 300 feet on the southeastern wall, and it will be open on the northwest end. Maximum pit perimeter will be approximately 850 by 850 feet. Map 6 shows the final pit plan and a cross-section drawn through the pit. Waste is removed by one D-9 bulldozer, one 7-yard front-end loader, and one 35-ton-capacity truck. The talc layer is easily ripped and usually loaded by a 3-yard-capacity front-end loader on a 10-ton-capacity truck for transportation to the stockpile, which is downslope to the west. The larger equipment is sometimes used for mining. Material is taken by contract truckers to the mill at Los Angeles or to Dunn Siding for direct shipment to mills in Grand Island, Nebraska, and Mexico.

PFIZER, INCORPORATED'S, MINES

Geology and Mineralization

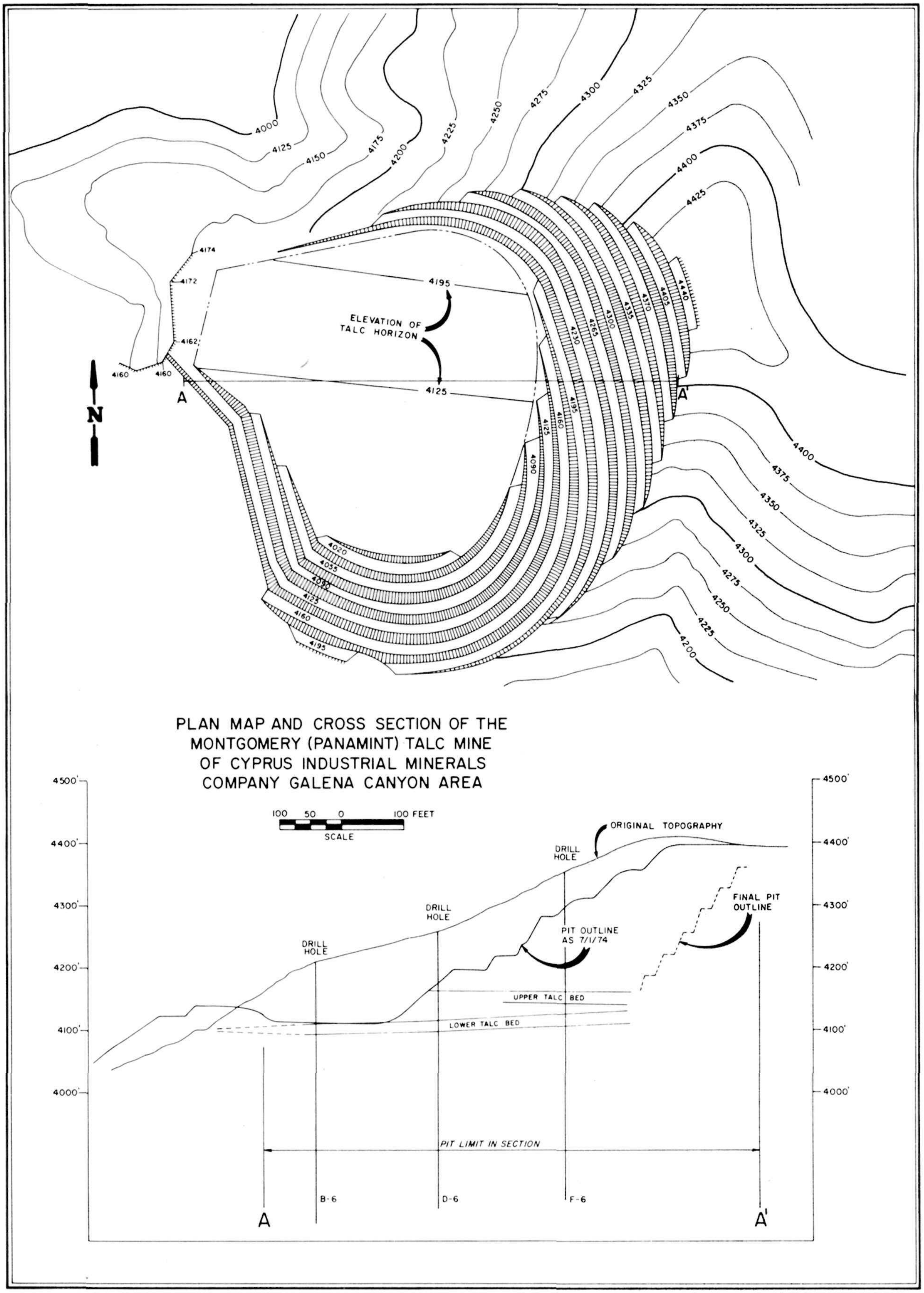
The Minerals, Pigments, and Metals Division of Pfizer, Inc., collectively operates five mines—the Bonny, the Mammoth, the Mongolian, the White Chief, and the White Eagle—all in Galena Canyon.

Most of the talc exposed in this area is contained in three adjacent, north-trending fault-bounded blocks on the south side of Galena Canyon (Map 4). Each block consists mostly of the typical sedimentary units and diabase of the Crystal Spring Formation. The talc bodies are at the characteristic stratigraphic position near the base of the carbonate member. The eastern and middle blocks dip eastward, whereas the western block contains a broad north-trending anticline, the axis of which is followed by the south branch of the canyon. Consequently, the talc-bearing zone can be seen repeated several times along the south side of Galena Canyon.

The main talc bodies in the eastern and middle blocks resemble, in composition and in cross-section, the principal bodies in Warm Spring Canyon 4 miles to the south. In each of the two blocks, a strongly silicated zone overlies a diabase sill and contains two layers of commercial talc, characteristically separated by brown silicate-carbonate rock several feet thick. The lower talc layer, which directly overlies the diabase, is ordinarily about 15 feet thick and consists of blocky talc-rich rock with local tremolitic masses. The upper layer is 6 to 15 feet thick and composed mostly of strongly foliated and friable talc-rich rock. Some of the talc in the upper layer is blocky.

Bonny Mine

The mine is near the mouth of Galena Canyon in a body of silicated rock, the footwall of which extends westward and upward beneath a body of diabase, which is flanked on three sides by alluvium. The footwall and the layering within the silicated body strike northward and dip gently eastward. Although no production was recorded for the Bonny mine during 1975, approximately 30,000 tons of talc have been produced from these deposits since 1970. Currently, the overlying dolomite and diabase on the downdip extension of these eastward dipping silicated beds is being removed by a stripping operation and production is planned to


PLAN MAP AND CROSS SECTION OF THE
MONTGOMERY (PANAMINT) TALC MINE
OF CYPRUS INDUSTRIAL MINERALS
COMPANY GALENA CANYON AREA
ELEVATION OF TALC HORIZON
N
A
A'
100 50 0 100 FEET
SCALE
ORIGINAL TOPOGRAPHY
DRILL HOLE
PIT OUTLINE AS 7/1/74
FINAL PIT OUTLINE
UPPER TALC BED
LOWER TALC BED
PIT LIMIT IN SECTION
B-6
D-6
F-6
4500'
4400'
4300'
4200'
4100'
4000'

MAP 6

resume in 1976. A patent was received for each of two claims in 1976 (see Map 4 and table 9).

Mammoth Mine

On the eastern fault block, the talc-bearing zone is exposed laterally for about 2,200 feet. Here, too, the zone strikes about N15°E and dips about 35° eastward. For much of the length of this segment, the two layers of commercial talc appear to have joined to form a single layer 10 to 30 feet thick. Elsewhere in the segment, especially in the southern part, the characteristic layer of brown silicate-carbonate rock divides the layers of commercial talc. This segment is cut by numerous cross-faults with apparent horizontal displacements of a few feet to a few tens of feet. The block on the south side of each fault has moved relatively westward. The north and south ends of the segment of the zone are terminated by faults. The talc bodies in the eastern fault block were explored underground in the late 1950s and the mining commenced late in 1960. They have been penetrated by a south-trending drift-adit which, in early 1967, was about 800 feet long.

Mongolian Mine

This talc body is exposed near the eastern margin of the eastern fault block and lies on a near dip-slope of a dolomite body which strikes northwest and dips about 45° to the southeast. Approximately 23,000 tons have been produced from this deposit from a downdip stripping operation begun in 1974.

White Eagle and White Chief Mines

The middle fault block contains two talc-bearing bodies separated by a cross-cutting bulge in the upper margin of the sill and by minor cross-faults. The northern body strikes N15°E, dips about 35° eastward, and is in a zone of strong silication overlying a diabase sill. Two layers of talc, separated by a body of brown colored silicate-carbonate rock, are found within this zone. The lower layer is the thickest (10 to 15 feet) and consists of blocky talc-rich rock while the upper layer is strongly foliated and friable talc-rich rock.

This outcrop has a strike length of 1400 feet and has been mined by a downdip stripping operation.

Mining Methods

Since 1971, Pfizer's talc production from its Galena Canyon properties has been from open pits. These open pits are more visible than any other current talc mines because they are close to the mouth of Galena Canyon and the white siliceous waste rock contrasts sharply with the dark colored dolomitic and diabasic rocks on the undisturbed surface.

When the depth of the talc bodies becomes excessive, open-pit mining will cease and all of them will probably be mined by underground methods.

Talc Mines and Reserves in the Southern Ibex Hills Area

This area, which lies partly in Inyo and partly in San Bernardino Counties, includes the Ibex, Monarch-Pleasanton, Moorehouse, Superior, Whitecap, and Saratoga mines. Most of these mines were brought into production when the ceramic tile market increased during the 1930s and 1940s. Rising mining costs and decreasing talc horizons at depth resulted in uneconomic operations and cessation of mining.

The Ibex and Monarch-Pleasanton mines are owned by Cyprus Industrial Minerals Company. The Ibex has produced 31,812 short tons of talc since 1970 and is now an open pit. Old underground workings were extensive, but most are caved. The Ibex deposit occurs in an arcuate slice of Precambrian rocks bounded by two northwest-trending, high-angle faults. This sliver, convex to the northeast, is about 700 feet in average width and is 1 1/4 miles in exposed length. Talc occurs in a discontinuous zone of white silicate-carbonate rock which, in plan view, is hook shaped. The mine yielded 424 tons of fibrous talc in 1975 and, although reserves do exist within dumps (see table 4), there are presently no plans to mine them (R.D. Lowe, Cyprus Industrial Minerals Company, personal communication, 1975).

The Monarch-Pleasanton mine produced 1,468 tons in 1973 and has been inactive since then. Both of these mines were originally mined by open cuts but now have extensive underground workings. Talc at these mines contains 1 to 5 percent tremolite. The mines are on a standby basis and could be reopened should there be a significant increase in demand for the talc (R.D. Lowe, personal communication, 1975).

The Saratoga mine is owned by Pfizer. In the mine area, the talc bodies of commercial interest form part of an elongate septum within the lower diabase sill of the Crystal Spring Formation. This septum is exposed on west-plunging ridges but is hidden beneath alluvium in intervening stream channels. Talc beds have a moderate to vertical dip and extend laterally for about 1 1/4 miles. The septum appears to average between 30 and 50 feet in thickness. Although silication usually extends completely through the septum, commercial talc has been confined to a single layer in the upper part of the septum which commonly is too thin or too intimately mixed with sub-commercial material to be profitably mined (Wright, 1966). The property has been developed by three small shafts; and although lateral and downdip extent of the commercial talcose zone remains unexplored, the talc-bearing zone appears to pinch out vertically within 100 feet of the surface.

Talc Mines and Reserves in the Owlshead Mountains

On the northeast edge of the Owlshead Mountains, which form part of the west margin of southern Death

Table 10. Sales of talc produced in Death Valley National Monument, 1970-1975.

Company and mine	1970		1971		1972		1973		1974		1975 (approximate)		1970-1975 totals	
	Short tons	Value @ $51.50/ton	Short tons	Value @ $53.00/ton	Short tons	Value @ $53.00/ton	Short tons	Value @ $55.00/ton	Short tons	Value @ $58.00/ton	Short tons	Value @ $60.50/ton	Short tons	Value
CYPRUS INDUSTRIAL MINERALS COMPANY														
Ibex	5,955	306,682.50	9,005	477.265.00	8,579	454,687.00	3,202	176,110.00	4,607	267,206.00	424	25,652.00	31,772	1,707,602.50
Monarch-Pleasanton	----------------------------Mine purchased from Pfizer in 1972						1,468	80,740.00					1,468	80,740.00
Panamint					16,406	869,518.00	22,643	1,245,365.00	28,341	1,643,778.00	24,000	1,452,000.00	91,390	5,210,661.00
Subtotal	5,955	$ 306,682.50	9,005	$ 477,265.00	24,985	$1,324,205.00	27,313	$1,502,215.00	32,948	$1,910,984.00	24,424	$1,477,652.00	124,630	$6,999,003.50
JOHNS-MANVILLE PRODUCTS CORPORATION														
Grantham (Big Talc and #5) and Warm Spring	67,551	3,478,876.50	59,807	3,169,771.00	60,000	3,180,000.00	67,656	3,721,080.00	89,835	5,210,430.00	54,000	3,267,000.00	398,849	22,027,157.50
Subtotal	67,551	$3,478,876.50	59,807	$3,169,771.00	60,000	$3,180,000.00	67,656	$3,721,080.00	89,835	$5,210,430.00	54,000	$3,267,000.00	398,849	$22,027,157.50
PFIZER, INC.														
Bonny	2,503	128,904.50	3,067	162,551.00	8,160	432,480.00	11,701	643,555.00	4,214	244,412.00			29,645	1,611,902.50
Mammoth											29	1,754.50	29	1,754.50
Monarch-Pleasanton			1,320	69,960.00	Mine sold to Cyprus Minerals in 1972--								1,320	69,960.00
Mongolian									10,091	585,278.00	13,263	802,411.50	23,354	1,387,689.50
White Chief	5,687	292,880.50											5,687	292,880.50
White Eagle	290	14,935.00	2,491	132,023.00	2,847	150,891.00	5,561	305,855.00	8,631	500,598.00	5,837	353,138.50	25,657	1,457,440.50
Subtotal	8,480	$ 436,720.00	6,878	$ 364,534.00	11,007	$ 583,371.00	17,262	$ 949,410.00	22,936	$1,330,288.00	19,129	$1,157,304.50	85,692	$4,821,627.50
TOTAL	81,986	$4,222,279.00	75,690	$4,011,570.00	95,992	$5,087,576.00	112,231	$6,172,705.00	145,719	$8,451,702.00	97,553	$5,901,956.50	609,171	$33,847,788.50

*Annual average market value for California talc as quoted in each December issue of "Engineering and Mining Journal".

Valley, sedimentary units and diabase bodies of the Crystal Spring Formation dip moderately and uniformly to the northeast. The talc-bearing rock is confined to a body of altered carbonate rock that immediately underlies the sill and can be traced laterally for several hundred feet. It strikes eastward, dips about 50° northward, and is exposed on flat parts of the crests of two small ridges. The zone averages between 20 and 40 feet in thickness and consists mostly of incompletely altered carbonate strata and green tremolitic rock. White, well-foliated talc forms lenses and layers within the zone. Most of the talc appears to occur in bodies 5 feet or less wide and less than 200 feet in exposed length. The workings consist of a few small pits and cuts (Wright, 1966).

Talc Mines and Reserves in the Talc Hills

The Talc Hills lie at the southern end of the Black Mountains between the Ibex Hills and southern Death Valley. The known bodies of commercial talc in the Talc Hills occur in a 3 1/4-mile strip of Crystal Spring Formation in the northern part of the hills. Here, as elsewhere, virtually all of the alteration to magnesium silicate minerals has been localized in the lower strata of the carbonate unit and is associated with a diabase sill intruded at or near the base of the member. The talc-bearing rock that is of possible commercial interest averages between 5 and 10 feet thick and is as much as 20 feet thick. Most of this rock is thinly laminated to blocky; but friable, foliated material is common. Development consists of several adits and drifts, but as far as can be determined, the area has not been thoroughly explored by drilling (Wright, 1966).

Talc Reserves and Resources in Death Valley National Monument

In calculating these talc reserves and resources, the definitions in the section on borate reserves and resources were used. All tonnages are in short tons, and a tonnage factor of 150 pounds per cubic foot was used in calculating tonnage from the volume measurement. In all deposits, an average commercial zone thickness was used in the volume measurement and no correction was made for mineral grade. The tonnages given in table 9 are in-the-ground values and do not reflect the tonnage that can be recovered by mining. However, an estimate of the amount recoverable appears in table 9. It is dependent upon the mining method and geologic factors involved.

Measured reserve figures are not available on most of the currently operating talc mines. The only mines where data are sufficient to give measured reserves are the Panamint (Montgomery), Bonny, Grantham (Big Talc and No. 5), Mongolian, and No. 2 mines. Deposits in the Warm Spring-Galena Canyon area are indicated reserves and resources because of their extensive strike length exposure and relatively constant commercial talc horizons. The geologic information about the downdip extension of talc bodies that was gathered from underground mine maps indicates that the talc beds are continuous, but they may be discontinuous locally. Although the dip slope of these talc beds precludes open-pit operations, inference of extensive underground resources is warranted. Thus, the Warm Spring-Galena Canyon area contains a large potential area of white, high-purity talc. At least 4 million tons of talc (a 30- to 35-year supply at the present rate of production) appears to be recoverable. However, the eventual recovery could exceed this figure.

An approximate current sales values of reserves and resources can be obtained by reducing the tonnages in table 9 by the appropriate recovery factor. A total of 1,361,000 tons of measured reserves with about 1,030,000 recoverable tons was determined. This recoverable tonnage, valued at $60 a ton, represents a sales value of about $62,000,000. Similarly calculated, indicated reserves and resources account for respective sales value of $3,250,000 and $181,000,000. The total sales value of known talc reserves and resources in the Monument based upon current sales prices is estimated to be $246 million. These figures show the economic significance of talc deposits in the Monument and do not indicate that these tonnages could be sold in the current market if mined.

Alternate Sources of Talc in California

SOUTHERN IBEX HILLS-KINGSTON RANGE REGION

This eastward trending belt of deposits extends to the California-Nevada border and is the largest source of talc outside of Death Valley National Monument. These deposits also occur in the Crystal Spring Formation.

This region contains the Acme, Ibex, Western, Eclipse, Tecopa, and Vulcan mines. Of these, only Pfizer's Eclipse mine is currently operating, although on a limited production basis. Talc reserves exist within this region, but almost all production would have to come from underground workings.

INYO MOUNTAINS AND NORTHERN PANAMINT RANGE

These deposits have yielded nearly all of the steatite-grade and pharmaceutical-grade talc mined in California. Deposits generally are much smaller and more irregular than those in the southern Death Valley-Kingston Range region. The largest bodies were about 500 feet long and 50 feet in a maximum width. Most of the bodies were only a few tens of feet long and a few feet wide and lenticular to very irregularly shaped. Most of the deposits have been mined, both laterally and downdip, to points where they pinch out or are too thin to be mined profitably (Wright, 1966).

The Talc City deposit was the largest in this area and, although Talc City sustained production for many years, current work by the Cyprus Industrial Mineral Division has shown that a few thousand tons of resources exists in the old, caved workings. Drilling on the east-west strike projection has proved negative, and the only way production could be resumed from the caved workings would be by surface mining and beneficiating the pit-run material in a flotation plant. Talc resources that could be mined by open pit have not been determined. They would also have to be treated in a flotation plant. Sufficient water to run a flotation plant was not available in 1975.

SILVER LAKE-YUCCA GROVE AREA

A small group of talc deposits occur in Precambrian metamorphic and igneous rocks. Discontinuous layers and lenses of dolomite apparently have been thoroughly altered to rock composed mostly of talc and tremolite. All deposits appear to pinch out within 300 feet of the surface.

WESTERN FOOTHILLS OF THE SIERRA NEVADA

The talc deposits that occurs in the foothills appear to have been altered from bodies of igneous rocks. For this reason, the talc typically contains several percent iron oxide and thus cannot be used for most of the purposes to which the low-iron talcose material is put. These deposits are characteristically lenticular and rarely exceed 50 feet in width and 400 feet in length. Although the resources of relatively dark, iron-rich talc appear to be high, this type of talcose material is not acceptable to current talc-consuming industries (Wright, 1966).

Processing, Production, Sales, and Uses

All of the current talc operations in Death Valley National Monument are integrated from mining to a finished mill product. Most California talc, including the talc from the monument, is prepared for market by means of a preliminary crushing in jaw or rotary crushers and then grinding in roller or vertical hammer mills in closed circuit with air separators. Figure 2 shows a simplified mill flowsheet for a typical California talc plant. At this mill, the talc can be reduced to a salable particle size ranging from -200 mesh to -12 microns, depending upon the customer specifications.

In 1974, California crude talc was valued from $15 to as much as $30 a ton at the mine, dependent upon the grade and fiber content. This is an arbitrary figure and does not reflect the sales value because very little, if any, crude talc is sold directly to consumers.

The average value in 1974 for California ground talc was $58.50 per ton f.o.b. millsite. The value of talc increases with additional grinding to finer sizes and, in 1975, some prices for ground and bagged talc were as follows:

Standard ground, 96% passing 200 mesh	$58.50/ton
Fractioned, which may be 325 or 400 mesh	$71.00/ton
Micronized, 100% passing -12 micron	$104.00/ton

Generally, the 200 mesh material is marketed to the ceramic industry; the 325 and 400 mesh material is used as a paint extender; and the micronized talc is used in the paper industry for resin control, brightener, and filler.

Of the 169,023 tons of talc mined in California in 1974, approximately 45 percent was used as a ceramic raw material, 18 percent as a paint extender, and 11 percent as an insecticide carrier. The remainder was used as a rice-polishing medium, as paper filler and opacifiers, and as an adhesive filler.

Approximately 60 to 70 percent of the talc mined in California is consumed within the state; the remainder is distributed nationally and internationally. Approximately 50 percent of the talc marketed in California goes into the Los Angeles area and about 20 percent into the San Francisco area.

United States and California Production of Talc

The United States is self-sufficient in most grades of talc and soapstone. In the past, most of the block steatite and the cosmetic-grade talc were imported, but for many years United States imports of talc have remained comparatively stable. In 1974, only 35,000 tons of cosmetic talc was imported—mainly from France, Italy, and Canada—in contrast to an export of 195,000 tons. The Bureau of Mines, in its "Commodity Data Summary for 1975", estimated United States reserves at 150 million short tons and world reserves at 330 million short tons.

Until the early 1950s, California was the source of almost all of the steatite-grade talc produced in the United States, but Montana now far outranks California in production and reserves of such talc. This decline of production of steatite-grade talc has been dwarfed by the increase in the production of other types of talc, particularly those that supply the building industry of the western states. According to U.S. Bureau of Mines data, California, in 1974, was ranked fifth behind Vermont, New York, Texas, and Montana in total talc production and accounted for approximately 14 percent of the national talc production. However, California ranked first in total sales value because California talc commands premium market prices. Preliminary data for 1975 show talc production from Death Valley National Monument down about 30 percent. As economic conditions improve, production could increase.

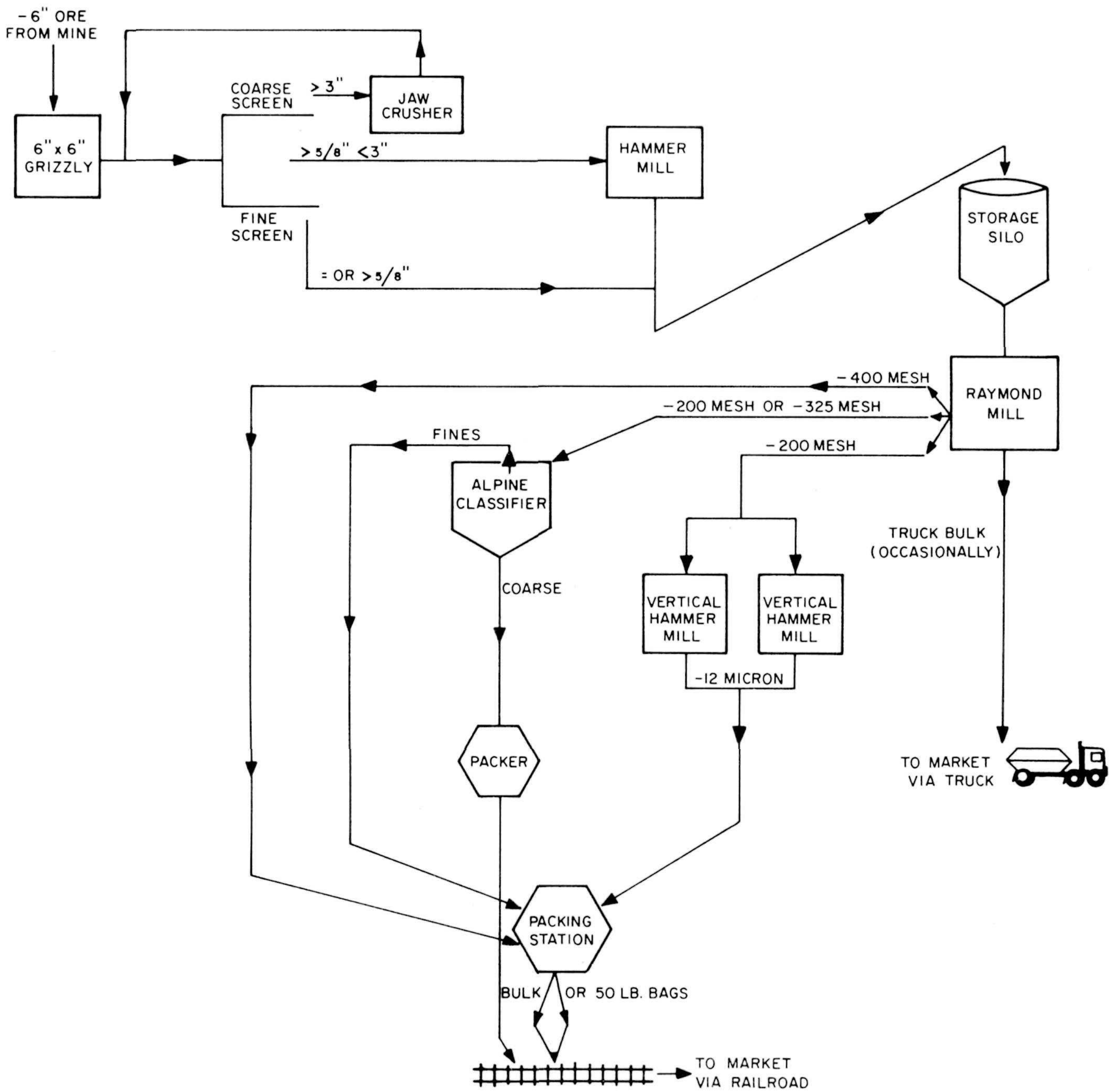


Figure 2. Schematic diagram of a typical California talc mill.

Table 11. Talc production, 1971-1974.

	TALC PRODUCED (SHORT TONS)			PERCENTAGES		
YEAR	Death Valley National Monument	California	United States	United States talc produced in California	California talc produced in Death Valley National Monument	United States talc produced in Death Valley National Monument
1970	81,986	184,660	1,028,000	18%	44%	8%
1971	75,690	153,227	1,037,000	15%	49%	7%
1972	95,992	155,155	1,107,000	14%	62%	9%
1973	112,231	179,191	1,247,000	14%	63%	9%
1974	145,719	169,023	1,250,000	14%	86%	12%

Market Considerations

California talcs possess several unique features that, combined, command premium prices and excellent salability to statewide consumers. California talcs possess a high whiteness or brightness factor and low tremolitic fiber content. Consuming industries state that because of mineralogical and chemical differences, other talcs, such as those produced in New York, Vermont, and Montana, cannot be directly substituted for California talcs and the consuming industries would have to change their product formulations if sources were to change.

If talcs are to be imported into California from Montana, New York, or Vermont, freight rates will have to be considered. The rate from Montana to Los Angeles is $29.40/ton in 75-ton carlots; from Vermont to Los Angeles, it is $65.60/ton in 30-ton carlots or $52.00/ton in 50-ton carlots; from New York to Los Angeles, it is $70.60/ton in 30-ton carlots or $56.00/ton in 50-ton carlots. In 1975, the freight rate per ton in 50-ton carlots from mill railheads at Victorville or Dunn Siding to Los Angeles was $6.20.

Governmental regulations concerning exposure to mineral dusts are becoming more numerous and more restrictive. Those talc deposits containing "asbestiform" fiber (tremolite is considered a fiber by the Occupational Safety and Health Administration) may decrease in importance as the filler industry shows preference for very high-purity platy or hard talcs presenting minimal health hazards. Thus, California talcs could become increasingly important, as they have low tremolite fiber content in comparison to Eastern talcs.

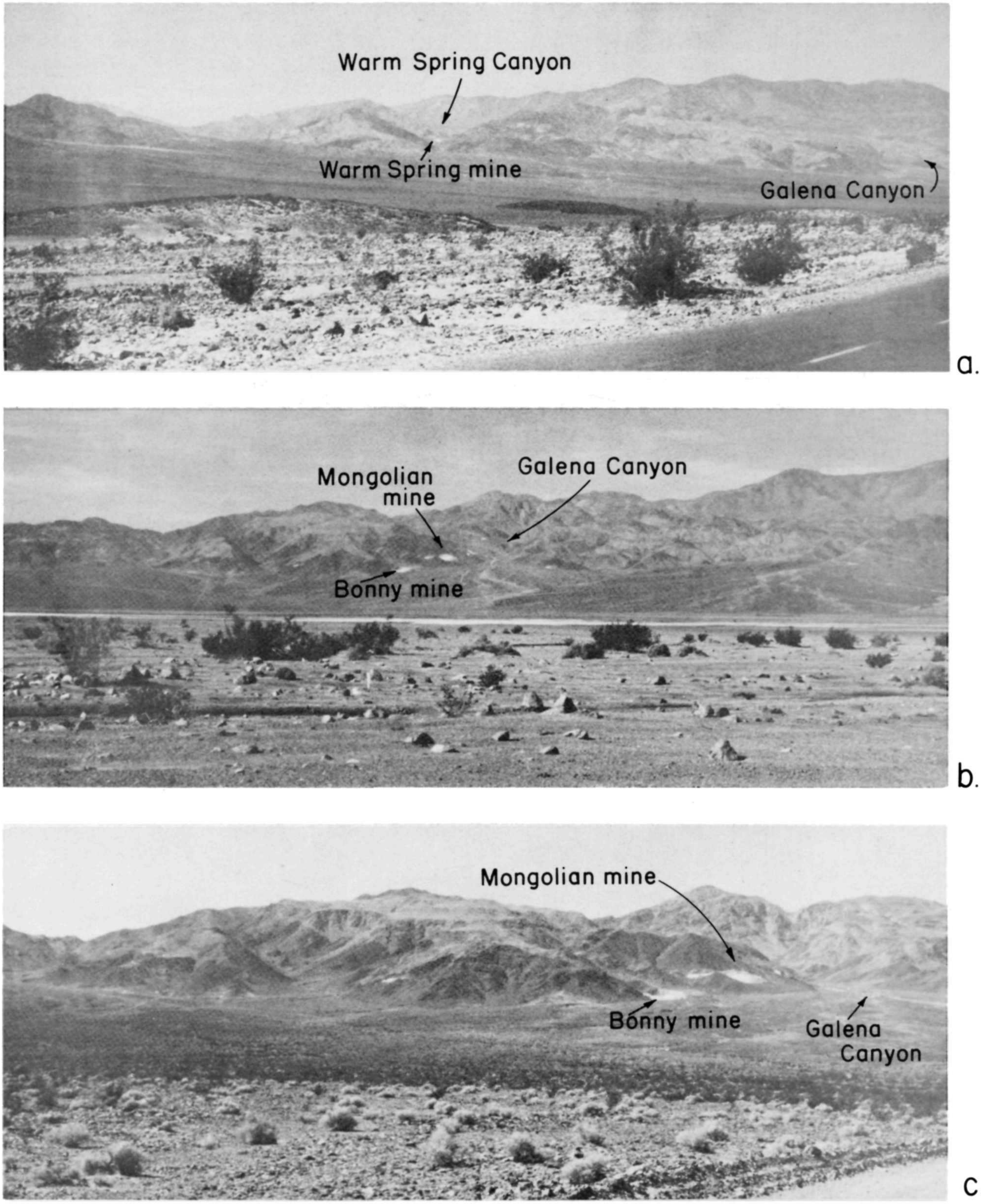


Photo 9. (a) Warm Spring talc mine of Johns-Manville Products Corporation as viewed west from the paved highway near Ashford Junction. Distance is approximately 16 miles.
(b) Talc mines of Pfizer, Inc., as viewed southwest from near Mormon Point from the paved highway along the eastern side of Death Valley. Distance is approximately 8.5 miles.
(c) Talc mines of Pfizer, Inc., as viewed southwest from the Galena Canyon road (private haulage road) approximately 3.5 miles away. White areas are largely waste dumps. (All photos taken in October 1975).

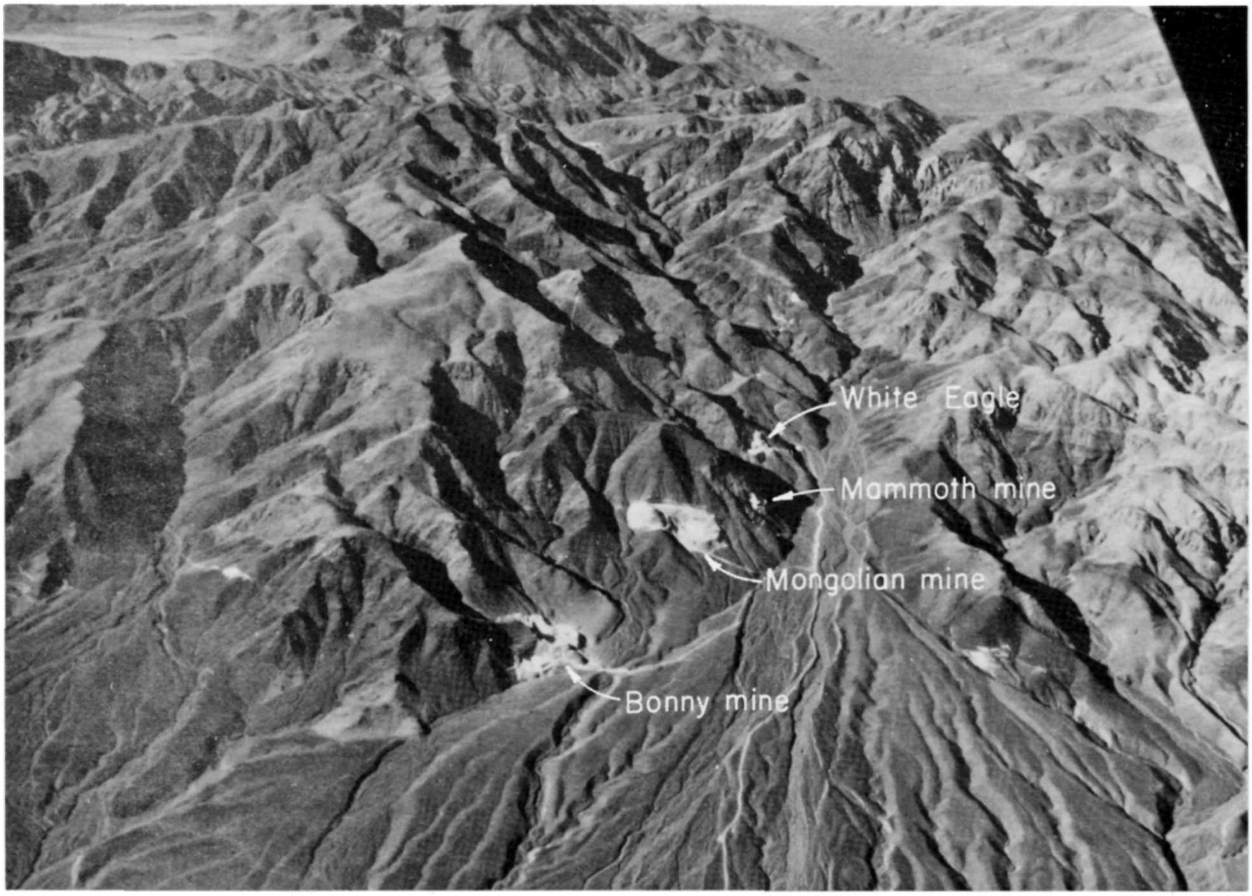


Photo 10. Talc mines of Pfizer, Inc., in Galena Canyon as viewed from the west on January 14, 1976 (Map 4).

Photos 11 and 12. Bonny talc mine of Pfizer, Inc., in Galena Canyon as viewed from the north, January 14, 1976.

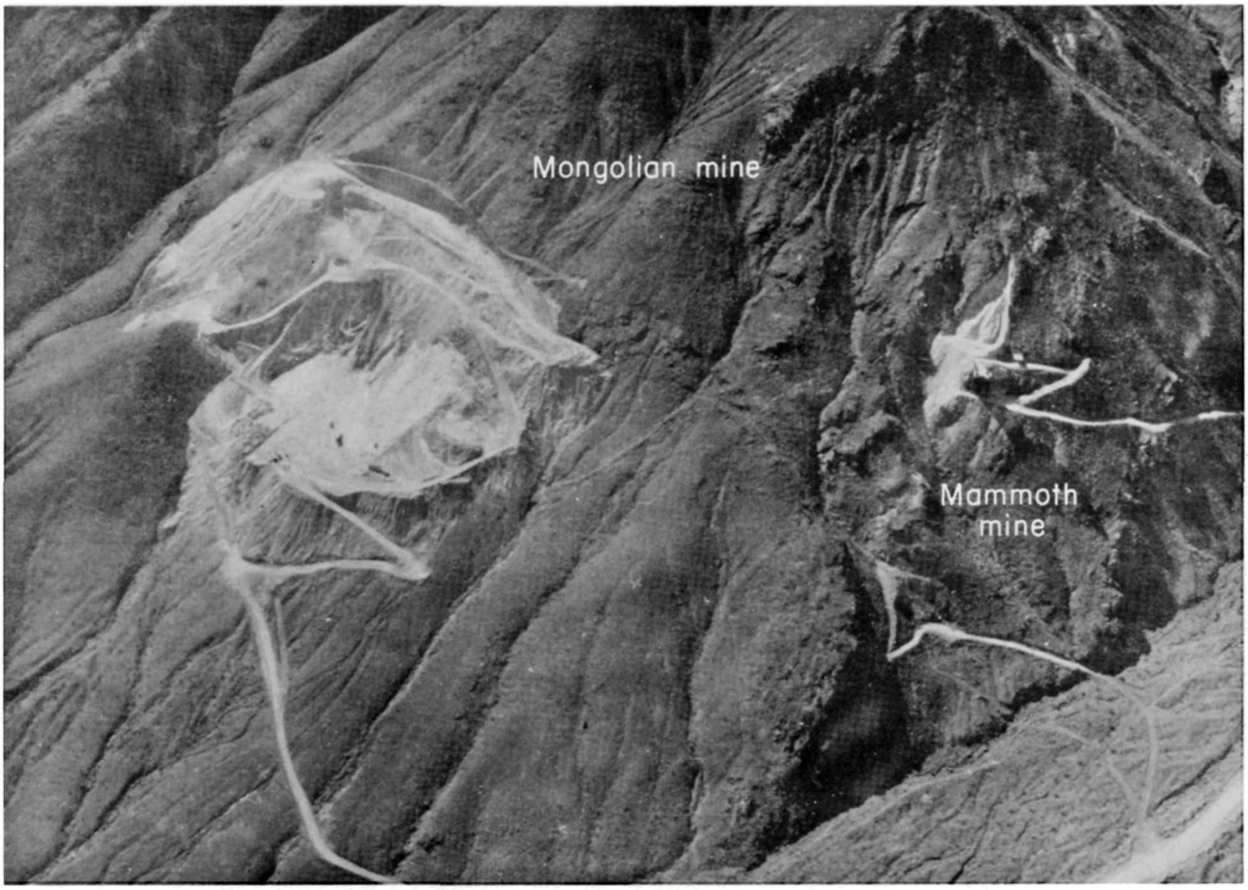


Photo 13. Mongolian and Mammoth talc mines of Pfizer, Inc., in Galena Canyon as viewed from the north, January 1976.

Photo 14. White Eagle talc mine of Pfizer, Inc., in Galena Canyon as viewed from the north, January 1976.

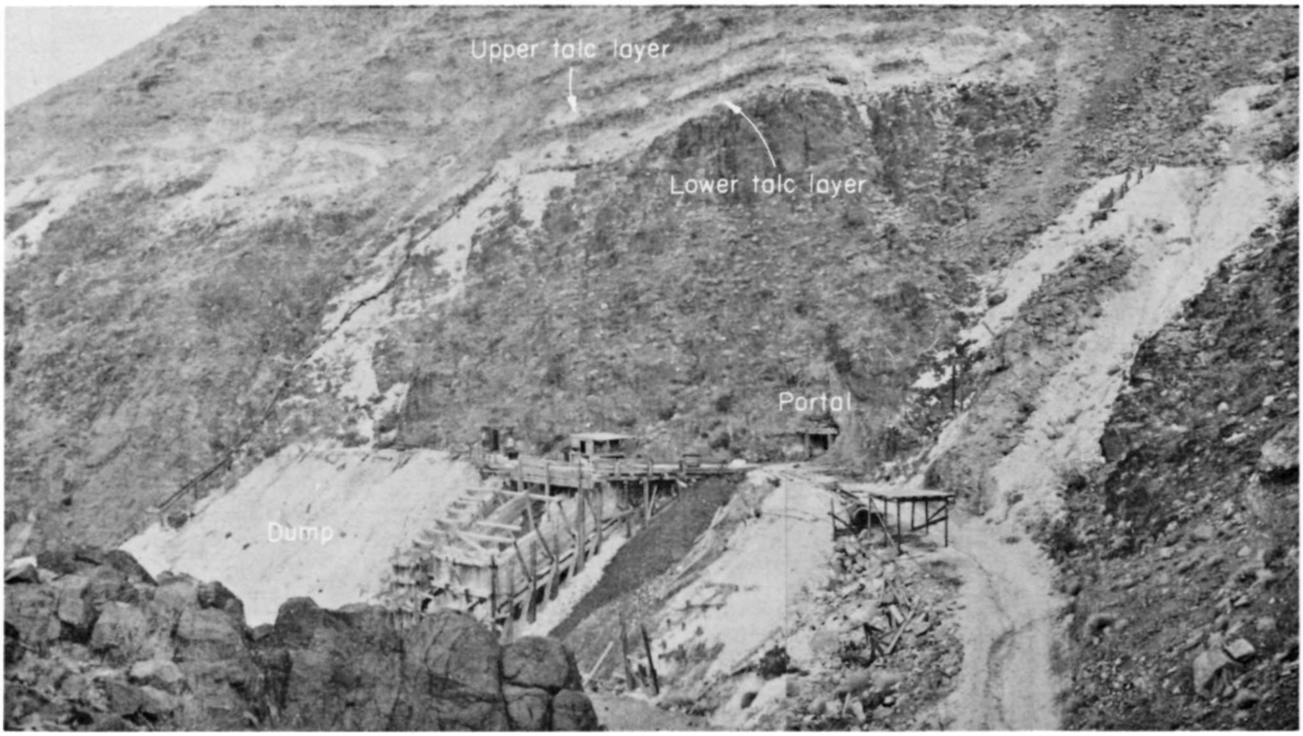


Photo 15. Death Valley underground mine workings (part of Pfizer's White Eagle mine) in Galena Canyon on January 16, 1976.

Photo 16. Panamint talc mine of Cyprus Industrial Minerals Company as viewed from the west on January 14, 1976. Death Valley (D); stockpile (St).

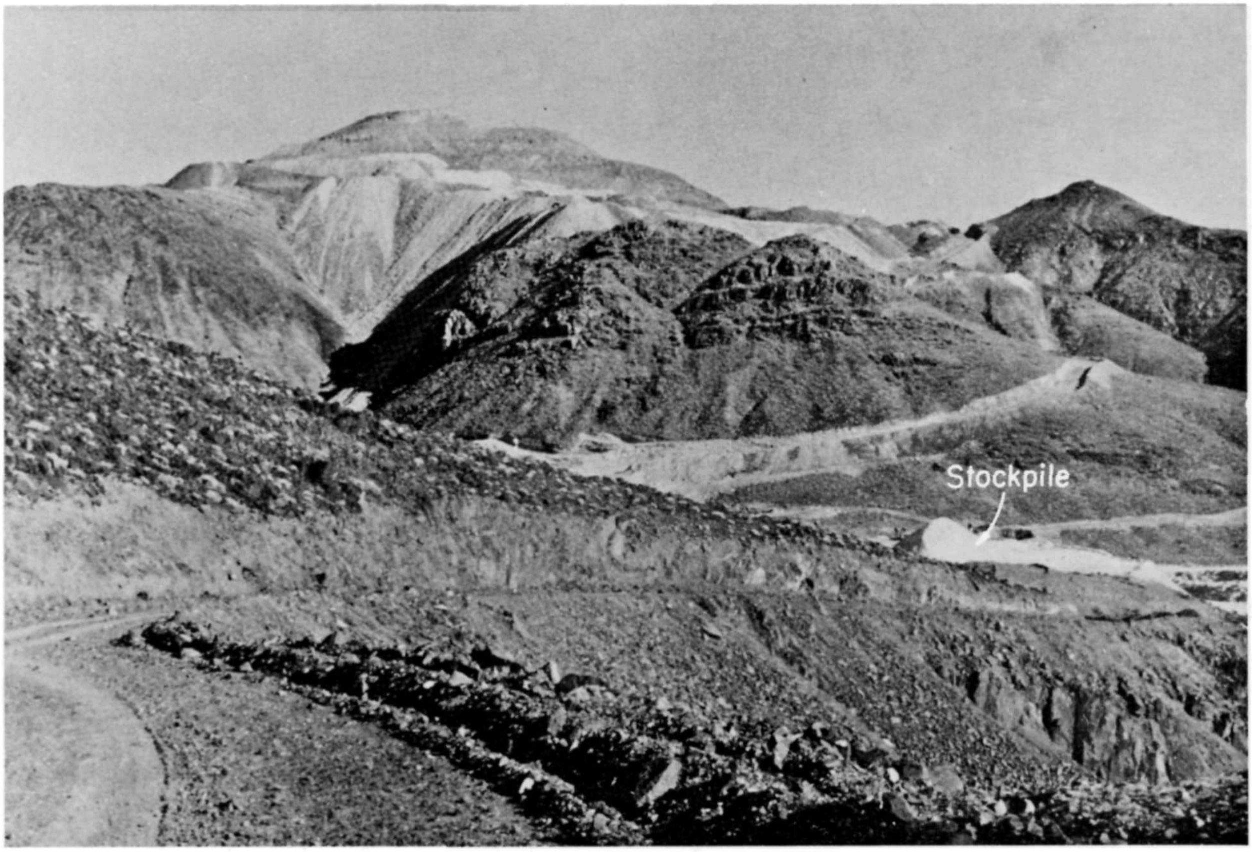


Photo 17. Panamint talc mine of Cyprus Industrial Minerals Company as viewed from the west, October 1975.

Photo 18. Talc stockpile at the Panamint mine, October 1975.

Photo 19. Talc mines of Johns-Manville Products Corporation in Warm Spring Canyon as viewed from the west on January 14, 1976. (#3) Number 3 mine, (#2) number 2 mine, (Ww) Warm Spring West mine, (W) Warm Spring mine, (G) Grantham (Big Talc and #5) mine.

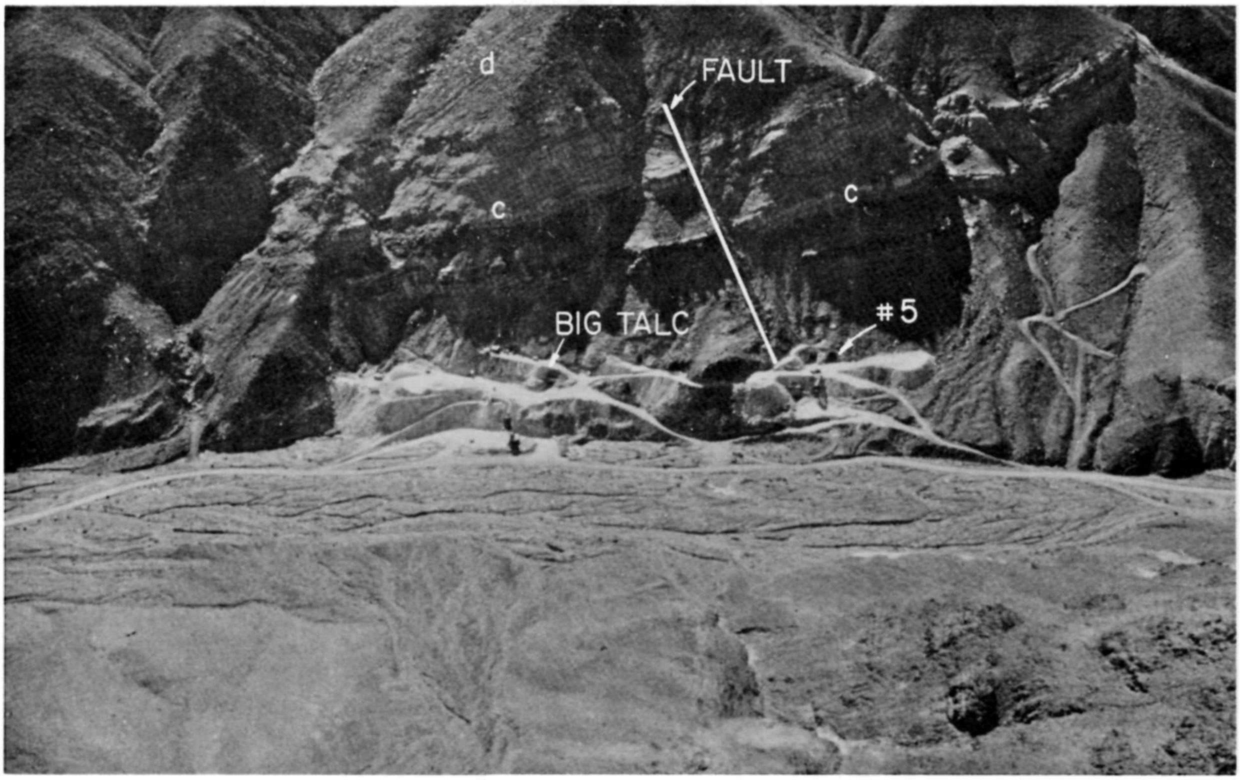
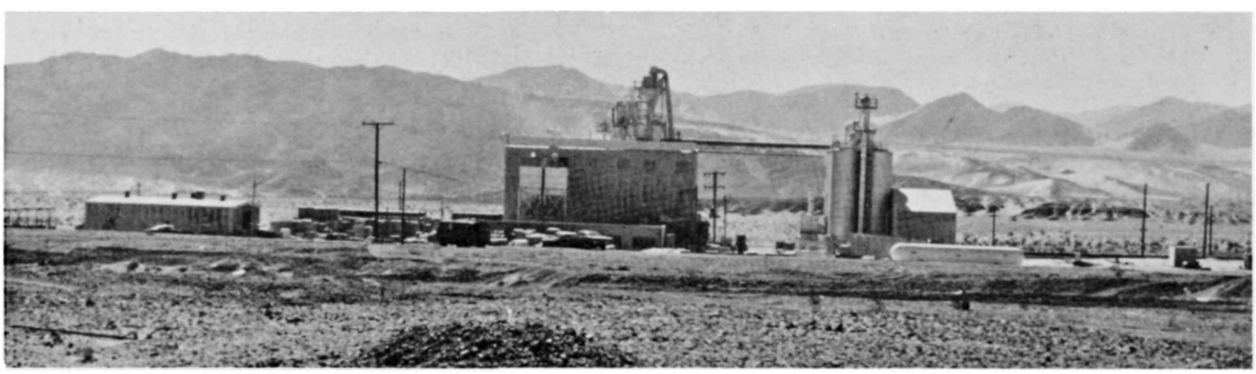


Photo 20. Grantham (Big Talc and 5) underground talc mine of Johns-Manville Products Corporation as viewed from the northeast on January 14, 1976. (B) Portal of Big Talc, (#5) portal of #5, (F) fault offsetting talc horizons, (d) diabase, (C) Crystal Spring Formation.

Photo 21. Warm Spring mine of Johns-Manville Products Corporation as viewed from the north on January 14, 1976. (P) pit, (D) dump.

Photo 22. Warm Spring pit of Johns-Manville Products Corporation as viewed from east, October 1975. Two commercial talc beds (T) separated by 4 to 6 feet of silicated rock (S) are visible at the bottom of the pit on the south wall.

Photo 23. Saratoga talc mine in the Saratoga Hills as viewed from the west on January 14, 1976. This is the southernmost talc mine in Death Valley National Monument and is in San Bernardino County. Most of the mine workings are underground, although there are some surface cuts. Talc bodies (T) and adjacent silicated zones are completely enclosed in diabase (d) which intrudes the Crystal Spring Formation (C).



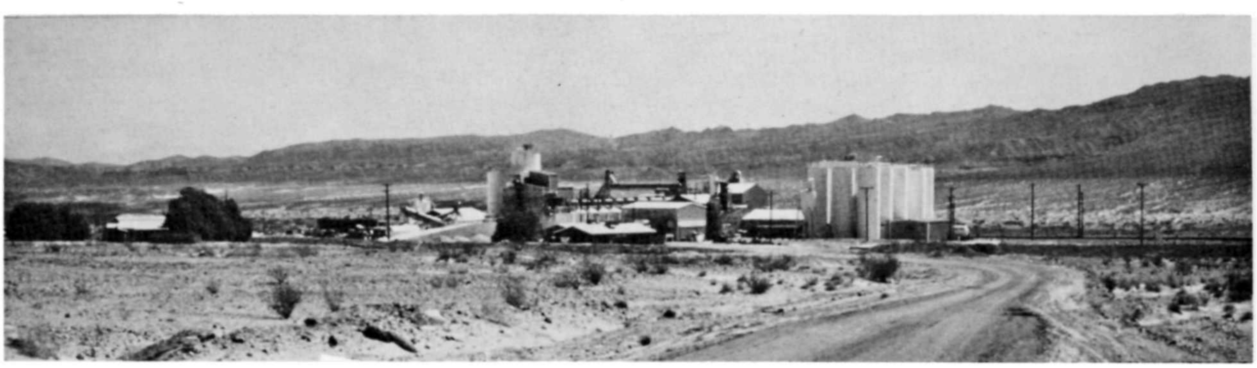


Photo 24. (a) Dunn grinding plant of Johns-Manville Products Corporation at Dunn Siding, about 30 miles west of Baker, California, October 1975. Talc is trucked from the mines in Warm Spring Canyon directly to the plant.
(b) Dunn grinding plant of Tenneco Mining, Inc., at Dunn Siding, October 1975. Ulexite and probertite are trucked about 100 miles directly from the Boraxo mine. Colemanite is shipped from the mine to the Lathrop Wells calcining plant and then to the grinding plant.

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MINES AND MINERAL DEPOSITS IN DEATH VALLEY NATIONAL MONUMENT, CALIFORNIA Special Report 125