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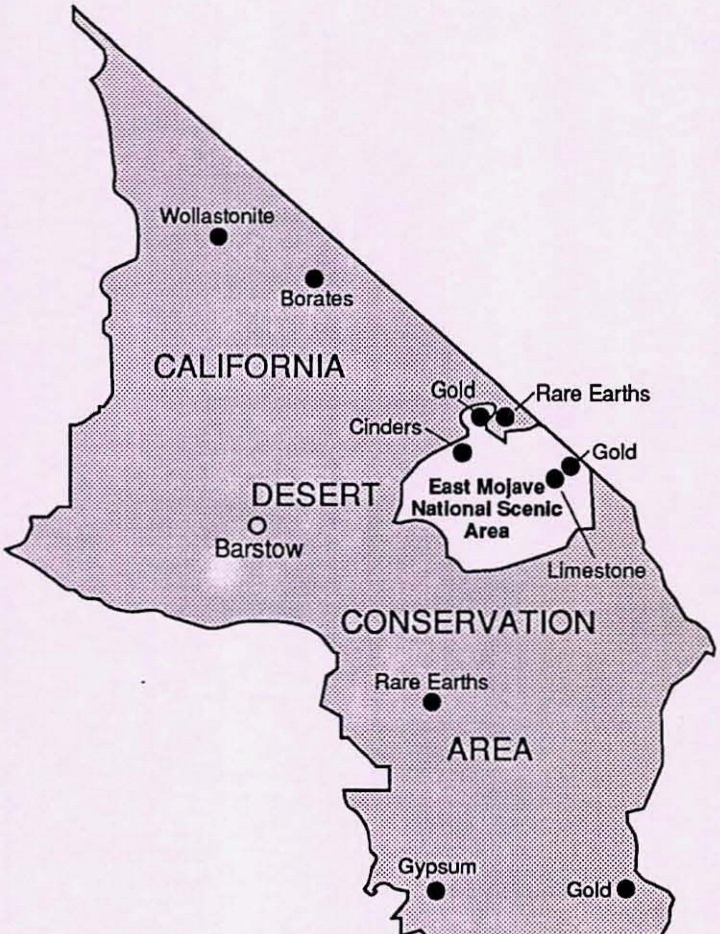
MINERAL DIVERSITY IN THE CALIFORNIA DESERT CONSERVATION AREA



Bureau of Mines
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May 1992

MINERAL DIVERSITY IN THE CALIFORNIA DESERT CONSERVATION AREA

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UNITED STATES DEPARTMENT OF THE INTERIOR
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BUREAU OF MINES
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PREFACE

The Bureau of Mines is charged by the Congress to help ensure that the United States has an adequate and dependable supply of minerals to meet its defense and economic needs at acceptable social, environmental, energy, and financial costs. Founded in 1910 to study "the safety of miners," the Bureau also is required to collect, analyze, and disseminate information on minerals and to conduct minerals research.

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INTRODUCTION

A basic precept in mineral exploration is that the best places to prospect are where minerals have already been found. The California desert has many old mining districts once thought to be "played out" that are currently producing more mineral wealth than at any time in the past. Because no "crystal ball" exists that will enable us to predict the Nation's future mineral needs, land management plans must be flexible enough to respond to these often unforeseen needs.

MANAGEMENT ISSUES

The California Desert Conservation Area (CDCA) (figure 1) encompasses 25 million acres, nearly one-quarter of the total area of California. Passage of the Federal Land Policy and Management Act of 1976 (FLPMA) launched an intensive program by the Bureau of Land Management (BLM) to study this vast area. Painstaking scientific investigations were made of wildlife and plant populations, soil, air, and mineral resources, range use, and wilderness characteristics, among other environmental concerns.

Based on BLM's studies mandated by FLPMA, a bill known as the "California Public Lands Wilderness Act" has been introduced into the 102nd Congress. Competing legislation such as the "California Desert Protection Act" (CDPA) has also been introduced.

Under the proposed CDPA legislation (figure 2), lands dedicated to preservation would more than double, to 10.4 million acres, and would encompass numerous mining districts considered by proponents of the bill to be "played out." Federal lands open to mineral exploration and development would be reduced by 66 percent to 4.3 million acres. Significant portions of these open lands lack rock outcrop, making mineral exploration difficult.

PURPOSE

The following nine articles present case histories selected to highlight the diversity of deposits, commodities, and markets represented in the CDCA. The articles illustrate the variety of potential impacts which could occur should the California Desert Protection Act or similar legislation become law.

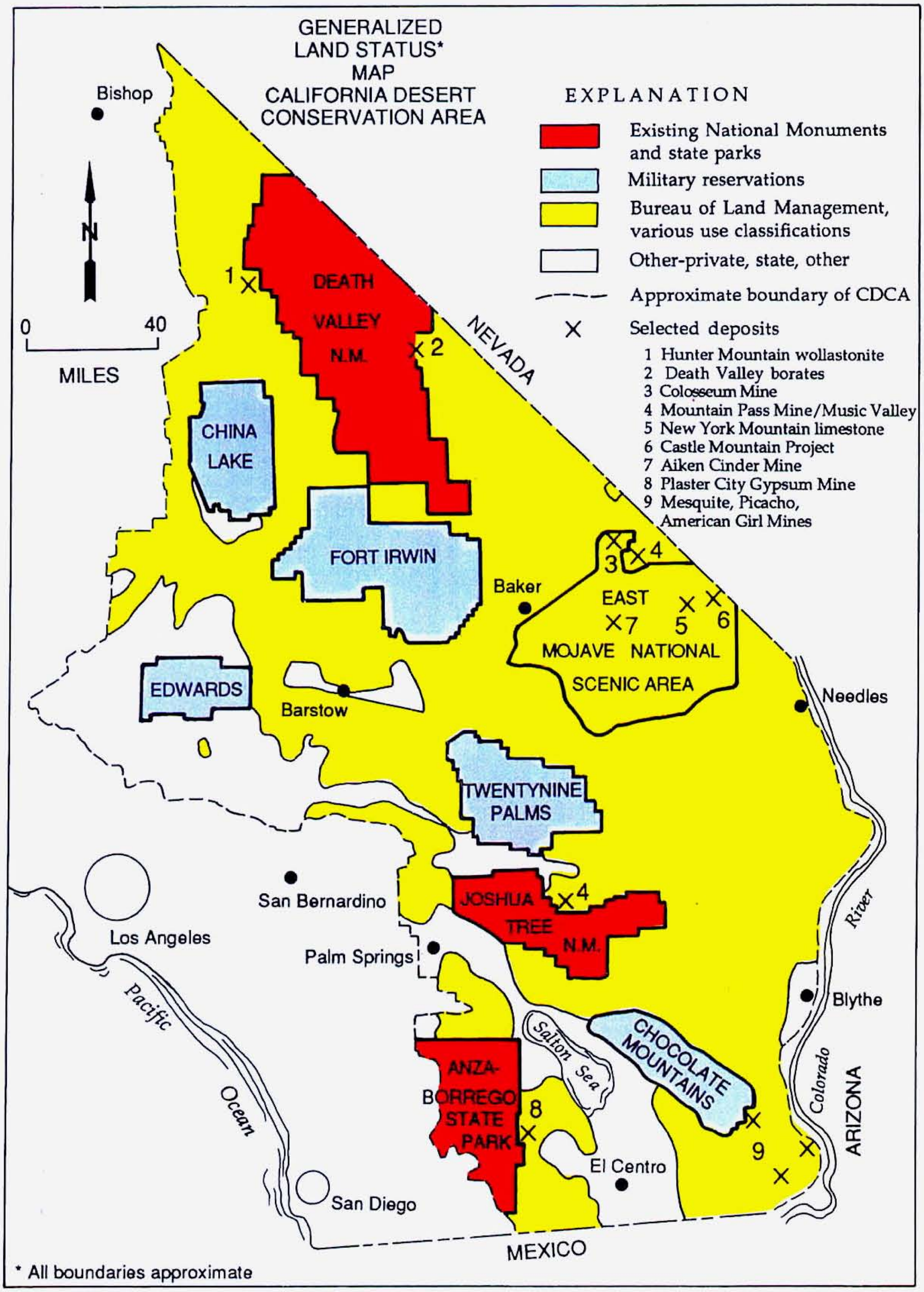

Figure 1.- Generalized land status map with locations of selected deposits in the California Desert Conservation Area.

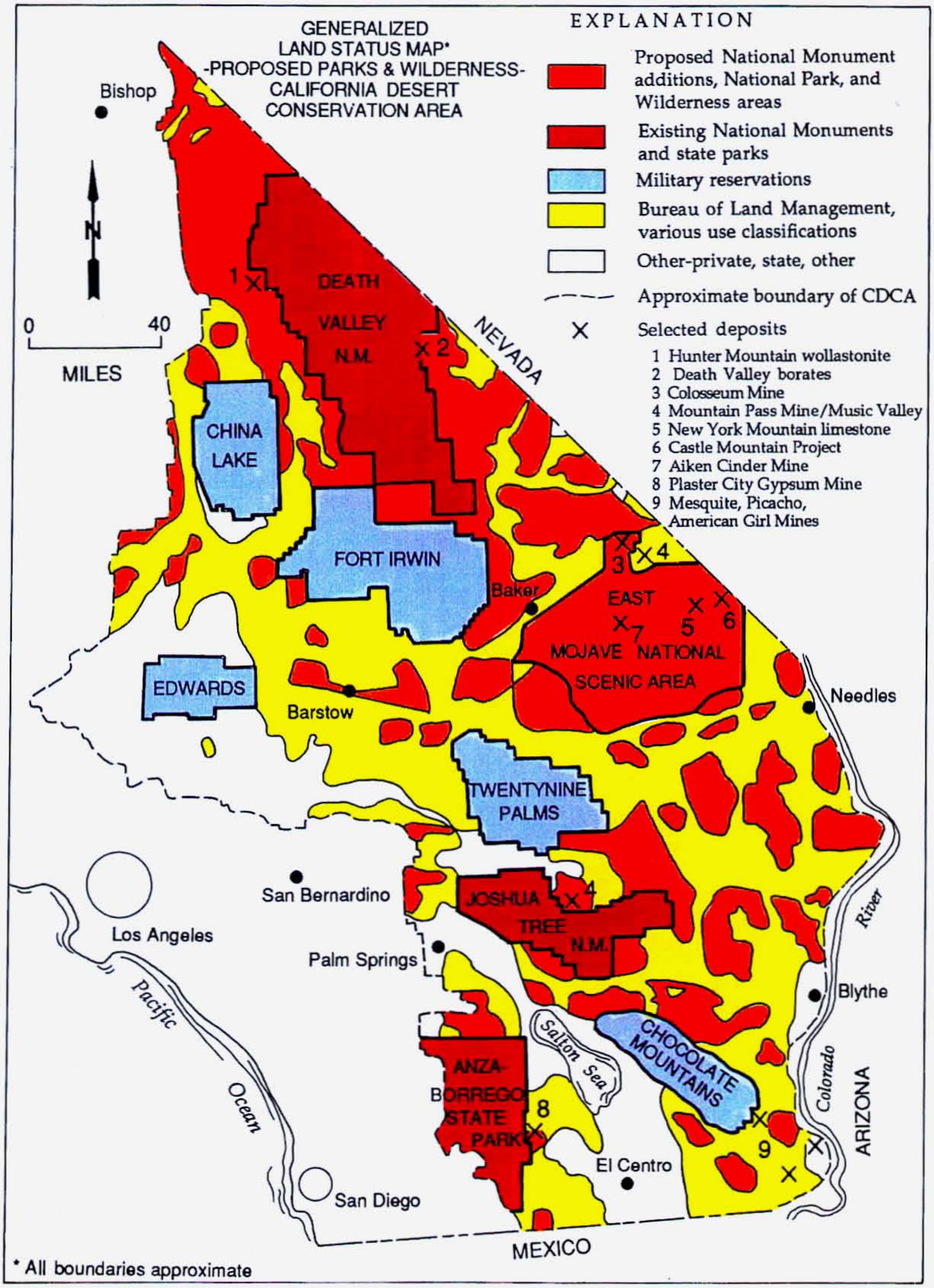

Figure 2.- Proposed National Parks, park additions, and wilderness areas in the "California Desert Protection Act", and location of selected deposits, in the California Desert Conservation Area.

CASTLE MOUNTAIN
NEW DISCOVERY IN AN OLD MINING DISTRICT

The Castle Mountains (figure 1) lie about 60 miles south of Las Vegas, NV, and host extensive deposits of low-grade gold. In the early days of mining, this gold was by-passed because it was uneconomical to mine. However, a modern-day gold rush has resulted from recent technological advances and, since the late 1960's, a dramatic rise in the free-market value of gold. From an average of $36.41 per troy ounce in 1968, the price of gold rose to over $600 per troy ounce in 1980. From 1985 through 1989, gold averaged over $390 per troy ounce.

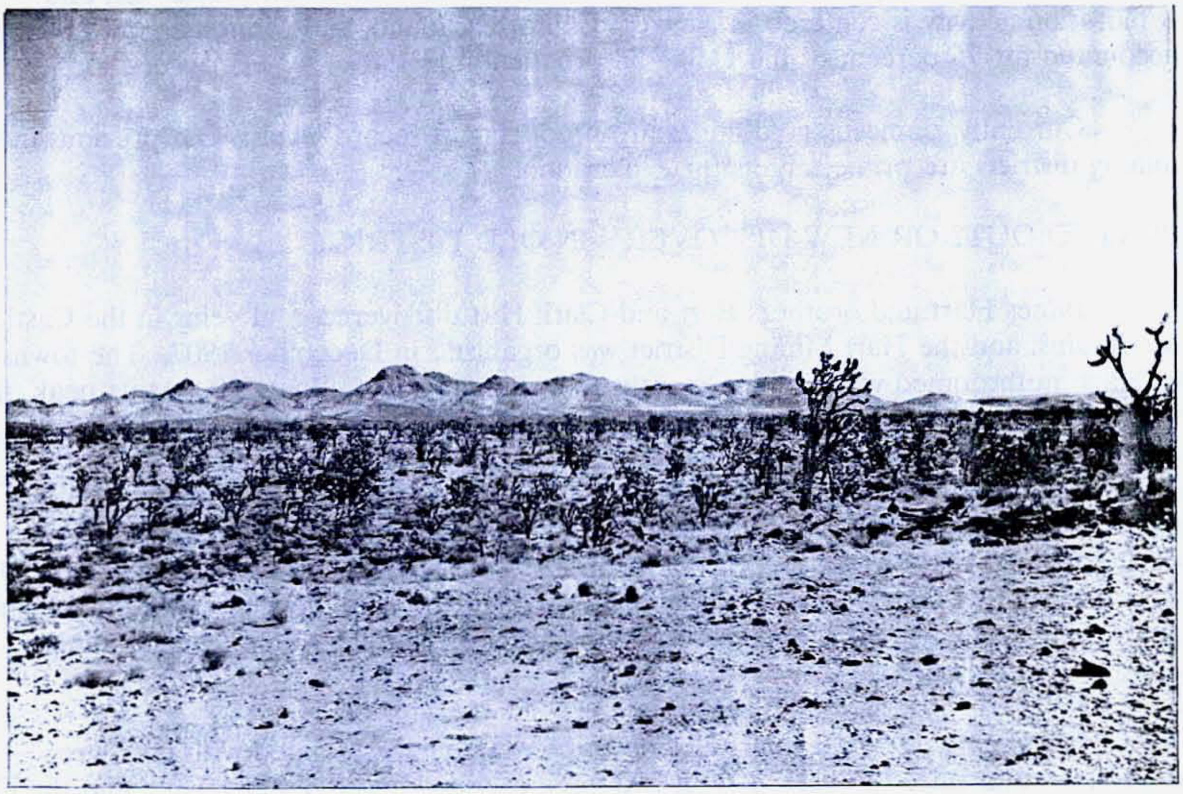

Figure 1.--View looking east at the Castle Mountains, San Bernardino County, California. Viceroy mine site is right (south) of center.

WHAT IS THIS PRECIOUS METAL?

Gold is a yellow metal nearly 20 times the density of water and so soft that it can be scratched with a fingernail. Because of its malleability and beauty, it was one of the first metals mined; objects have been found dating to 4000 B.C. One of its most unusual and valuable properties is its high resistance to corrosion and tarnish; another is that gold is a good conductor of heat and electricity.

In the twentieth century, traditional uses of gold, such as in jewelry and coins, have been partly displaced by industrial and dental applications. U.S. consumption of gold in 1988, according to the U.S. Bureau of Mines Minerals Yearbook, was 3.2 million troy ounces (1 troy ounce equals 1.1 avoirdupois ounce). About 55 percent was used for jewelry and the arts, 37 percent in industry, and nearly 8 percent for dental work, such as fillings, crowns, inlays, and bridges. Electroplating accounts for the greatest portion of industrial use; other uses involve microwave tubes, microelectronics, infrared radiation reflectors in heaters and missiles, and solid lubricants in high-vacuum environments. In medicine, gold compounds are used for the treatment of arthritis and other problems.

Domestically, gold is produced from several hundred lode mines and numerous placer mines, primarily in Alaska and the western states. However, production and exploration activity is centered in Nevada, California, Idaho, and Montana, and 25 mines accounted for 75 percent of the U.S. gold production in 1989.

Currently, domestic gold mines are producing at record levels. Old precious-metal mining districts are prime targets for exploration.

PLAYED OUT? OR NEW DISCOVERY IN OLD DISTRICT

James Hart and brothers Bert and Clark Hitt discovered gold veins in the Castle Mountains, and the Hart Mining District was organized in December 1907. The townsite of Hart mushroomed within a few months to a population of about 700. At its peak, the town had several hundred tent and frame buildings, six saloons, and a newspaper.

Gold was mined from narrow, high-grade veins of limited extent. Most ore averaged 1 or 2 troy ounces of gold per ton, but veins carrying as much as 500 troy ounces of gold per ton were reported. Workings consisted of shallow trenches and short adits and shafts. Only a few mines had extensive underground development. The high-grade veins were not deep, and the ore was quickly exhausted; within 3 years, mining attempts were abandoned.

In the early 1920's, extensive deposits of white clay associated with gold were developed, and since the early 1930's, two large clay pits, the P.S. Hart Mine and the C-1 Clay Mine, have produced over 560,000 short tons of clay for use in sanitary ware, such as lavatory fixtures. Seven million short tons of clay resources reportedly remain.

The only other precious-metal mining reported from the district was at the Big Chief Mine, which operated from 1933 to 1942. However, only small amounts of gold were produced.

Exploration for low-grade gold in the early 1980's led to the discovery in 1986 of the two Castle Mountain deposits by Harold Linder, a consultant for Viceroy Gold Corporation. The Jumbo South deposit is associated with a small, gold-bearing surface outcrop, while the Lesley Ann deposit is buried under 300 feet of alluvium. Exploration techniques used to discover both ore bodies included examination of the old Hart workings, extensive geochemical sampling and geologic mapping, and drilling 634 holes (over 343,000 feet of total core) (figure 2). State-of-the-art technology and sound geologic principles were primarily responsible for the new discovery in the supposedly "played-out" mining district.

Figure 2: View looking south at proposed open-pit mine site, Castle Mountain Project, San Bernardino County, California. Note historic workings and old millsite foundations in core of Hart mining district.

CASTLE MOUNTAIN GEOLOGY - PART OF A LARGER SYSTEM?

Geologically, the Castle Mountains are composed of a large block of rhyolitic lava, ash, and cinder that overlies older volcanic and sedimentary rocks. The mineralizing event occurred about 15 million years ago within a volcanic center containing channels for mineralizing fluids. Although the host rock was chemically uniform throughout, ore emplacement was structurally controlled by the amount of fracturing. Ore in the deposits occurs as free gold and as a natural gold-and-silver alloy called electrum. Silver content is low, and base metals, such as copper, lead, and zinc, are absent.

Regionally, the Castle Mountain deposit may lie on the rim of a much larger structure, or caldera, around which additional deposits may lie. Presently, exploration is continuing, and the likelihood of new discoveries appears favorable.

MINING

Viceroy Gold Corporation's Castle Mountain project is located in the East Mojave National Scenic Area near the California-Nevada state line (figure 3). The corporation plans to employ open-pit mining and modern heap-leaching methods to extract gold from the Castle Mountain deposits. Combined minable and geologic reserves are 40 million short tons. The average grade of 0.05 troy ounces of gold per ton is just one-twentieth of the minimum grade sought by early miners.

Approximately $28 million has been spent on exploration, engineering evaluations, and environmental studies and protection. An additional $48 million in capital investment is needed to bring the mine into production.

The flow sheet shown in figure 4 is a simplified representation of the proposed mining and processing operation at the Castle Mountain site. Plans call for approximately 8,000 tons a day, about 2.8 million tons a year, to be extracted from the open-pit mine. About 2.2 tons of waste must be removed for each ton of ore, and gold recovery is expected to be 65 percent. Mining will consist of drilling and blasting rock in the pit, transporting the ore in haulage trucks to the crushing plant, and crushing the ore in three stages to reduce the diameter of rock fragments to less than 3/8 inch. Ore will then be mixed with lime (cement) and water to enhance percolation characteristics by agglomerating the fine particles. The agglomerated material will be stacked in rectangular piles to a maximum height of 80 feet.

To leach the gold from the ore, a weak cyanide solution will then be applied to the "heap" by means of drip irrigation. The gold-bearing solution will be caught by an impermeable plastic pad liner and piped through a series of tanks containing activated charcoal, which removes gold from cyanide solutions by adsorption. Further processing will plate the gold onto steel wool, and the combination will be burned in a furnace so that the precious metals will melt. The molten gold and silver will then be poured into "dore" bars and sold to a refinery for processing. All cyanide solutions are to be recycled in a closed system to protect the environment. The overall cost to operate the mine is expected to be about $200 per ounce of gold produced.

THE ENVIRONMENT AND REMEDIATION

An Environmental Assessment of the proposed operation was completed by the BLM, and a favorable decision was issued in 1987. In September 1990, after 3 years and the expenditure of $3 million, the final Environmental Impact Statement and Review was issued by the BLM and the County of San Bernardino. Public meetings followed before the permits were finally issued in late 1990.

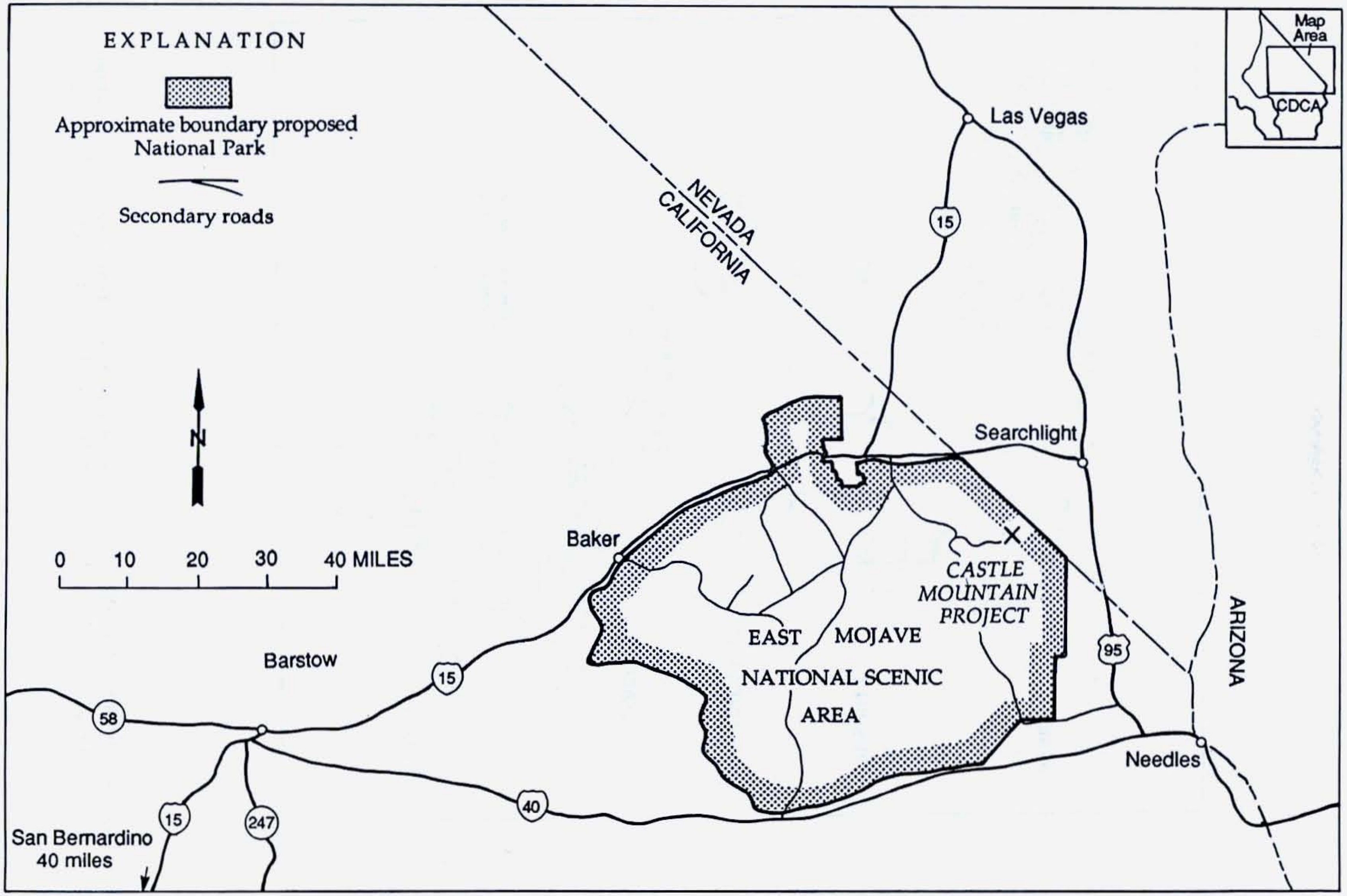

Figure 3.- Location of the Castle Mountain Project in the East Mojave National Scenic Area, San Bernardino County, California

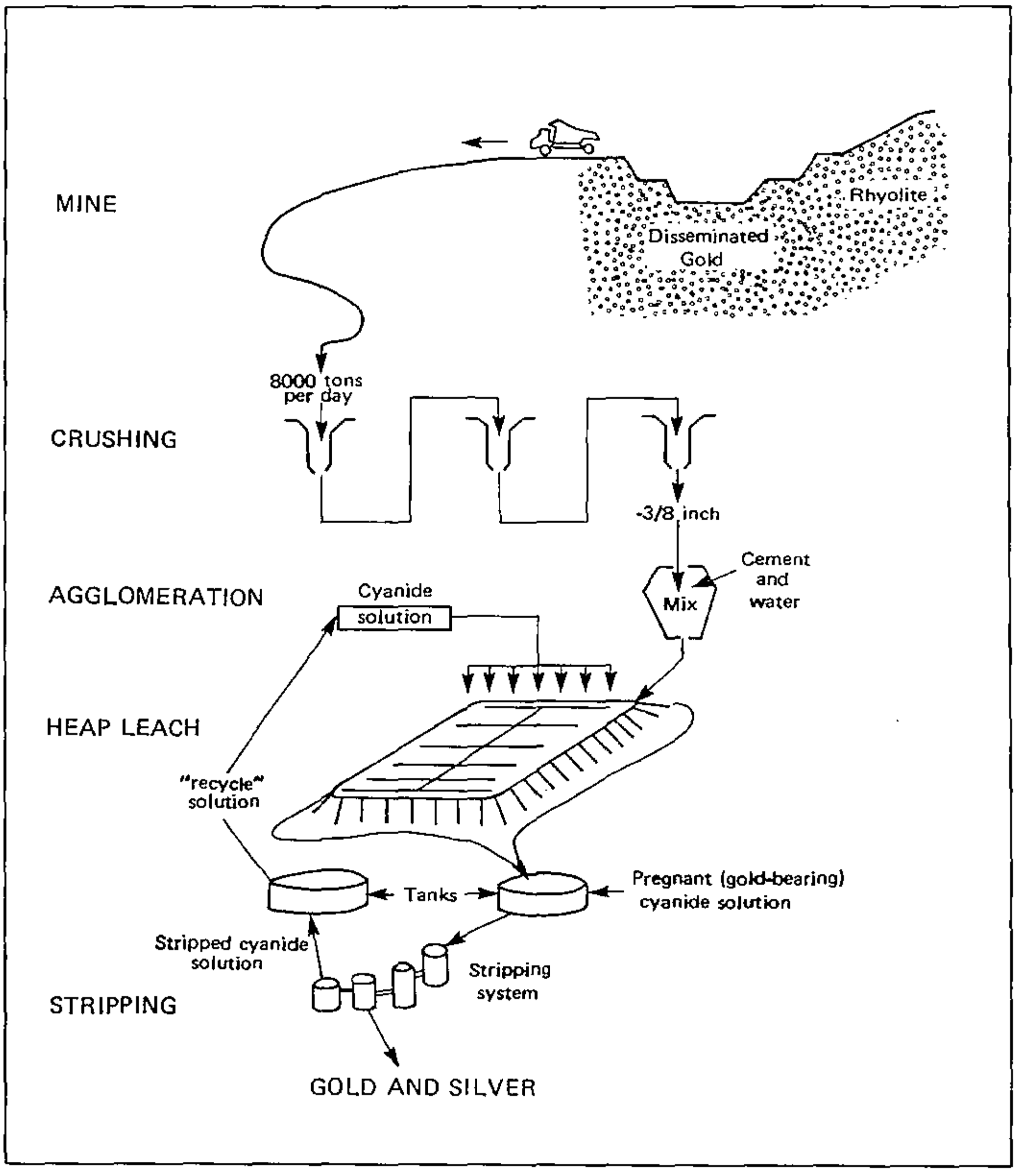

Figure 4.- Simplified flow diagram showing sequence from mine to end product at the proposed Castle Mountain operation, San Bernardino County, California

Major environmental issues associated with the proposed Castle Mountain project include possible impacts of the operation on the desert tortoise, groundwater depletion, and site reclamation. Examples of some of the numerous mitigation measures mandated by state regulation or voluntarily planned and implemented by Viceroy Gold Corporation include:

1. Purchase of the Walking Box Ranch and application to place the ranch on the National Register of Historic Places. Establishing a desert tortoise reserve at the ranch.

2. Relocation and reclamation of a county-maintained road to avoid desert tortoise habitat.

3. Donation of funds to The Nature Conservancy for programs to mitigate impacts on desert tortoise populations.

4. Use of enclosed cyanide solution storage tanks and a system of liners with leak detection systems to prevent groundwater contamination.

5. Reduction of anticipated annual water consumption by 35 percent through fine crushing and drip irrigation. Installation of monitoring wells to assure maintenance of aquifer conditions.

6. Purchase and reclamation of the previously mined north and south clay pits, which would not have otherwise been reclaimed.

7. Development of a comprehensive reclamation program that includes landform contouring and revegetation with indigenous plant species. On-site revegetation research and staining of pit walls will reduce color contrast between fresh rock and the surrounding environment.

Although mining operations at Castle Mountain are expected to begin in the first quarter of 1992, pending federal legislation may affect the future of the project. The California Desert Protection Act proposes establishing the East Mojave National Scenic Area as a national park, which could inhibit gold production and preclude further exploration in the Hart Mining District. On the other hand, the California Public Lands Wilderness Act would have no effect on the Castle Mountain project.

The socioeconomic impacts the California Desert Protection Act on the Castle Mountain project and, therefore, to local and regional economies, could be severe. At least 2 million troy ounces of gold are expected to be produced during the life of the project. Construction work to bring the project on-line currently employs a workforce of about 50, while approximately 160 workers are expected to be employed in mining and processing. Total annual contributions to the local economy are estimated to be $17.5

million in payroll and supplemental services and supplies. An additional $60 million will be paid in revenues to local, state, and Federal governments. Much of the $48 million capital investment will also be spent in the local economy.

DEATH VALLEY BORATES - A WASTED LEGACY?

More than 100 years have passed since the last wagon shipment of borate[1/] was pulled out of Death Valley by the legendary twenty-mule teams. Since then, changes in domestic borate mining have been profound. Mule teams pulling two 12-ton-capacity wagons have been replaced by diesel trains pulling 30 to 35 100-ton-capacity hopper cars. Underground mining has largely been replaced by open pit methods. Although the southern California desert remains the center of borate production in the U.S., except for limited production from the Gerstley Mine near Shoshone, the mines in the Death Valley area are inactive.

Instead, since the late 1920's, world borate production has been dominated by a single mine at Boron, California. This huge open pit mine, owned by United States Borax and Chemical Corporation (U.S. Borax), is located about 120 miles north of Los Angeles in the Mojave Desert. It began production in 1927 and is currently the largest borate producer in the world with reserves estimated to last another 30 to 40 years at current mining rates. Depletion of the deposit at Boron will leave the U.S. without significant domestic borate reserves unless alternate sources are available.

Is it important for the U.S. to have domestic borate resources? Can U.S. industry obtain a sufficient supply of borates if it must rely on foreign sources? Will borates continue to play an important role in world industries? It is important to ask these questions now for two reasons. First, it could take 15 to 20 years to discover and bring on line new borate resources, and second, large deposits in the Death Valley region, long assumed to represent future domestic borate reserves, are being threatened by pending legislative proposals. One of these, the California Desert Protection Act (CDPA) would create nearly 7.2 million acres of new wilderness and National Park lands, and thereby eliminate mining and ranching in large areas of the southern California desert. The attendant enlargement of Death Valley National Monument (figure 1) and creation of several wilderness areas nearby would severely restrict or eliminate future borate mining in the Death Valley area.

THE EVOLVING BORATE INDUSTRY

Borate products are now used in many of the worlds industries. Besides traditional uses as fluxes and components of cleansing preparations, boron compounds have become important components in today's technologies. Glass, fiberglass, enamels, ceramics, herbicides, fertilizers, neutron absorbers in the nuclear industry, and fire retardants are some of the more common uses for borates. About one-half of the domestic borate production is consumed in the manufacture of various kinds of glass including fiberglass insulation, important for energy conservation. Boron nitride is used in the thermal tiles to protect the

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1/A borate is any compound containing the element boron combined with oxygen, and usually calcium and/or sodium.

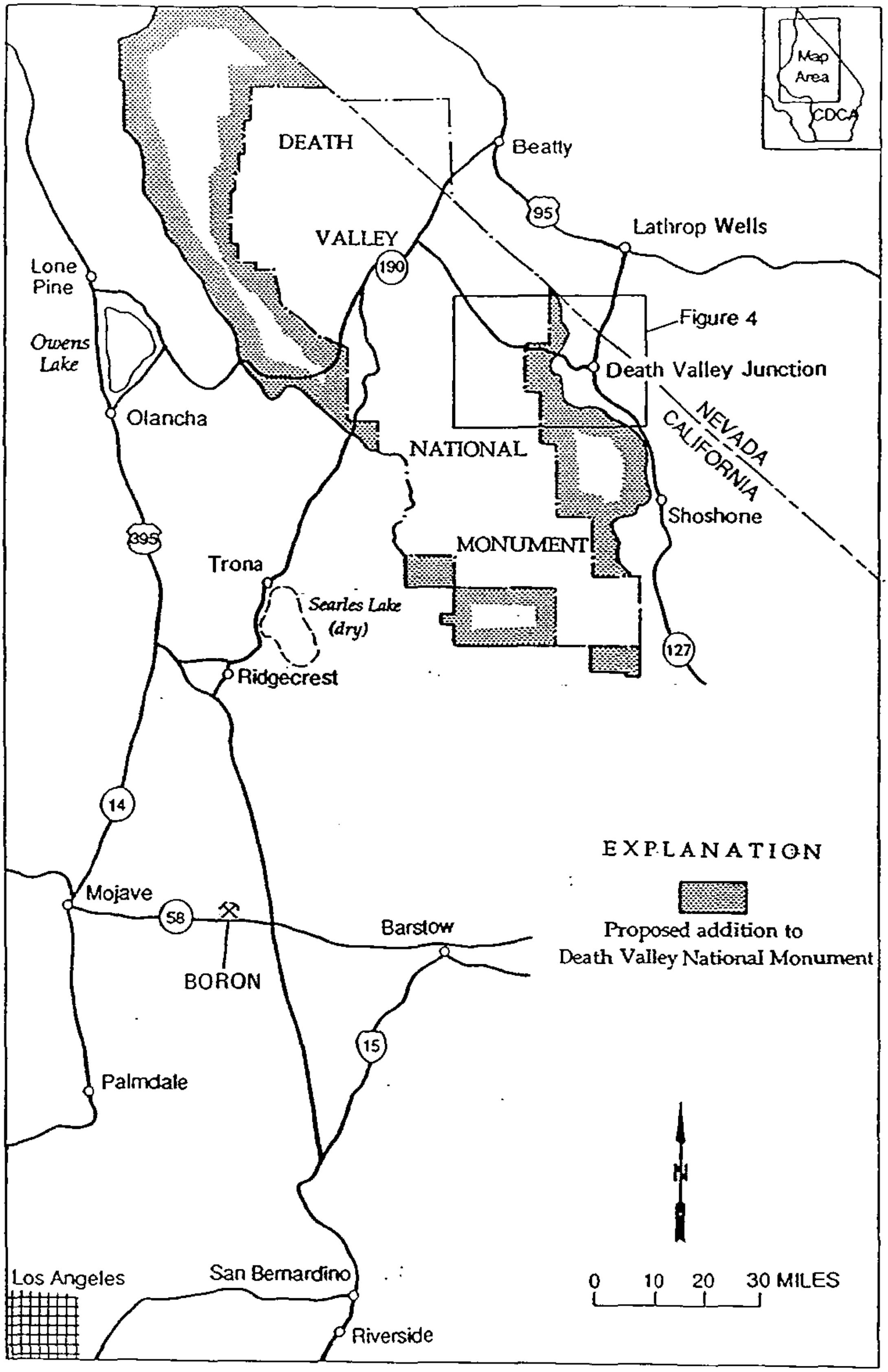


Figure 1.- Death Valley National Monument and proposed additions

U.S. Space Shuttle upon re-entry, and boron carbide is used in abrasion-resistant applications and nuclear shielding. It is estimated that 50 percent of domestic production is consumed in the U.S. (figure 2), while the rest is exported.

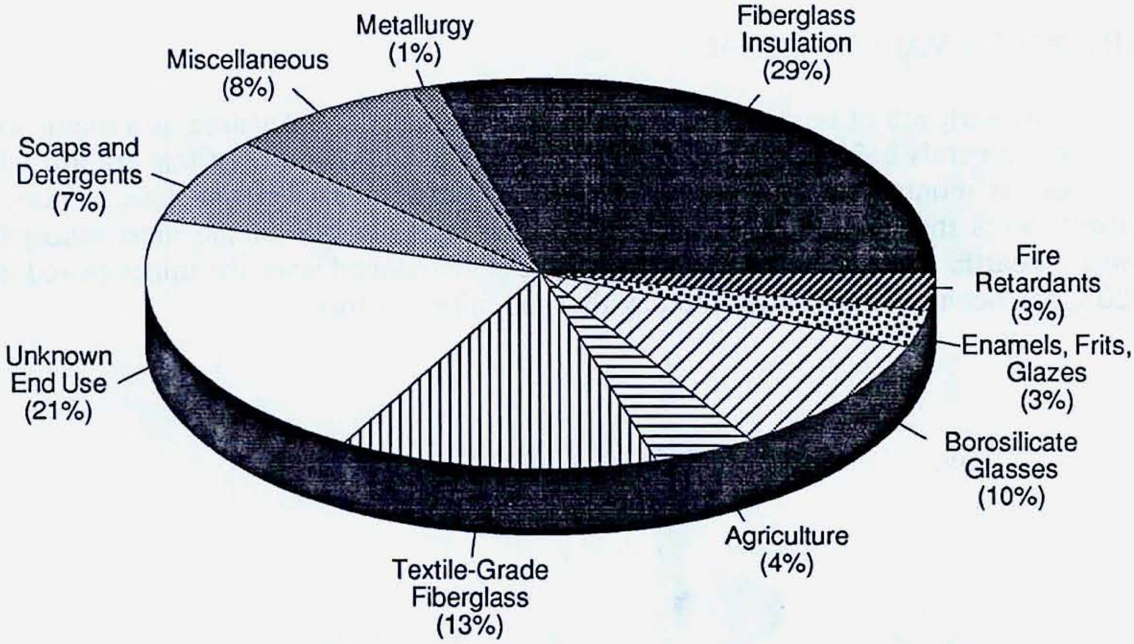


Figure 2: U.S. consumption of boron compounds in 1988.
(Source: U.S. Bureau of Mines - Minerals Yearbook, 1988)

BORATES - A GEOLOGIC ODDITY

Minable borate deposits are geological oddities much rarer than gold or silver deposits. Borate deposition requires the simultaneous interaction of special climatic, physiographic, and geologic conditions that have happened at only a few places on earth. The deposits in the Death Valley region were formed about six million years ago when boron-bearing thermal springs flowed into relatively small fault-bounded sub-basins in a larger northwest-trending basin. Restricted circulation of water in the sub-basins, in concert with apparently high evaporation rates in the region, provided conditions suitable for the crystallization of borate minerals from the resulting concentrated brine. Borate crystal accumulation on the sub-basin floors gradually formed a series of generally lenticular borate deposits. Continued sedimentation covered the borates with calcium carbonates, gypsum, volcanic ash, silt, basalt and alluvium.

Some of the borate deposits were subsequently exposed by uplift and erosion of the overlying sediments. Early borate mining in what is now the Monument focused on recovering "cottonball" ulexite, a calcium-sodium borate, from dry lake bed crusts that were leached from boron-rich clays underlying the valley floor. Later, when colemanite, a calcium borate, was discovered, the large subsurface resources were mined.

THE DEATH VALLEY LEGACY

The early era of borate mining established the Death Valley area as a major source of borate minerals before the turn of the century (figure 3). Relics of this era are still treasured as monuments to the ingenuity and courage of the prospectors, miners, and entrepreneurs that attempted to wrest their fortunes from one of the most inhospitable places on earth. The mining camp at Ryan, all but abandoned since the mines closed in the 1920's, has been maintained for the day that the miners return.

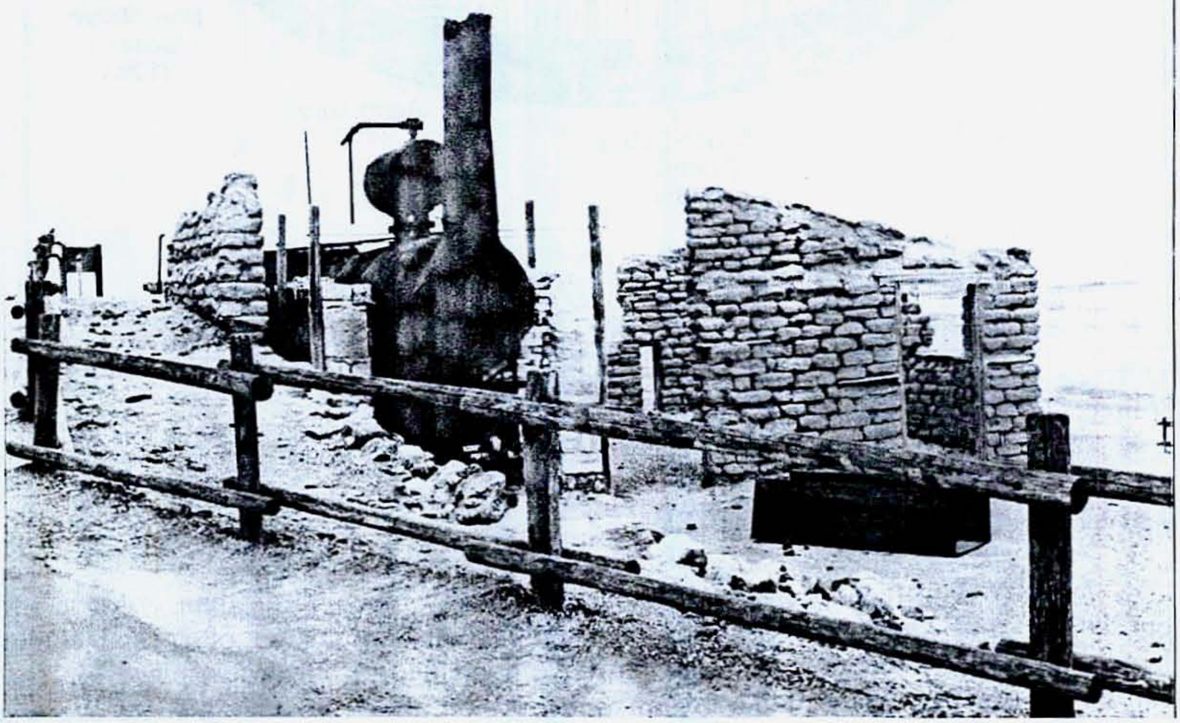


Figure 3.--The Harmony Borax works - a relict of early borax mining in Death Valley.

Although large borate resources remain in the Death Valley area, the combination of expensive mining and refining methods has placed them at a competitive disadvantage. Since 1957, the ore at Boron has been mined by open pit methods, resulting in lower operating costs. Because ore at Boron is primarily sodium borates, refining is less expensive than for the calcium and calcium-sodium borates that predominate in the Death Valley area. The most recent borate production in the Death Valley area came from the Boraxo open pit, operated in Death Valley National Monument during the 1960's and 1970's, and the Billie Mine, which extends beneath the Monument (figure 4), from 1979 to 1985. These ores were processed at a plant near Lathrop Wells, NV; the plant continues to produce borate products from stockpiled ore. The Gerstley Mine, operated by U.S. Borax near Shoshone, intermittently produces borates for specialty uses.

Continued exploration by private companies (figure 5) and studies by government agencies have delineated a zone of favorable borate potential in the Death Valley area that extends southeast from Furnace Creek Inn at least 30 miles (figure 4). The zone includes an estimated 21 million tons of borate ore at the American Borate Company-owned Billie Mine, the largest underground colemanite mine in the world. The favorable zone also includes about 75 million tons of borate resources identified by U.S. Borax. Borate resources in this zone make the Death Valley area potentially one of the world's largest borate producing regions. An estimated 51 million tons of these resources are within the bounds of Death Valley National Monument. Most claims that have resources were filed before the Monument was established; the remainder predate the 1976 legislation that ended recordation of mineral claims in National Parks and Monuments. In principle, these resources are minable (although no new claims can be filed in the Monument). However, in addition to a variety of other requirements, Federal regulation requires that no plan of operation be approved by the Regional Director of the Parks Service "... where the operation would preclude management for the purpose of preserving the pristine beauty of the unit for present and future generations, or would adversely affect or significantly injure the ecological or cultural resources of the unit". This will likely prohibit future open pit mining in the Monument.

Forty-five million tons of borate resources were identified outside the Monument's boundaries. Many of the claims that include these resources are on land that would, effectively, be withdrawn from mining as part of the CDPA. If mining were allowed at all on this land, the restrictions would be at least as stringent as those currently in place in Death Valley National Monument. Some of the resources are completely surrounded by proposed wilderness or proposed National Parks.

At present, borate mining represents a significant portion of California's nonfuel mineral production, accounting for about 16 percent of the gross revenues (figure 6). Yearly production from the California desert exceeds 650,000 tons of boron oxide (B_2O_3) valued at $430 million. The Boron operation is the principal producer, and directly supports almost 1,000 employees at the mine, processing plant, refinery, and shipping plant. The only other domestic borate production comes from brines entrapped in sediments that underlie the

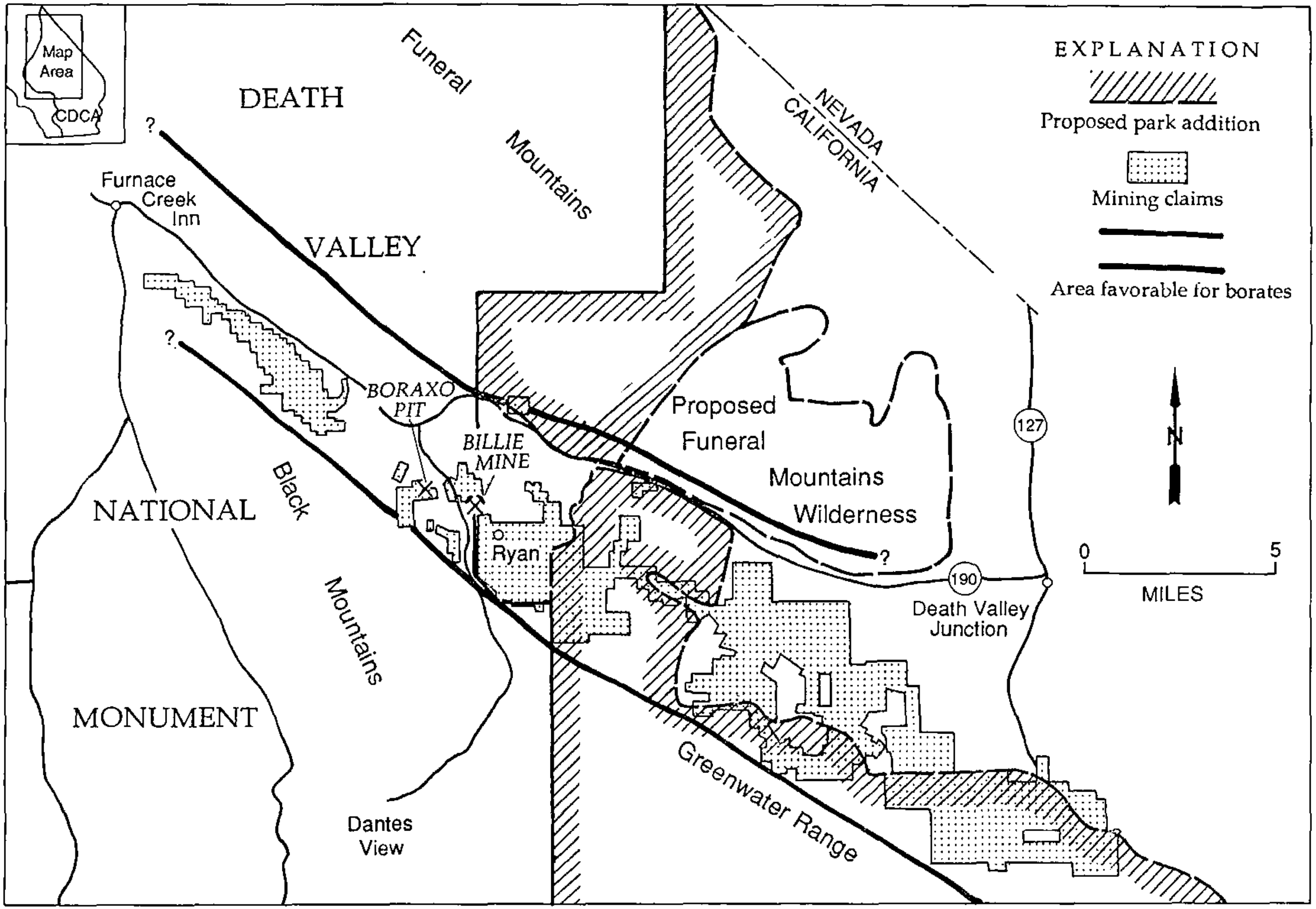


Figure 4.- Relationship of borate claims to proposed wilderness and national park boundaries in the Death Valley area

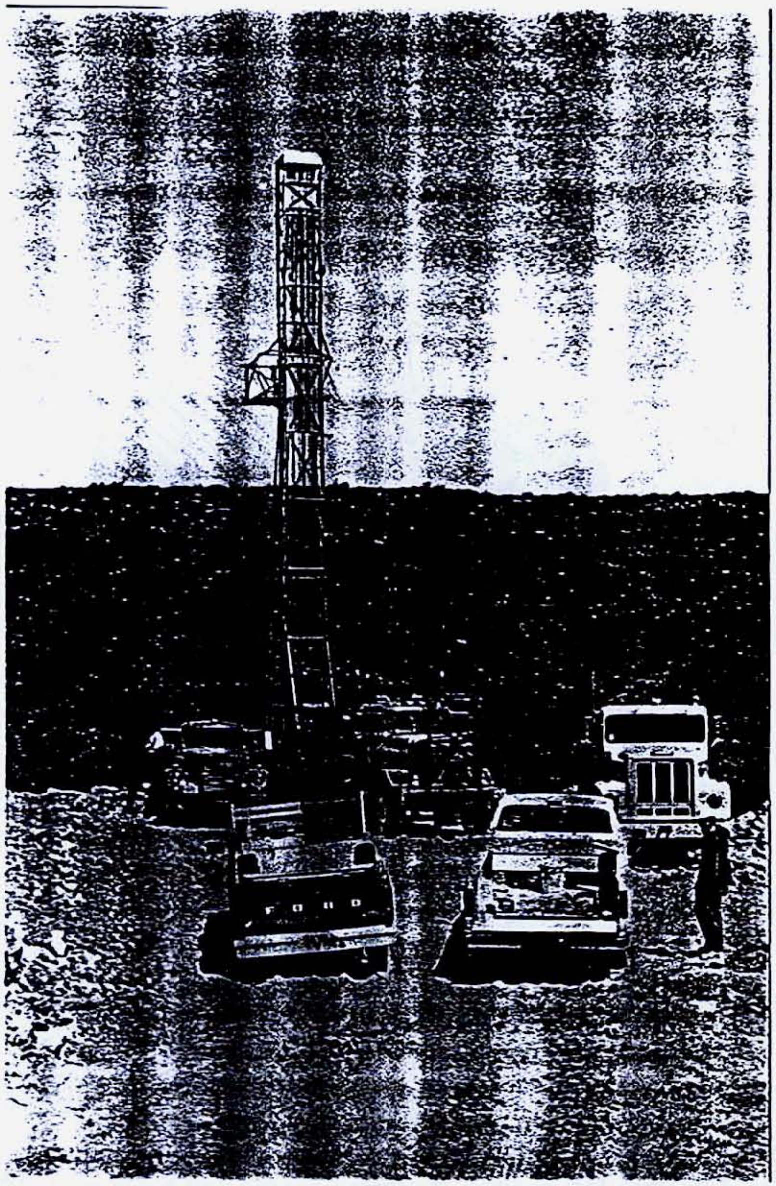


Figure 5.--Modern-day borate exploration near Death Valley.

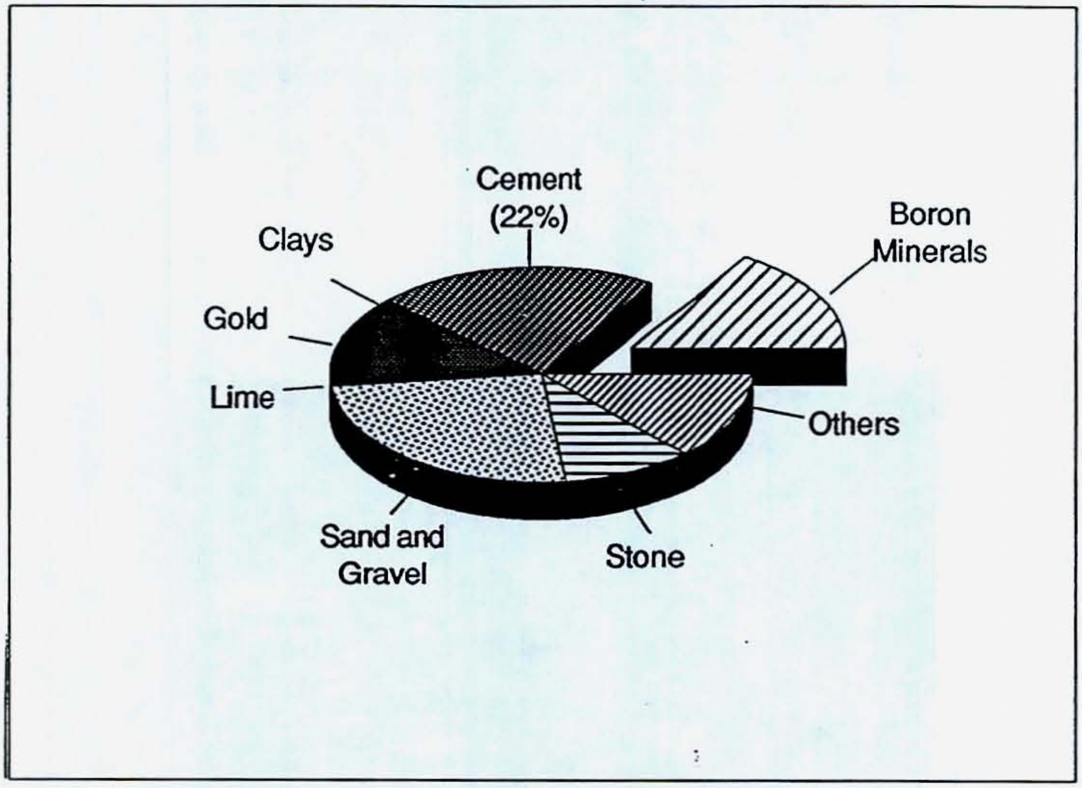


Figure 6.– Value of nonfuel mineral production in California for 1988.
(Source: U.S. Bureau of Mines - Minerals Yearbook, 1988)

generally dry Searles Lake in San Bernardino County, CA. Two plants owned by Kerr-McGee Chemical Corporation produce sodium borates and boric acid. The plants account for less than 3 percent of domestic borate production.

It is unlikely that domestic borate production could be maintained at present levels after depletion of the deposit at Boron even if the Death Valley deposits were allowed to come on line. However, if the CDPA becomes law, there is a danger that the borate resources in the Death Valley area could not be mined. The result could be the stifling of most domestic borate production.

WORLD COMPETITION FOR A UNIQUE AND VERSATILE COMMODITY

Although borates are produced in other countries, it is estimated that the U.S. and Turkey have about 90 percent of the world reserves. In 1988, the California desert accounted for about 41 percent of the world production of borate (figure 7). In view of the extensive use of boron compounds in modern manufacturing, insuring future domestic borate sources is vital to many U.S. industries in order for them to compete in world markets. The following statements by the U.S. Bureau of Mines underscore this importance.

> "There is no secondary recovery and reuse of boron compounds, since almost all go into dissipative uses."
>
> "...there is no other substitute material that possesses the unique and versatile qualities of boron."

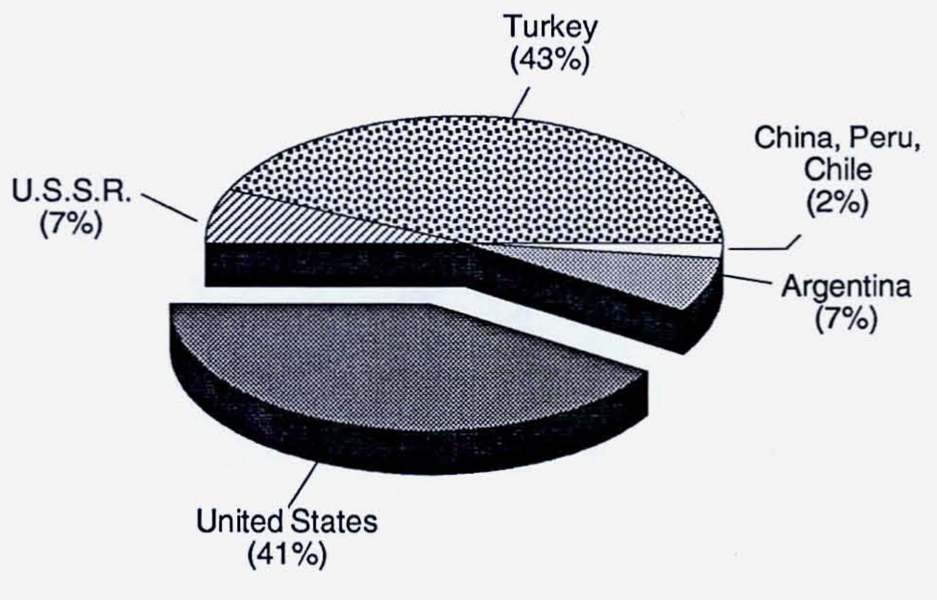


Figure 7: Estimated world borate production by country for 1988.
(Source: U.S. Bureau of Mines - Minerals Yearbook, 1988)

It is difficult, if not impossible, to accurately forecast the impact of the Death Valley borate resources on the regional economy or on domestic industry in 30 to 40 years. Too many changes in technology, global economy, and mining and processing methods are possible. The world demand for borates has been slowly but steadily increasing at an annual rate of 2-3 percent. It was expected that this gradual growth in demand would continue into the foreseeable future. Recent developments in Eastern Europe may change this forecast. New trade agreements could put additional demands on Turkish borate production if foreign investment spurs industrial growth in these Eastern European economies.

Without adequate borate resources of its own, the U.S. would be competing with rapidly expanding European markets for Turkish borate. Higher costs for imported borates, in part due to higher shipping costs, would place U.S. products at a competitive disadvantage in foreign and domestic markets and cause the U.S. consumer to pay higher prices.

Borates are no longer a commodity used primarily in the laundry room. Instead, they are a vital ingredient in today's technologies. Land-use decisions made today on the Death Valley region will have far reaching impacts on U.S. competitiveness in future world markets. It could mean the difference between having additional expensive products to import, or valuable products to export.

HIGH-QUALITY LIMESTONE DEPOSITS IN THE NEW YORK MOUNTAINS

> "Hardly a sector of today's industry would be able to survive for long without a supply of carbonate rocks, or their products. Indeed, limestone alone is the most useful and versatile of all the industrial rocks and minerals".
>
> Harben and Bates, 1990

The New York Mountains, about 65 miles south of Las Vegas, NV (figure 1), host what may be the largest undeveloped deposits of high-purity, high-brightness limestone in the southwestern United States. The importance of these deposits was officially recognized in 1985 when the California Division of Mines and Geology classified the deposits as MRZ-2b: "Areas underlain by mineral deposits where geologic information indicates that significant inferred resources are present."

Limestone is a rock composed chiefly of calcium carbonate, primarily in the form of the mineral calcite. Although ordinary industrial-grade limestone is commonly used for a variety of purposes, high-brightness, high-purity deposits are needed for very specialized fillers and extenders.

Because existing sources of high-quality limestone in southern California may be depleted in as little as 20 years, a gradual transition of resource development from current source areas to the New York Mountains will be necessary to avoid supply shortages or prohibitively high transportation costs. However, the New York Mountains are located in the East Mojave National Scenic Area (EMNSA) and future minability of those deposits may be precluded by legislation before the Congress. The "California Desert Protection Act" proposes to designate the entire EMNSA as a National Park.

USES OF HIGH-QUALITY LIMESTONE

Mineral fillers and extender pigments are inert materials added to a product to lower costs and enhance the physical characteristics of that mineral, such as density, hardness, brightness, color, shape, strength, and electrical conductivity. Fillers that enhance the properties of a product are called "functional fillers." Finely ground calcium carbonate is most commonly used, but barite, various clays, diatomite, gypsum, talc, and several other minerals are also used.

Currently, kaolin (clay) is the mineral filler most commonly used by the paper industry in the western United States, but the use of calcium carbonate as a filler and coating agent is expected to increase because calcium carbonate inhibits acid formation, thus slowing the deterioration of paper.

The market for high-quality, high-brightness limestone is expanding in part because of the rapid growth of the polyvinyl chloride (PVC) industry in the 1980's. Calcium carbonates ground as small as 1 to 2 microns (4/100,000 to 8/100,000 inch) are

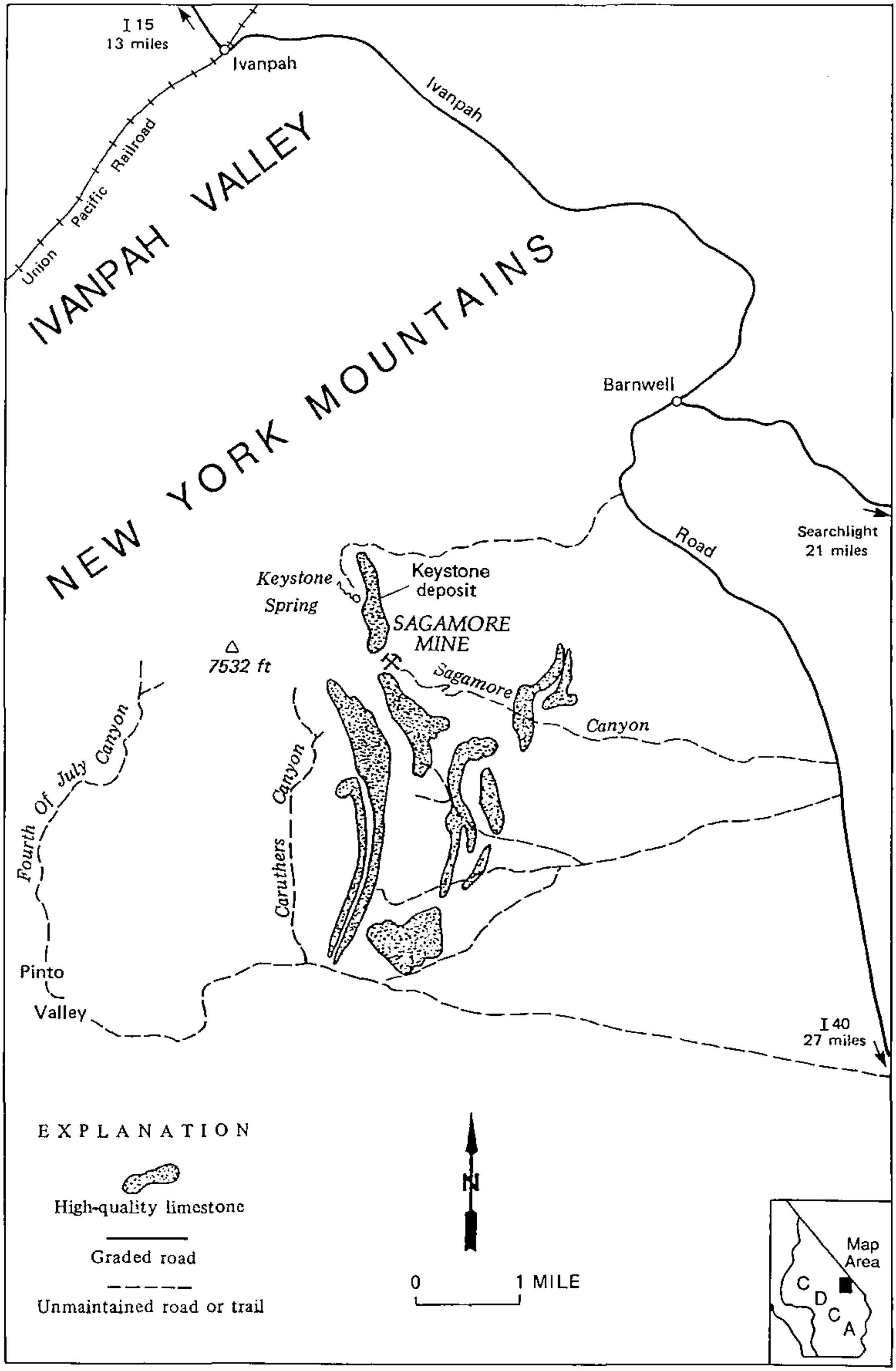


Figure 1.- Location of high-purity, high-brightness limestone deposits in the New York Mountains, San Bernardino County, California

particularly important in plastics because they do not absorb oil, they are easily and quickly mixed with resins when surface treated. and they are high in brightness, relatively soft, and low in abrasion. Some calcium carbonate fillers are chemically coated to achieve improved processing efficiency or more effective end-product performance. Ground limestone is also the predominant filler in foam carpet backing, as much as 6 parts of filler to 1 part urethane or latex polymer. Large quantities of calcium carbonate are also used in rubber products, such as footwear, and in drywall cement compounds, ceiling textures, and putties.

The paint industry makes significant use of finely ground calcium carbonate as an extender and as white pigment. Required properties include chemical purity, specific particle size distribution, high brightness, low abrasiveness, inertness, density, and resistance to weathering. A finer particle size imparts a higher gloss to the paint.

MINE TO MARKET

Limestone deposits are generally mined using traditional bulk-tonnage open-pit methods. A deposit detected at or near the surface is mined laterally into a mountain side or below the surface by a series of stair-stepped levels (figure 2). To meet strict product specifications, such as for purity and whiteness, selective mining may be necessary. Several different limestone quarries may be mined to meet varying end-product specifications.

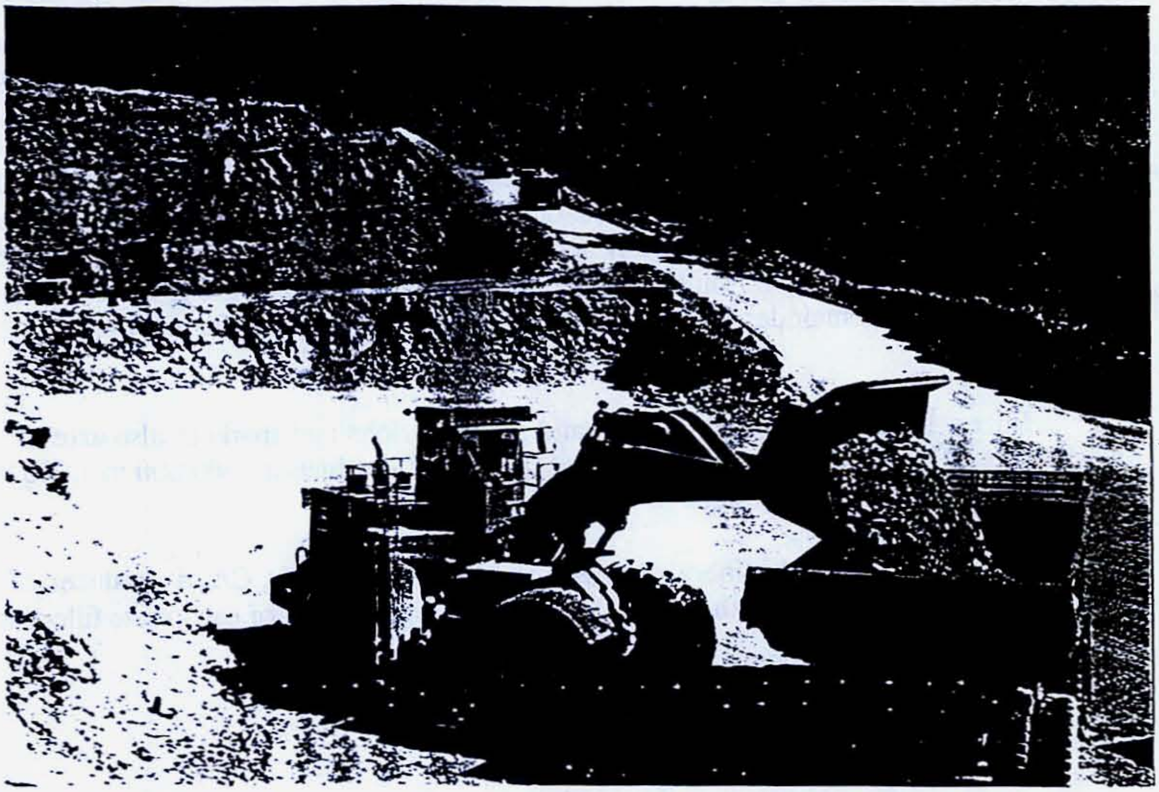


Figure 2.--View of mining operations at a Pluess-Staufer (California) Inc. high-purity, high-brightness limestone quarry in the San Bernardino Mountains about eight miles from plant in Lucerne Valley, California. (Photo credit: Howard Brown)

Pluess-Staufer (California) Inc. and Pfizer, Inc., both located in Lucerne Valley, CA, are two of the three major suppliers of white carbonate filler in the southwestern United States. Pluess-Staufer is a subsidiary of New York-based Pluess-Staufer Industries Inc. owned by Pluess-Staufer AG of Switzerland, the worlds largest producer of functional fillers and extenders.

The flow sheet in figure 3 is a simplified representation of the overall mining and processing system at the Pluess-Staufer operation. The limestone is quarried from deposits near the crest of the San Bernardino Mountains. Approxi-mately 3,000 short tons a day are reduced to chunks 7 inches in diameter or smaller by a primary crusher near the quarries, hauled 8 miles to the plant site in Lucerne Valley, and stockpiled according to quality. The plant is fed by underground conveyors from the stockpiles. Additional crushing, grinding, and air classification further reduce and sort the rock into particle sizes ranging from "medium sand" to "talcum powder." Some sizes are surface treated for use in manufacturing PVC and similar products. Size screening and reflectivity tests are conducted on samples taken from various stages of the milling circuit to control product quality. The mill is fully automated; just two employees are required to manage milling and quality control. Approximately 75 percent of the products are shipped by bulk container, and 25 percent are packaged in 50- or 1,800-pound bags. Overall, the mine and plant (figure 4) operations employ approximately 70 people.

Pluess-Staufer's 15 products, marketed under the Omya series, are aimed mainly at the high-end of filler markets such as plastics and paint. Product prices at the plant site in 1985 ranged from $19.50 to more than $100 a ton, depending on purity, brightness, particle size, and special product treatment. Shipping costs of ground limestone from Lucerne Valley to southern California markets ranged from $8 to $11 a ton in bulk carriers. Transportation costs of similar products by bulk carriers to Arizona are approximately $25. Approximately 50 to 75 percent of Pluess-Staufer's limestone products (350,000 to 400,000 short tons per year) are marketed in the greater Los Angeles area; the remainder is shipped as far east as Texas and as far north as Vancouver, BC.

Pfizer, Inc., was founded in 1849, and its operations and markets also extend world wide. Pfizer ships over 90 percent of its annual production (800,000 to 1,000,000 short tons) to California markets.

Excepting National Mineral Products in Monterey County, CA, a producer of white magnesium carbonate, the nearest major alternate source of carbonate fillers is Alabama.

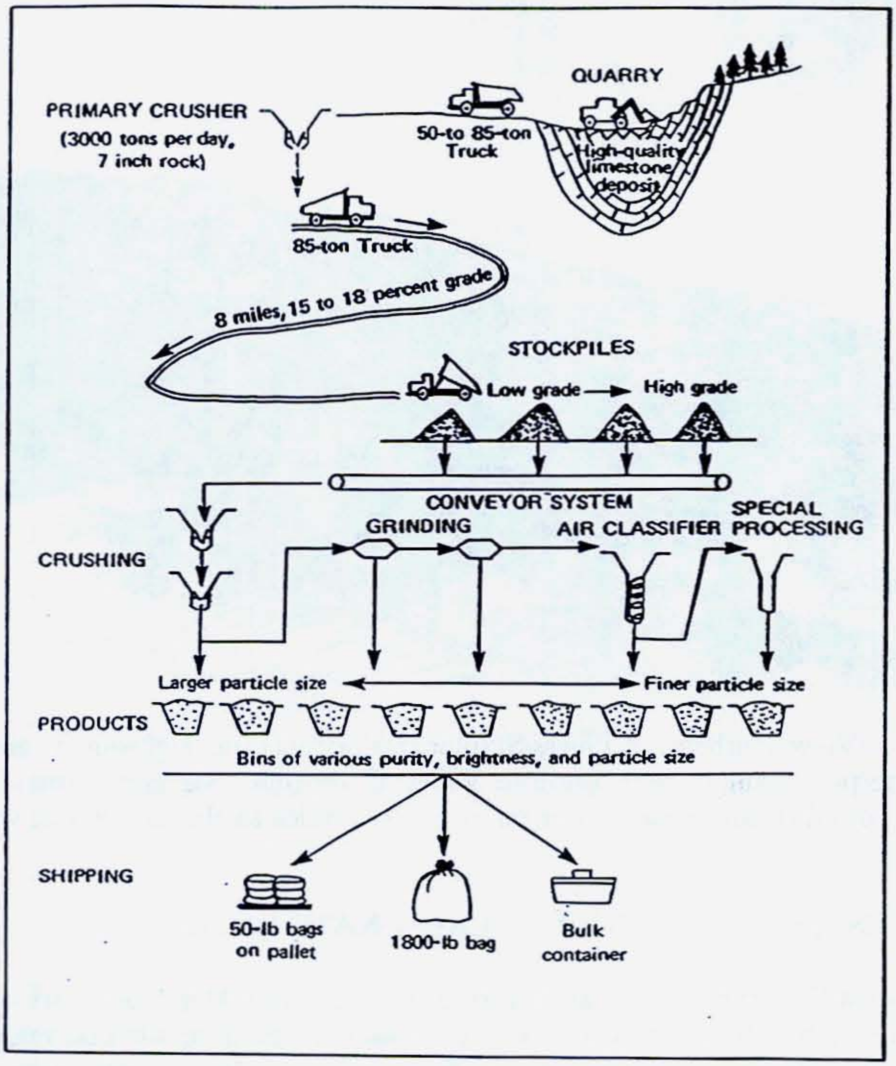


Figure 3.- Simplified flow diagram showing the sequence from quarry to end product for finely-ground limestone at the Pluess-Staufer (California) Inc. San Bernardino Mountain-Lucerne Valley operation

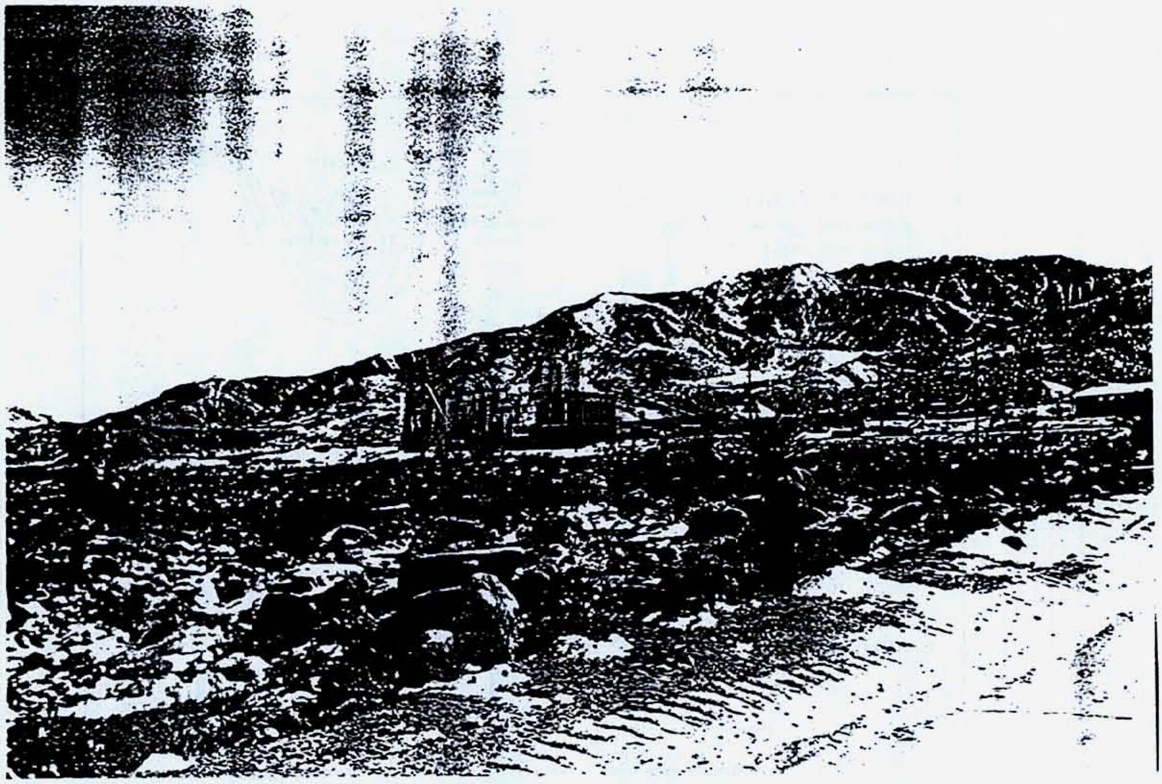


Figure 4.--View southeast of Pluess-Staufer (California) Inc. high-purity, high-brightness limestone processing plant in Lucerne Valley, California. San Bernardino Mountains are in background to south, and Pfizer plant lies two miles to the east out of view.

SOURCES AND CHARACTER OF CARBONATE ROCKS

Most limestones in the area were formed 250 to 600 million years ago from sediments originally deposited in ocean environments near continental margins, although limited amounts of sediments were also deposited in freshwater environments. Formation of high-purity, high-brightness limestones depends on two distinct processes: 1) deposition of sediments in a near-shore, usually high-energy, environment where ocean currents can winnow out most contaminants and 2) later "cooking and bleaching" of the limestone bed by deep burial or exposure to molten rock, which recrystallizes the limestone into marble and cleans out any remaining impurities. Uplift and exposure of the limestone is necessary to make the deposit economically minable.

To be considered economically viable, limestone must possess physical and chemical characteristics that meet strict specifications as demanded for each of the uses discussed above. The most important specifications are high purity, high brightness, and uniform particle size. Very small amounts of contaminants, such as organic matter, iron oxide, or silica, can drastically restrict the suitability of calcium carbonate for specialized uses. For example, a concentration of less than 1 percent iron oxide can add a pronounced orange tint to what would otherwise be a white limestone.

STATUS

Both Pluess-Staufer and Pfizer mine limestone from 250- to 380-million-year-old formations in the San Bernardino Mountains about 80 miles east of Los Angeles and 120 miles southwest of the New York Mountains. It is estimated that remaining reserves of high-quality limestone will last 20 years or more at current rates of production. Given the eight-fold increase of Pluess-Staufer production since it acquired the Lucerne Valley operation in 1976 (figure 5), additional resources of high-quality limestone must be found and developed within a relatively short time to avoid supply shortages or prohibitively high transportation costs.

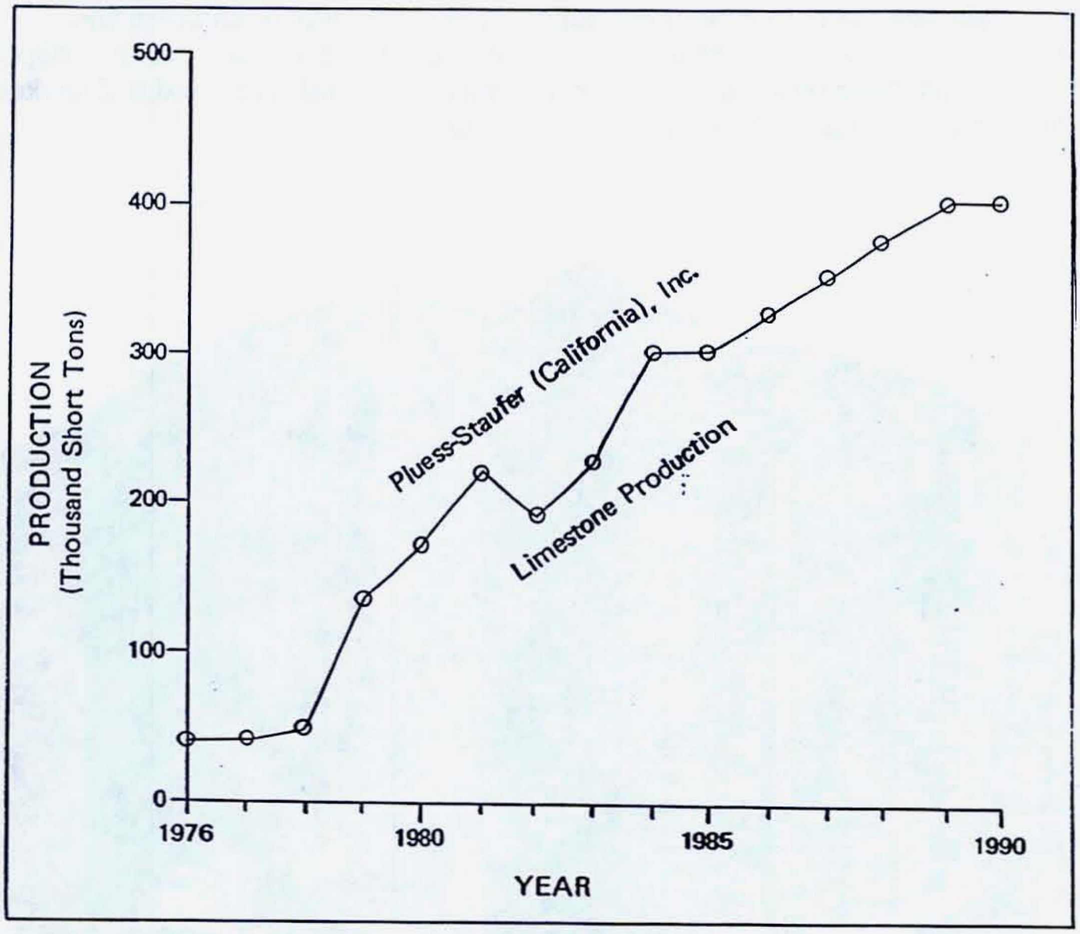


Figure 5.--Graph depicting high-purity, high-brightness limestone production at the Pluess-Staufer, CA operation - showing eight-fold increase from 1976 to 1990 (data interpolated).

Since the quality of these deposits is variable, however, the ability to meet the specifications of all 15 end products throughout the remaining mine life is doubtful. Ideally, as San Bernardino Mountain reserves are depleted, mining operations would gradually shift from existing quarry sites to comparable deposits in the New York Mountains. In all likelihood, however, the modern processing plant in Lucerne Valley would not be relocated until all reserves at existing quarries were depleted because it would not be cost effective to do so.

Pluess-Staufer acquired the original Snow White mining claims on 1981; these claims encompassed a portion of the New York Mountain deposits. Subsequent geologic mapping, shallow drilling, and rock chip and bulk sampling served to define nine distinct minable deposits over an 8-mile square area near the old Sagamore Mine (figures 1 and 6). Estimated sizes of the individual deposits range from about 3 million to more than 20 million short tons, for a cumulative resource of at least 100 million tons. Although quality of each deposit varies, approximately 67 million tons of high-purity limestone (98 percent or more calcium carbonate) with high-brightness characteristics may be economically recovered by careful development, selective mining, and blending. Substantial additional resources may be present at depth. The quality of these deposits is sufficient to continue production of the end products currently produced and marketed by Pluess-Staufer from its Lucerne Valley operation.

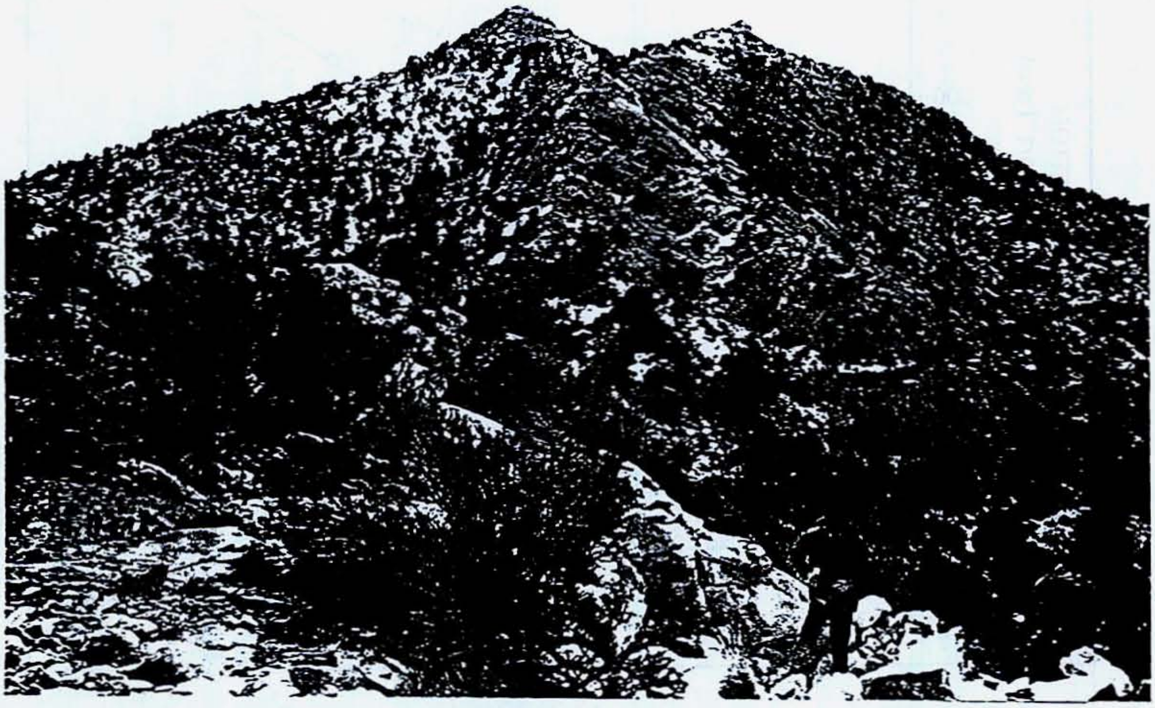


Figure 6.–View looking south at outcrops of high-purity, high-brightness limestone at the Keystone deposit in the New York Mountains, California.

Presently, Pluess-Staufer is undertaking elaborate phased reclamation of abandoned quarries and roads in the San Bernardino Mountains. Coincident with this, they are developing integrated mine and reclamation plans for resources in the New York Mountains.

IMPACTS

Because the New York Mountains are located in the East Mojave National Scenic Area, the California Desert Protection Act would make this area part of a 1.5-million-acre national park. Although a large part of the New York Mountains is designated and managed by the BLM as an Area of Critical Environmental Concern, the BLM has not recommended the area for wilderness, in part because of the high mineral potential.

Several negative socioeconomic impacts would occur if development of high-purity, high-brightness limestone resources in the New York Mountains were severely restricted or prohibited. The loss of 70 jobs caused by the eventual closing of mines and related operations in the Lucerne Valley area as a result of resource depletion in the San Bernardino Mountains would not be offset by new jobs and attendant support services associated with the opening of a new mine in the New York Mountains. The net loss of the payroll and income tax base would have a negative impact on local economies. Also of significance in the long term would be the loss of the largest undeveloped high-purity, high-brightness limestone deposit in the southwestern United States. If less suitable substitutes were used or if transportation costs soared because of an increase in haulage distance, the prices of fillers and extenders would increase significantly. A chain reaction of increased prices for PVC products, carpeting, dry wall joint cements, ceiling textures, putties, various rubber products, paints, and most of the other products in which finely-ground limestone is used as a functional filler or extender could result in increased building costs in the western United States.

CINDERS FOR A GROWING CITY

The phenomenal growth of Las Vegas, NV, has resulted in a sprawling desert metropolis. Its population of 768,228 (July 1989) is increasing by about 5,000 people a month. The minerals industry has played a major role in supporting this growth by supplying the raw materials necessary for construction. An important building material in this area is cinder block, a preformed concrete block in which cinders are substituted for sand and gravel aggregate. The substitution provides a lightweight block with improved thermal and acoustic insulating properties.

A principal source of cinders for the Las Vegas area is the Aiken cinder deposit in the Cima volcanic field (figure 1). Located about 20 miles east of Baker, CA, and about 70 miles southwest of Las Vegas, the deposit is well situated to supply cinders not only for block, but also for a variety of other uses, such as road and building construction, landscaping, and soil conditioning.

Cinder is formed during the eruption of viscous lava with enough gas trapped in it to solidify into rock fragments containing many cavities. The fragments commonly form cone-shaped hills that may reach several hundred feet in height. Physical properties, such as strength, low bulk density, inertness, moisture retention capabilities, thermal and acoustic insulating properties, and color variety, make cinders a versatile commodity. However, many deposits are unsuitable for commercial use because they have been too weathered or their structural characteristics are too poor. Because cinders are a relatively low-value commodity, inexpensive bulk mining techniques and short distances to markets are required for cinders to have commercial value.

Small-scale mining of cinders in the Cima volcanic field may have taken place as early as the late 1940's at the Cima Cinders deposit. In the mid-1950's, the deposits became vital to Aiken Builders Products, a concrete and cinder block plant operator in Las Vegas. Aiken's previous source of cinders had been Cind-R-Lite, a Las Vegas firm owning a cinder deposit about 95 miles north of the city. However, in 1953, Cind-R-Lite changed management and would no longer sell cinders to competitors. Aiken began buying most of its cinders from Cima Cinders, although it purchased smaller amounts from the Red Beauty claims (figure 2) located nearby. Throughout the 1950's, production from the two sources averaged an estimated 20,000 tons a year; over time, purchases from the Red Beauty gradually grew to equal the amount obtained from Cima Cinders.

In 1961, Aiken bought the three Red Beauty claims and the two adjoining Valco claims. These deposits have been operated almost continuously since that time, and from 1963 to 1977, they were the principal source of cinders for the Aiken Builders Products block plant. The block plant (figure 3) was sold in 1977 to WMK Builders Products,

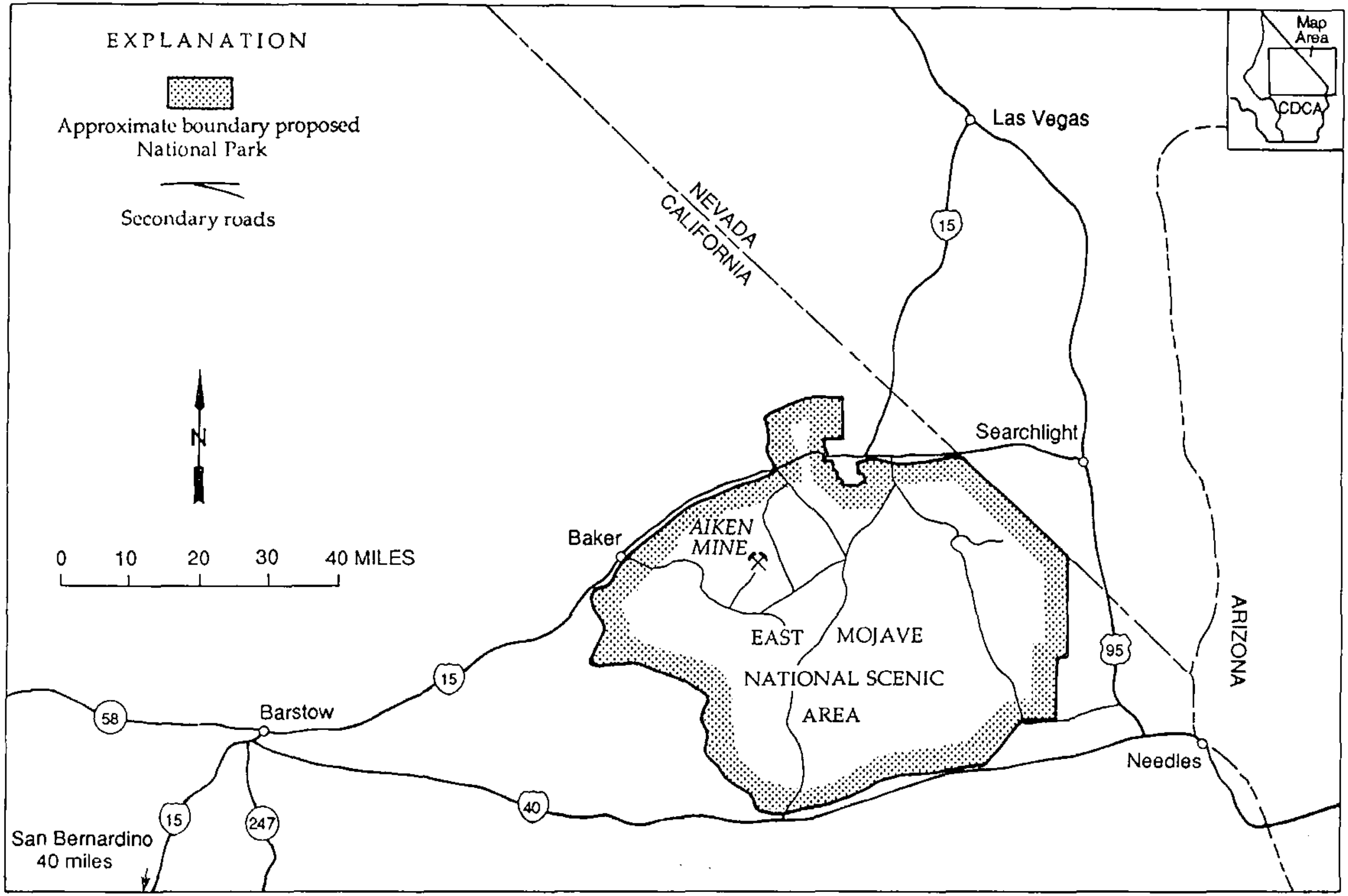


Figure 1.- Location of the Aiken Cinder Mine, San Bernardino County, California

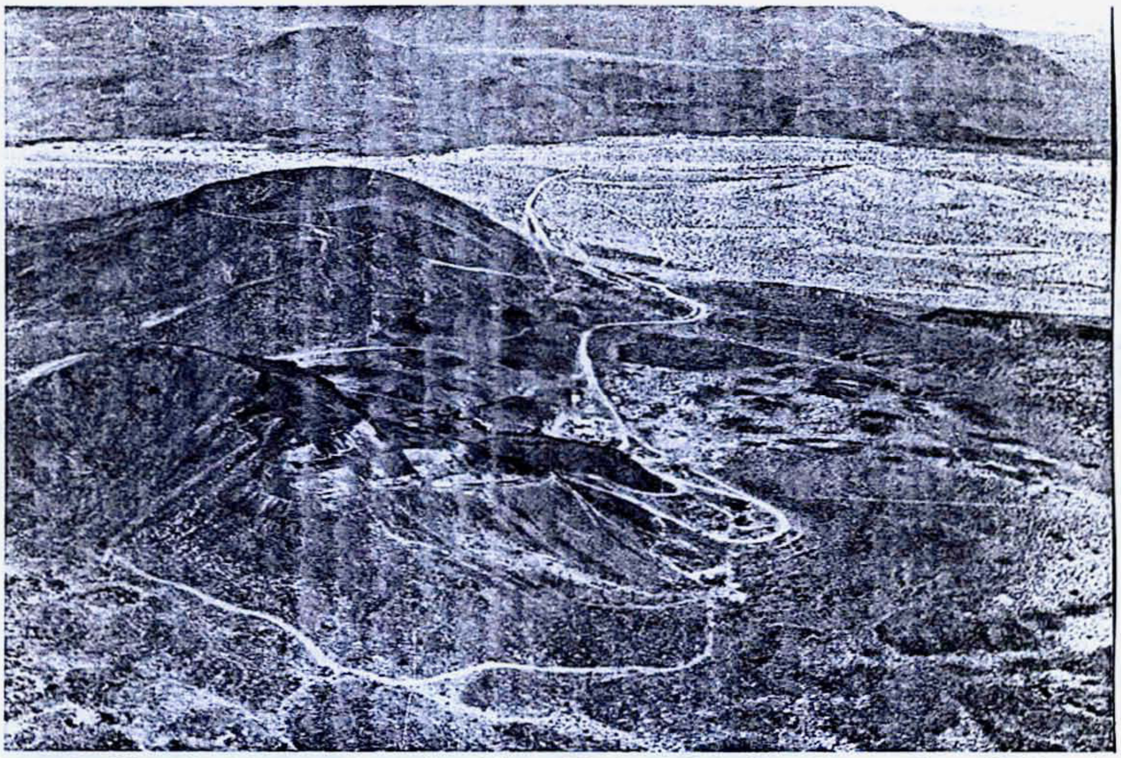


Figure 2.--View looking north at the Aiken Cinder Mine, San Bernardino, California.

Figure 3.--View of part of WMK Builders Products block plant in Henderson, Nevada.

which continues to use the Aiken Cinder Mine as its principal cinder source. The property currently consists of six mineral claims (Valco No. 3 was recently posted) and six mill sites.

Cinder production at the mine reflects the growth and construction needs of the Las Vegas area. Production was erratic through the 1960's and 1970's, with a low of 14,057 tons in 1967 and a high of 84,663 tons in 1978. In recent years, the plant has produced at an approximate rate of 80,000 to 100,000 tons a year and has supplied cinders for about 35 to 40 percent of the cinder blocks manufactured in Las Vegas (figure 4). The deposit is also a source of cinders for road surfaces, insulating material in the bottom of barbecues, roofing granules, soil and sewage treatment, filters, and athletic tracks. Cinder has also been proposed as an aggregate for transit mix, a concrete mixed while en route to the site where it is to be used.

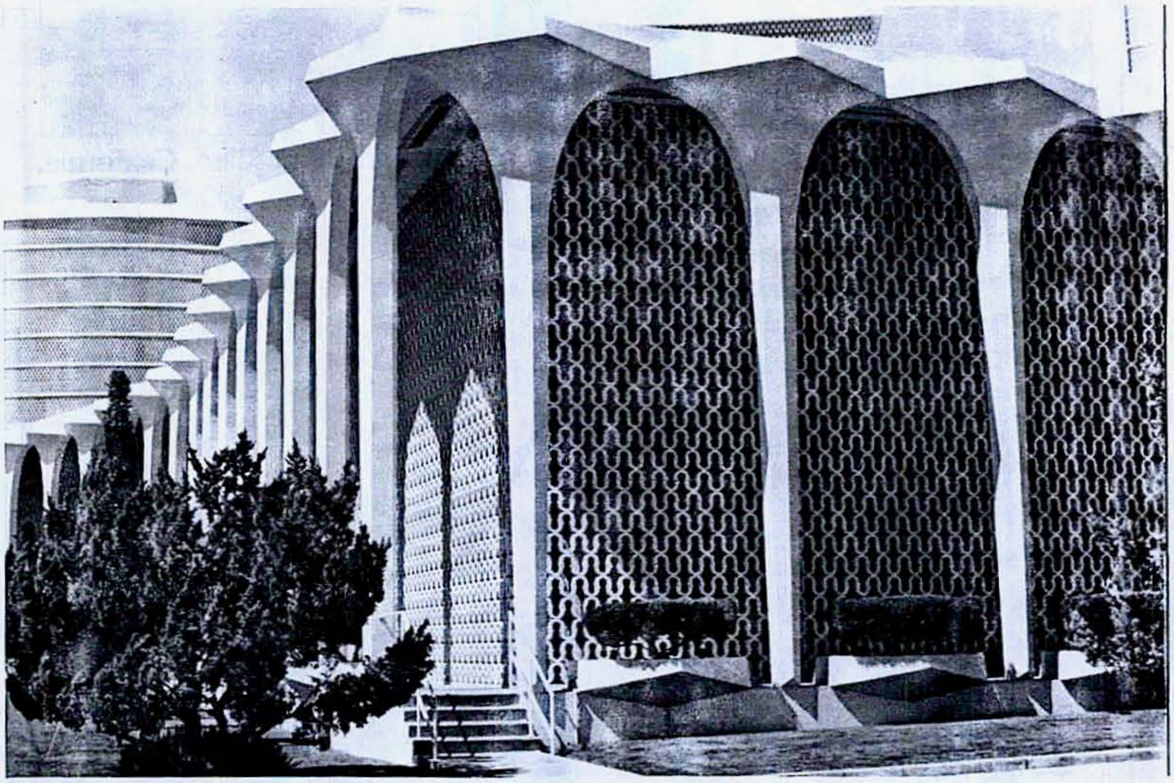


Figure 4.--Cinder block and screen block were used to build Caesars Palace Casino in Las Vegas, Nevada.

Cinders are currently mined and processed (figure 5) at a pit on the Red Beauty claims. Both red and black cinders are found in different parts of the cinder cone and are generally selectively mined. A large dozer gouges the cinders from the working face and a front-end loader moves them to a screening and sorting plant; no blasting is required. The plant sorts the material with a series of vibrating screens into sizes ranging from less than 1/4 inch to larger than 8 inches.

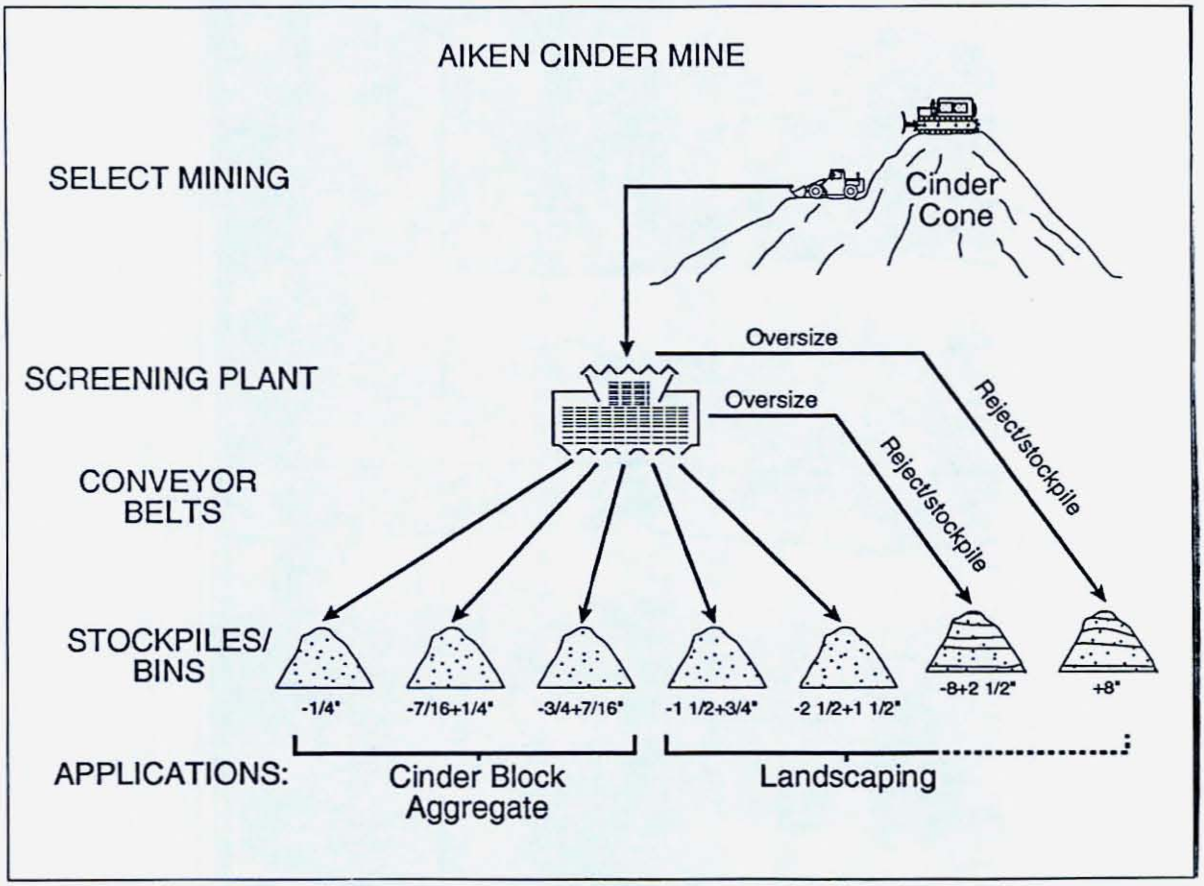


Figure 5.--Simplified flow diagram showing the sequence from quarry to end product for cinders from the Aiken Cinder Mine.

The screening plant typically operates 6 days a week, 8 hours a day. About half the production is the minus 1/4-inch fraction used as lightweight aggregate in cinder block. The 1/4- to 7/16- and 7/16- to 3/4-inch fractions are used in split-faced block, where the cinders give an attractive color and texture on exposed surfaces (figure 6). The 3/4- to 1-1/2- and 1-1/2- to 2-1/2-inch fractions are commonly employed for landscaping. Material larger than 3 inches is used only for landscaping. Conveyor belts transport the sized material to 100-ton capacity bins where it is stored.

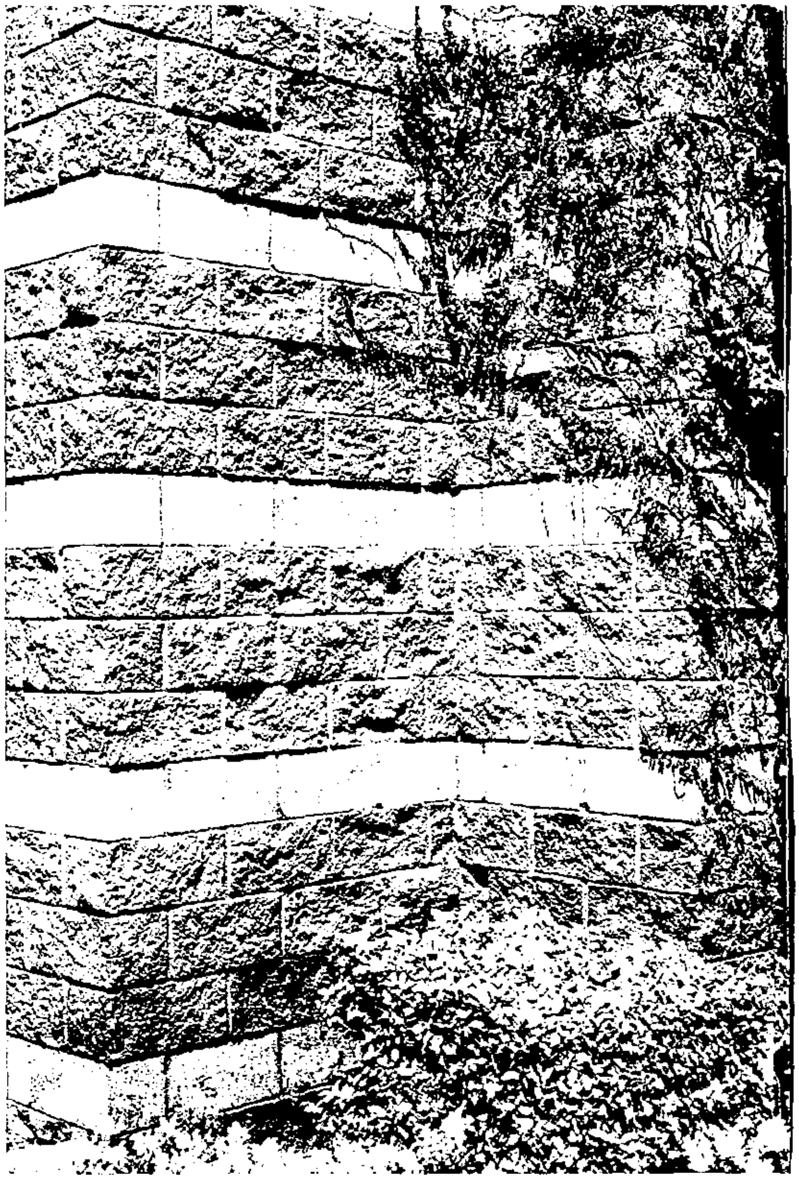


Figure 6.--Photo showing the contrast between split-face cinder block and smooth block on a business building in Las Vegas.

The mine and screening plant employs three to four people and while it can produce a maximum of about 900 tons of cinders a day, recent production has averaged only 250 to 300 tons a day.

Because of on-going litigation with the BLM concerning the validity of the mining claims, and more recently, the additional threat of closure because of the proposed creation of the East Mojave National Park, Aiken has found it prudent to scale down capital investments at the cinder mine. The results have been increased downtime as the equipment ages and the danger that WMK Builders Products will start looking elsewhere for a source of cinders for their growing needs. Because new sources are likely to be farther from the block plant, the increased costs of transportation will probably result in more expensive cinder blocks in the Las Vegas area.

ECONOMIC MODEL

Closure of the cinder mine would not only deprive Las Vegas of an important source of building material, but would also have a negative impact on the economy and tax base of the east Mojave Desert area. To estimate the impact, a hypothetical 20-year model of the operation was prepared. The model included the necessary capital reinvestment and was based on a reserve of 8,000,000 tons of marketable cinders mined at a rate of 320 tons a day, one shift a day, 312 days a year. The material was fed to a grizzly (a metal grate), at which point material larger than 8 inches was removed and stockpiled. Undersized material was screened at 3 inches and oversized material went to a roll crusher to be combined with the minus 3-inch fraction. Further screening resulted in production of 200 tons a day of minus 1/4-inch cinder for use in cinder block and 54 tons a day of various sizes of landscape rock.

Operating costs during the 20-year period were estimated to be about $308,000 a year. Because the model was based on a facility that had been in operation for many years, existing equipment was assumed to be fully capitalized. Capital reinvestment costs were estimated by assuming replacement of mobile equipment over a 10-year period and mill processing equipment over a 20-year period. Accordingly, capital reinvestment averaged $106,000 a year. Based on price levels required for a 15 percent rate of return on the investment, the model operation would pay $89,880 in state corporate income tax and $330,120 in federal income tax over the next 20 years. Property taxes would total about $100,000 during the same period.

In addition to the obvious loss of over $400,000 in tax revenues if operations were discontinued, another regional impact would be higher costs of cinders and cinder-based products in the Las Vegas area if cinders had to be transported from a source more distant than the Cima volcanic field. If WMK Builders Products were unable to find a suitable alternative source of cinder, a cinder block shortage of 35 to 40 percent would ultimately result in more expensive blocks in the Las Vegas area.

The closure of this operation would result in lost jobs at the mine and possibly layoffs at the block plant if cinder block were no longer part of WMK Builders' product line.

COLOSSEUM MINE
ANOTHER NEW DISCOVERY

The history of the California desert is inextricably bound to mining. From prehistoric turquoise mines that were worked with stone implements to present day open pits mined with front-end loaders, the region has yielded raw materials that reflected the state of man's changing technologies. It was early recognized that this mineral wealth was not uniformly scattered throughout the region. Instead, mineral discoveries tended to be clustered in areas favorable for mineral deposition. Many of these areas, known as mining districts, are now recognized in the California desert. Most are not characterized by a single mineral discovery. The districts have evolved erratically through a series of developments spurred by new mining or milling methods, recognition of new types of deposits, improved transportation to mills or other markets, changes in economic conditions, or new discoveries. Many mining districts have lain inactive for years waiting for the right set of circumstances to bring them back to life.

This is the story of the Colosseum gold mine, the most recent incarnation of mining in the Clark mining district (figure 1). The Colosseum Mine was the result of one of the first discoveries in the district in 1865. However, the discovery was initially overshadowed by silver mining at the nearby Allie, Beatrice, Lizzie Bullock, Monitor, and Stonewall Mines. The lack of a nearby railroad plagued all early development efforts in the district. Before 1892, supplies were transported by wagon from Mojave and San Bernardino, 170 miles southwest of the district. Completion of a rail spur from Goffs to Vanderbilt in 1892 provided easier access to supplies and a means of shipping concentrates from the mill. Unfortunately, silver mining had been waning in the district since the 1880's when several of the principal mines closed due to depletion of high-grade ore. Declining silver prices in the early 1890's ended the first episode of mining in the district.

A resurgence of interest in the district came with the completion of the Union Pacific Railroad from Salt Lake City to Barstow, CA in 1905. Although it was the discovery of gold at Tonopah, NV that again attracted prospectors to the area, the discovery of copper, lead, and zinc in the Clark district resulted in sporadic mining, especially during World War I.

The Colosseum Mine had no recorded production until 1929. However, examination of the property in that year showed a 560-ft adit, several hundred feet of drifts, and a 200-ft shaft had already been developed on the property, suggesting earlier production. The onset of the Great Depression as well as the 1934 increase in the price of gold to $35 per ounce provided the impetus that resulted in activity at the Colosseum Mine. From 1929 until 1939 the mine produced about 600 ounces of gold from 3,016 tons of ore. All production came from underground workings. Exploration continued though 1940 and 1941, but mining activity at the Colosseum was brought to a close in 1942 when the War Production Board stopped all non-strategic metal mining.

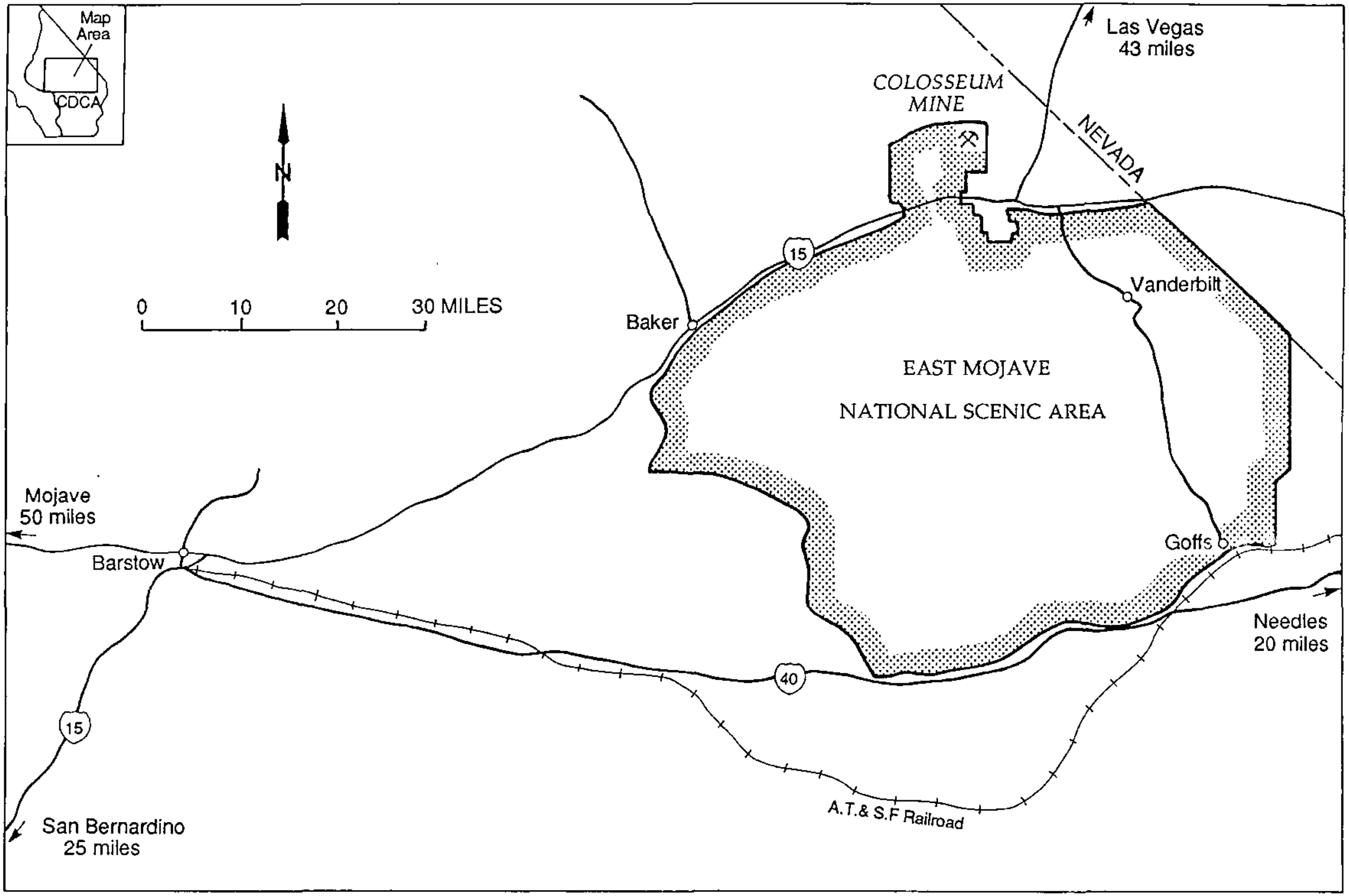


Figure 1.- Location of the Colosseum gold mine, San Bernardino County, California

After a long hiatus that included only minor exploration activities, interest in the district was rejuvenated on New Year's Day, 1970. Two exploration geologists while looking for molybdenum in the Colosseum Mine area found gold instead. The discovery was significant because it suggested that gold occurs not only in major fracture systems, but also in minor fractures and disseminations that include large volumes of rock. Subsequent drilling spanning several years revealed a major low-grade gold deposit and sparked renewed attempts to explain the distribution of metals in the vicinity of the Colosseum Mine.

The mineralizing episode at the Colosseum Mine began about 100 million years ago. A branching but roughly pipe-shaped body of molten rock was emplaced in Precambrian rock and overlying quartzite, shale, and carbonate rocks. Large volumes of heated water carrying dissolved metals circulated through surrounding rocks. As the pipe-shaped mass of rock slowly cooled, ore minerals began to crystallize from the circulating water in a zonal pattern. In the confines of the pipe, and to a more limited degree in the surrounding rock, pyrite (iron sulfide) was deposited with gold. This gold-pyrite combination was most abundant along fractures, but gold-bearing solutions also permeated unbroken rock and produced large volumes of low-grade ore. Higher in the system, where the solutions flowed into fractures in the carbonate rocks, silver minerals formed high-grade veins and replacement deposits.

After the mineralizing episode was complete, the picture was further complicated by faulting. Not everbody agrees on the sequence of events required to explain the present distribution of metals in the mine area. A geologist who discovered the deposit speculates that the top of the mineralized zone was cut by a nearly horizontal fault. The upper section slid about 2000 feet west carrying much of the silver ore with it. The silver-rich zone was then faulted downward relative to the gold-rich zone until both zones were at approximately the same elevation. Erosion has subsequently removed overlying rock to expose the mineral deposits. Whatever the cause, the result is two distinct mineralized zones. To the west, silver mineralization in veins and replacement bodies occurs in carbonate rock. To the east, gold occurs in veins cutting shale, and as veins and disseminations in the breccia pipe and surrounding Precambrian crystalline rock.

The old-timers probably realized that all of the gold was not confined to the veins that they were able to mine, but the economic and technologic prerequisites to mine the low-grade ore at the Colosseum were not yet in place in the 1930's. However, in 1968 the price of gold, which had been held at $35 per ounce since 1934, was allowed to rise to its free market value. While exploration continued at the Colosseum Mine, the price of gold rose from a yearly average of $36.41 per ounce in 1970 to $612.56 per ounce in 1980. In addition to spurring gold exploration in the U.S., the sudden rise in the price of gold also stimulated research into improved ways of extracting gold from low-grade ores. Improved methods of recovering gold from dilute cyanide leach solutions provided the technological breakthrough that permitted the boom in U.S. gold production that continues into the 1990's.

By 1982, the gold rush was in full swing in many areas of the western USA. At the Colosseum Mine, 53 holes had been drilled, and the decision was made to develop a plan of operations for an open-pit mine (figures 2 and 3). Choosing from several innovations in the art of recovering gold from low-grade ores, it was decided that a carbon-in-pulp mill would be well suited for the ore.

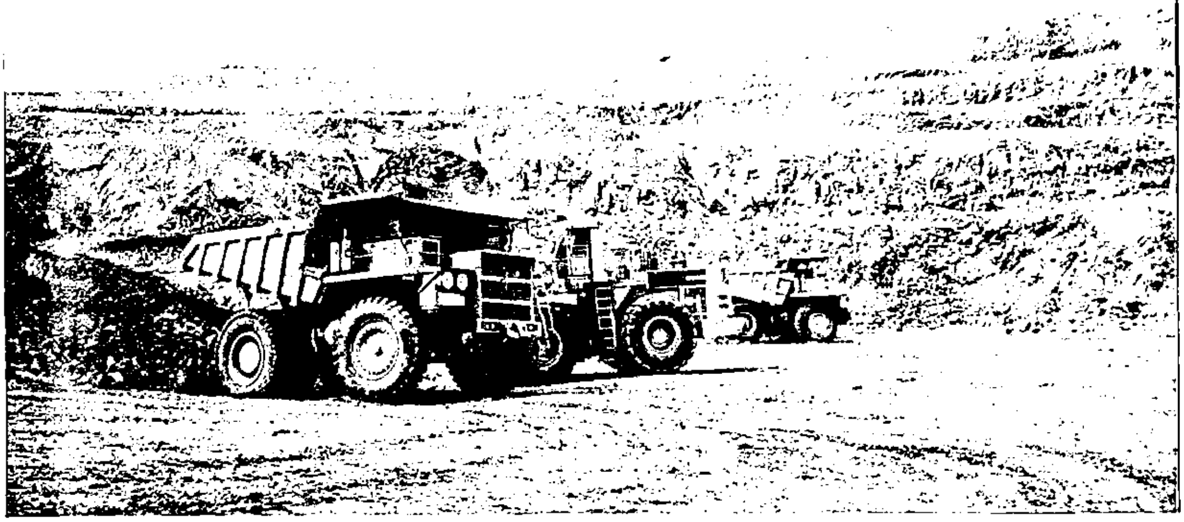


Figure 2.--Modern open-pit mining methods at the Colosseum Mine.

The process begins with the ore being crushed and ground to about 200 mesh (about .030 in). This "pulp" is then leached with a dilute cyanide solution and transferred to a tank containing carbon. The gold, now in solution combined with the cyanide, is adsorbed onto the surface of the carbon. When the carbon is sufficiently loaded with gold, it is separated from the pulp by screening. The carbon is eventually stripped of the gold under pressure with a hot caustic cyanide solution. Gold is recovered from the hot solution in a two-step electrowinning process. First, the gold is plated onto steel wool in an electrolytic cell. Then, the gold from the steel wool is plated onto stainless steel cathodes. A gold foil is recovered from the cathodes and melted in a furnace with fluxing agents that aid in melting and scavenging contaminating metals from the molten gold. A slag containing the metal contaminants is skimmed off, and the gold is poured as bullion. Silver is also recovered in the process.

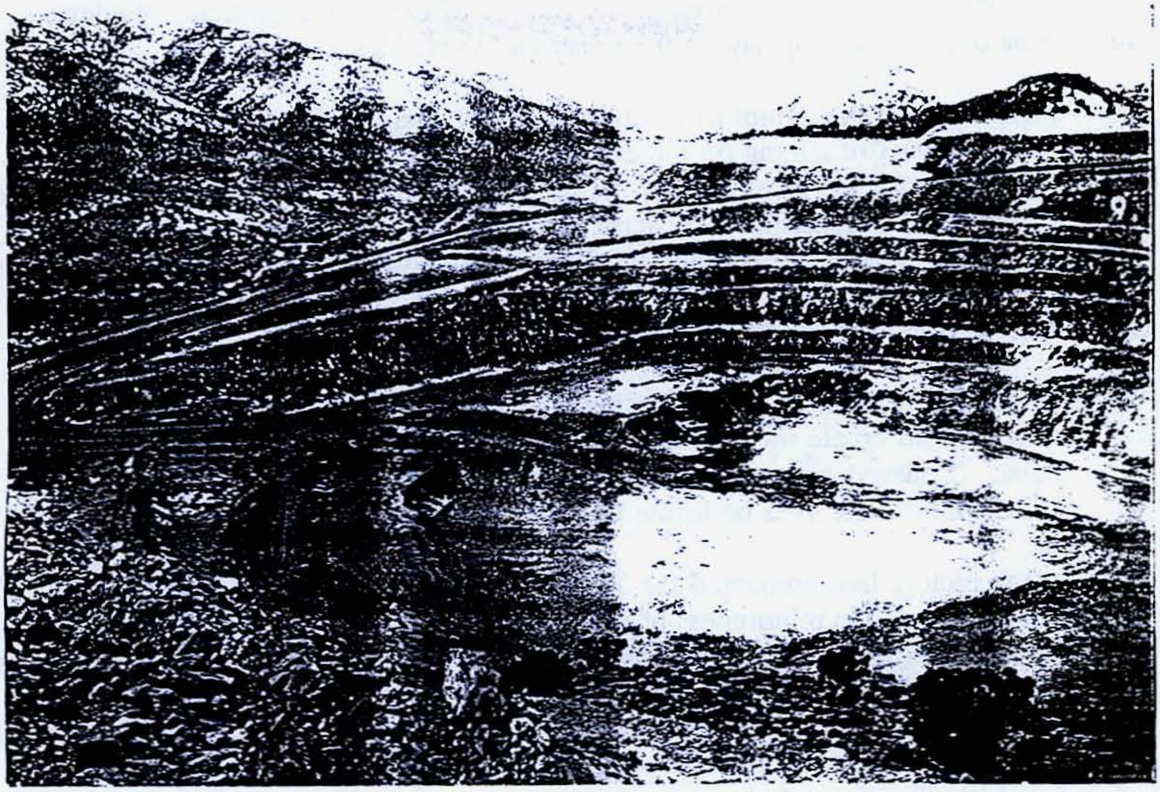


Figure 3.--Panoramic view of the open-pit Colosseum Mine.

The mill came on line in January 1988, and today is producing at a rate of 70,000 ounces of gold and 30,000 ounces of silver per year - all of the gold recovered from 1929 to 1939 could be produced in less than four days at the new facility.

Operation of a mine of this magnitude has a considerable impact on the regional economy. The mine and mill employ approximately 125 people. The operation is owned by a multinational mining company that pays about $756,000 per year in sales, use, and property taxes that support schools and other social benefits in the region. Annual payroll at the facility is about $2,100,000. A significant portion of this money is used to purchase homes, automobiles, and other items that provide an influx of capital to spur the growth of other sectors of the regional economy. These benefits will continue for the life of the mine, until about 1994 at current mining rates.

As production continues it is anticipated that exploration activities will reveal additional resources that could be mined with the existing facilities. However, environmental and legislative factors will likely influence future mining efforts at this site.

The mine property is within the boundaries of the East Mojave National Scenic Area which is a special management area of the Bureau of Land Management. Wilderness study areas border the property on the north and west sides.

Mine management employs a full-time environmental specialist and works to minimize the impact of mining on the environment. These efforts have included: providing funding for a Bureau of Land Management study on the population density of the desert tortoise; purchasing thirty acres for desert tortoise habitat; constructing guzzlers to provide water for wildlife; monitoring groundwater; and conducting baseline tissue studies to determine lead levels in birds and small animals. Yet an Environmentalist/Safety Coordinator for the mining company stated,

> "The biggest threat to our operation is [Senator] Cranston's Wilderness Bill which would create the Mojave National Park from the East Mojave Scenic Area. If passed, we would be unable to expand our operation should additional ore reserves be located."

Many factors have impacted the 125-year development of the Colosseum mine. In the early days it was the remoteness of the area. Then, falling metal prices, war production restrictions, and inadequate ore processing technologies inhibited production. Some of these conditions may have been predictable, others were not. At times in the past it would have been easy to write off the Colosseum Mine as uneconomic. Only after many years of exploration is the nature and extent of the gold mineralization at the Colosseum Mine beginning to be recognized.

Today, environmental issues have the potential to adversely impact mining at the Colosseum Mine as well as many other mines and mineralized areas in the California desert. Recently proposed legislation - known as the "California Desert Protection Act" - could prevent continued mining at the Colosseum Mine and would preclude further exploration in many historic mining districts. We will be required to make hard choices concerning land use in order to integrate a sound environmental policy into a viable mineral resource policy. The history of the Colosseum Mine shows that a mine, like a cat, can have several lives; it will never be enough to proclaim a mine or a district to be "worked out" because there has been no recent mineral production. One thing is predictable, conditions will change - mineral properties that today are assessed as uneconomic may be tomorrow's producing mines.

GYPSUM - IN NEARLY EVERY AMERICAN HOME

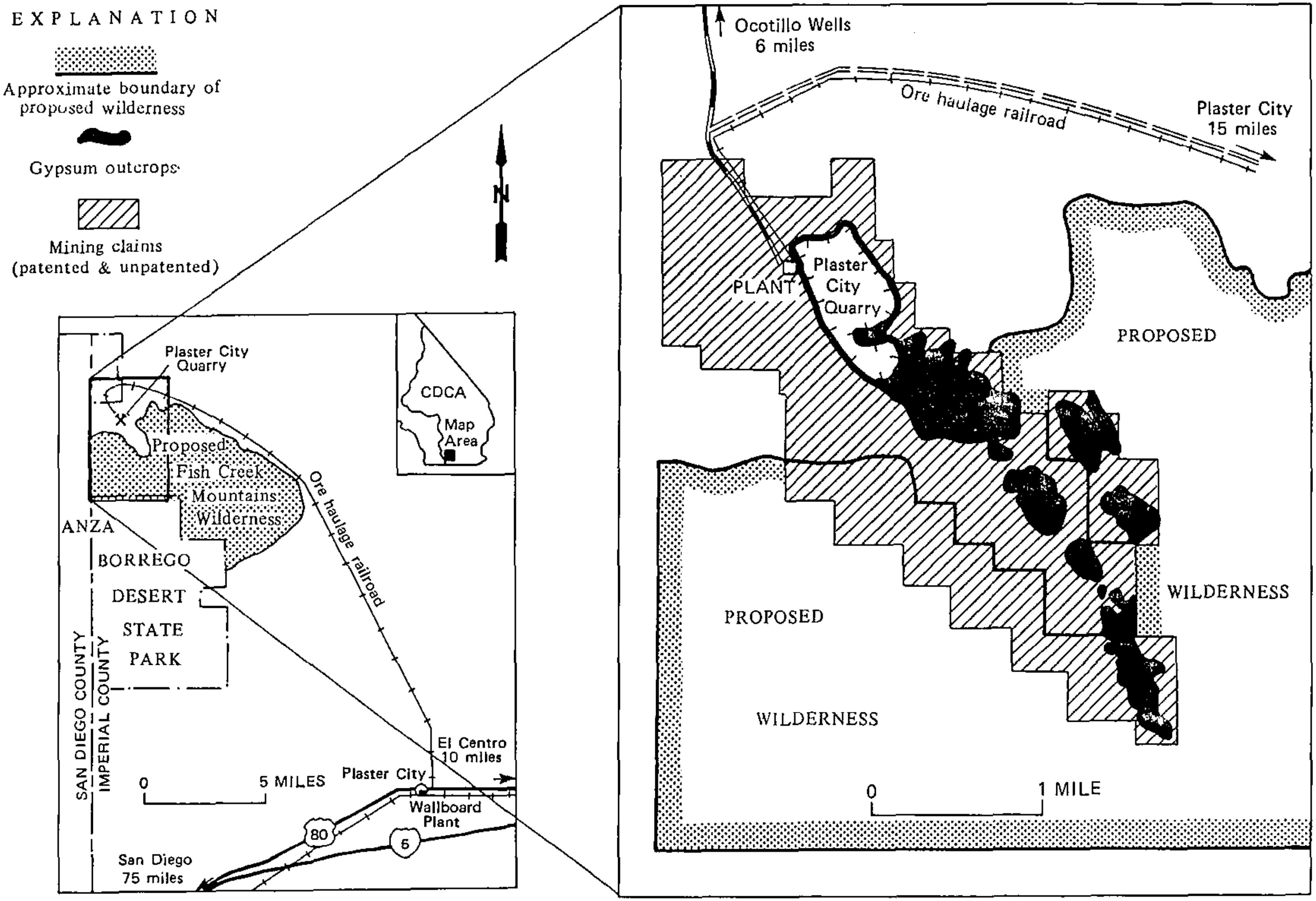
Gypsum is found in extensive bedded deposits in many parts of the world. Mined for various purposes since earliest recorded time, it is now processed into an assortment of building and industrial plasters and gypsum wallboards. Gypsum products are found in nearly every American home. The largest gypsum mine in the United States is the Plaster City Quarry in Imperial County, California, in the southwestern corner of the California Desert Conservation Area (CDCA) (figure 1). Extensive reserves remaining at the Plaster City deposit may be impacted by bills currently pending before the Congress. Under legislation known as the "California Desert Protection Act", a portion of the desert, with its vast gypsum resources, would be designated as wilderness. Loss of these valuable resources will have long term consequences in the western United States markets served by this deposit.

GYPSUM - UNIQUE PROPERTIES FOR COMMON USES

Gypsum is composed of hydrated calcium sulfate, a compound of calcium and sulfate with two attached water molecules (CaSO4.2H2O). Commonly occurring in the same deposits with gypsum are salts, shales, clays, and anhydrite. Gypsum and anhydrite (calcium sulfate without water molecules) are termed evaporites, having accumulated in basins or salt flats under very dry conditions when evaporation exceeds the inflow of fresh water. Other forms of gypsum include selenite, a crystalline variety, satin spar, a fibrous variety, and alabaster, a fine-grained variety which has long been used in the sculpture of art objects.

Gypsum's unique characteristics and its many industrial applications are primarily due to its reaction to the removal or addition of water. When finely-ground gypsum is heated, or "calcined" as it is called in the industry, three-quarters of the water molecules are driven off, converting it to a substance commonly known as "plaster of paris." When mixed with an appropriate amount of water, plaster of paris will recrystallize (harden) into gypsum as water is regained and heat is released.

About 75 percent of the gypsum used in the U.S. is calcined for "stucco" applications which include a variety of plasters and prefabricated wallboards. With its fire- and sound-proofing qualities and low cost, gypsum wallboard is one of the most popular building materials in the U.S.; it is now used in nearly every new American home. Uncalcined gypsum is added to cement to retard setting time, applied to neutralize alkaline and saline soils, and used as a filler in glassmaking, papermaking, and pharmaceuticals. Production and major uses of gypsum are illustrated in the accompanying graph (figure 2).



Map modified from Bureau of Land Management Mineral Report CA 20161 and Bureau of Mines MLA OFR 23-86

Figure 1.- Location of high-quality gypsum deposits at the Plaster City Quarry in the Fish Creek Mountains, Imperial County, California

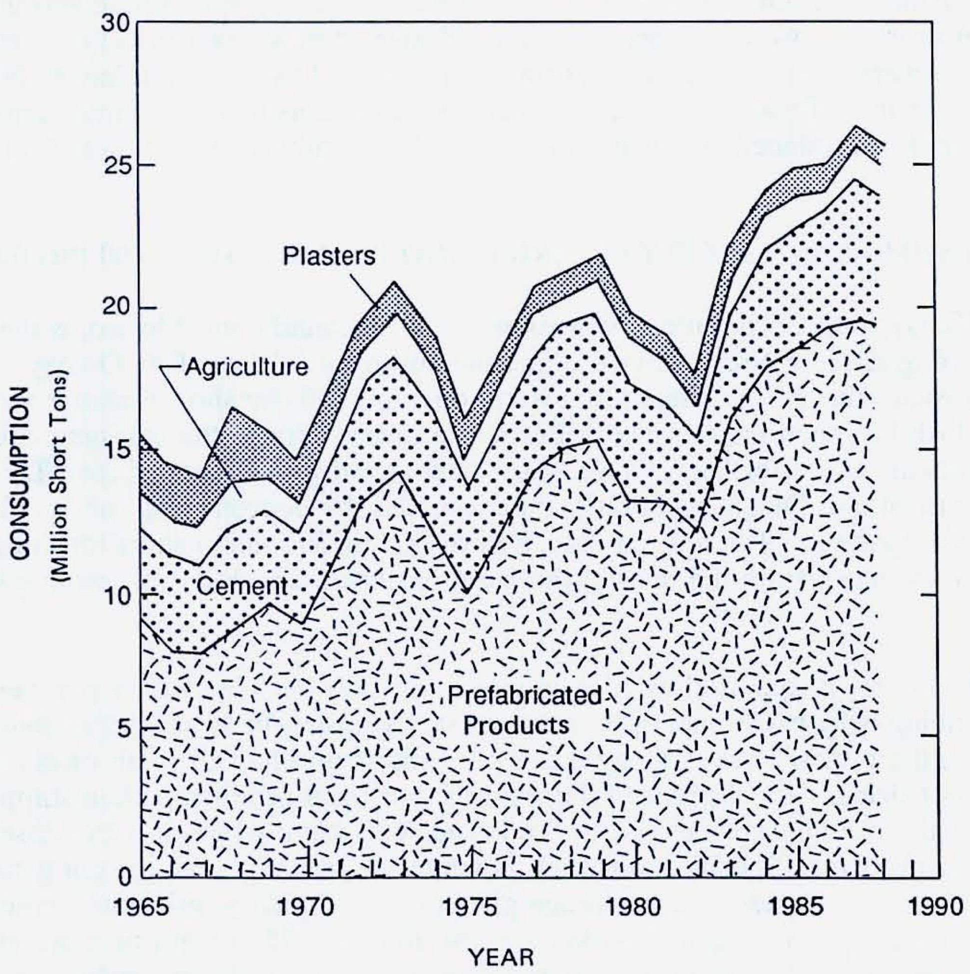


Figure 2: Sales of gypsum products in the U.S., by use (modified from Bureau of Mines Minerals Yearbook, 1987).

PRODUCTION VS CONSUMPTION - 30 PERCENT IMPORT RELIANCE

A review of U.S. production statistics reveals the enormous contribution made by gypsum to the building industry. Nation-wide, crude gypsum is mined by 36 companies from 65 mines in 21 states, predominantly in the western U.S., and gypsum is calcined at 71 plants in 28 states. U.S. consumption was nearly 27 million short tons (54 billion pounds) of gypsum in 1990, while production was only about 18 million short tons (67 percent) domestically. U.S. import reliance generally is about 30 percent; 93 percent of imported gypsum came from Canada and Mexico in 1990. Canadian imports are used to augment supplies in the eastern United States because there are no economically minable deposits of gypsum on the eastern seaboard.

As a whole, the gypsum industry is closely tied to new housing starts and remodeling markets. Of the total supply of domestic and imported crude gypsum, over 21 million short tons were calcined for use as plaster or in wallboard. The remaining 5.6 million tons were utilized as cement setting retardant and as soil conditioner. Nearly 22 billion square feet of wallboard were shipped by U.S. plants in 1990. Small amounts of gypsum are also produced as a byproduct of residues scrubbed from powerplant stack gases.

U.S. GYPSUM PLASTER CITY QUARRY AND PLANT - OVER 400 PRODUCTS

U.S. Gypsum Corporation, with subsidiaries in Canada and Mexico, is the largest producer of gypsum in North America, and the company's Plaster City Quarry is the largest gypsum mine in the United States, producing 1,000,000 short tons per year. The quarry, which has been mined since 1922, lies 26 miles north of the calcining and wallboard plant at Plaster City (figure 1) in the southwestern corner of the CDCA about 90 miles east of San Diego. U.S. Gypsum purchased the deposit from the Pacific Portland Company in 1945, and, to date, approximately 30 million short tons of gypsum have been produced from the quarry; the plant has been expanded several times since 1945.

The quarry is operated by 25 employees one shift per day, 7 days per week year round. Mining is by traditional open-pit methods. Gypsum beds are drilled and blasted, after which the broken rock is then loaded onto trucks and hauled to an on-site plant for crushing and sizing. "Land plaster," the crushed and sized product, is then shipped by trains over the ore-haulage railroad to the Plaster City plant where it is processed into various end-products. Specifications such as whiteness, salinity, and percent gypsum are used to determine processing and storage procedures. Typically, minimum mine grades required to meet processing and market specifications are 75 percent or more gypsum with a reflectance of 72 percent (compared to a standard). Calcining specifications require that land plaster contain at least 90 percent gypsum and have low salinity.

Approximately 275 people are employed at the processing and wallboard plant, which operates 24 hours per day year round. Land plaster is fed into one of the five milling-calcining lines in operation at the plant; each one of these five lines is dedicated to a selected end-product. A small percentage is diverted for non-calcined applications. The material is first pulverized and then fed into calcining kettles maintained at temperatures ranging from 200°F to 390°F, where it is converted to "stucco." The stucco product is packaged for plaster and casting applications or fed into one of two continuously-running lines for manufacturing wallboard.

Over 400 different end-products ranging from a variety of plasters to wallboards with various sizes, thickness, and qualities are manufactured at the Plaster City plant. Approximately 90 percent of the products are shipped by customer trucks and common carriers throughout the western United States..

Gypsum prices depend on the type of processing and end-product specifications. Average value-per-ton for gypsum in 1989, the most recent year of published Bureau of Mines data, was $7.29 for crude and $15.96 for calcined gypsum. Uncalcined gypsum products were valued at $13.44 per ton, whereas prefabricated products such as wallboard were valued at $85.96 per ton and plasters at $128.29 per ton.

RESERVES - THE ISSUE

Hidden in a secluded valley in the Fish Creek Mountains and visible only from nearby peaks, the Plaster City gypsum deposits contain approximately 25 years of surface-minable reserves in nearly flat-lying beds which are exposed at the surface (figure 1). To the west, the same gypsum beds are covered by alluvium. An additional 25 years or more of reserves are available if underground methods are utilized to mine these buried deposits. Gypsum reserves thought to be economically minable by room and pillar methods, traditionally used for buried, flat-lying, tabular deposits, are outlined by the area of mining claims shown in figure 1.

The Plaster City deposits are along the western boundary of and partially enclosed by the Fish Creek Mountain Wilderness Study Area, part of which is recommended for wilderness by the Bureau of Land Management (BLM). BLM geologists have examined the gypsum deposits enclosed in this area and are in the process of recommending issuance of patents on these lands to U.S. Gypsum for future mining, as well as recommending parts of the area for wilderness. In addition, BLM recognized the buried gypsum reserves west of the mine and did not recommended that part for wilderness.

The fate of the buried deposits still remains in doubt, however. The "California Desert Protection Act" would place much of the remaining reserves into wilderness status even though the land is in a secluded area already impacted by mining. Pending legislation known as the "California Public Lands Wilderness Act", which reflects the BLM recommendations, would have minimal effect on the these areas, effecting only the eastern perimeter of the deposits.

Although the effects of denying access to the deposits would not be felt for 20 years or more, the eventual impact would be more expensive or lower quality building materials in the western United States. Deposits in other states or Mexico or Canada would be exploited to replace the existing high-purity gypsum source. As with other transportation-sensitive industrial commodities, end-product prices, and consequently, the cost of building, would eventually experience significant increases in markets served by the Plaster City operation. The loss or displacement of 300 jobs and the forfeiture of tax revenues to Imperial County would also have a significant impact on the local economy.

MOUNTAIN PASS AND MUSIC VALLEY
RARE DEPOSITS IN THE CALIFORNIA DESERT

> "Perhaps of all the industrial minerals currently exploited, the rare earths appear to be the ones that are most readily associated with the world of 'hi-tech'. . . . But new generations of end-uses have not captured all the excitement of this industry. At the other end of the production line, that of supply, market growth has generated exploration and evaluation of potential new sources of rare earths."
>
> O'Driscoll, Nov. 1988
> Industrial Minerals

A world-class deposit of rare-earth minerals at Molycorp's Mountain Pass mine, located on the edge of the East Mojave National Scenic Area (EMNSA), lies on an 80-mile-long trend of rocks favorable for rare earths (figure 1). Potentially valuable deposits of rare-earth minerals also occur in Music Valley on the northern edge of Joshua Tree National Monument (JTNM) in the California Desert Conservation Area (CDCA) (figure 2). Rare earths are used in many high-technology applications including high-strength permanent magnets, optical fibers, laser crystals, and high-temperature superconductors. The fate of rare-earth deposits in the CDCA may be contained in bills currently pending before the Congress. Significant portions of the Mountain Pass rare-earth trend and the Music Valley deposits are in areas proposed for National Park status by pending legislation known as the "California Desert Protection Act." Future exploration for and development of these resources, potentially significant to the Nation, will be severely restricted or denied if such legislation is enacted.

RARE EARTHS - WHAT ARE THEY?

Rare earths comprise a group of 15 metallic elements called lanthanides, plus the element yttrium. Thorium and scandium also commonly occur with the rare earths because their chemical behavior is similar. Although these elements are not especially rare in the earth's crust, minable concentrations of them are scarce. Based on atomic weight and chemical association, rare-earth elements are divided into light (cerium) and heavy (yttrium) groups. Table 1 lists the rare earths by group and shows the chemical symbol and atomic number.

These elements are referred to as rare-earth oxides (REO) when they are combined with oxygen. REO's combine with other elements to form rare-earth minerals, the most common of which are bastnaesite, a fluorocarbonate, and monazite and xenotime, both phosphates. Bastnaesite is the principal rare-earth mineral at the Mountain Pass mine whereas monazite and xenotime are the chief rare-earth minerals in Music Valley (figures 1 and 2).

Table 1.--Rare-earth elements.

ATOMIC NO.	ELEMENT	SYMBOL
	Light -- Cerium Group	
57	Lanthanum	La
58	Cerium	Ce
59	Praseodymium	Pr
60	Neodymium	Nd
61	Promethium	Pm
62	Samarium	Sm
63	Europium	Eu
	Heavy -- Yttrium Group	
39	Yttrium	Y
64	Gadolinium	Gd
65	Terbium	Tb
66	Dysprosium	Dy
67	Holmium	Ho
68	Erbium	Er
69	Thulium	Tm
70	Ytterbium	Yb
71	Lutetium	Lu

In fact, the deposit at Mountain Pass is geologically extraordinary. Rare earths there occur in a rock called carbonatite, associated with ultrapotassic (high in potassium and deficient in silica) rocks deposited from a magma 1.4 billion years ago. Cerium-group rare earths predominate at Mountain Pass. Rare-earth-bearing minerals at the Music Valley deposits are thought to have been deposited as placers (deposits of heavy minerals concentrated by streams or rivers) in an ancient sediment later subjected to extreme heat and pressure. The sediments were recrystallized into a metamorphic rock now referred to as the Pinto Gneiss. Yttrium is the chief REO at Music Valley, but cerium and lanthanum are also present.

DIVERSE HIGH-TECHNOLOGY USES - LIGHTER FLINTS?

Use of monazite in incandescent gas mantles in 1883 launched the first important recorded use of rare earths. Only limited applications of REO's, such as mischmetal (a natural mixture of rare-earth metals) for lighter flints, iron additives, and glass coloring,

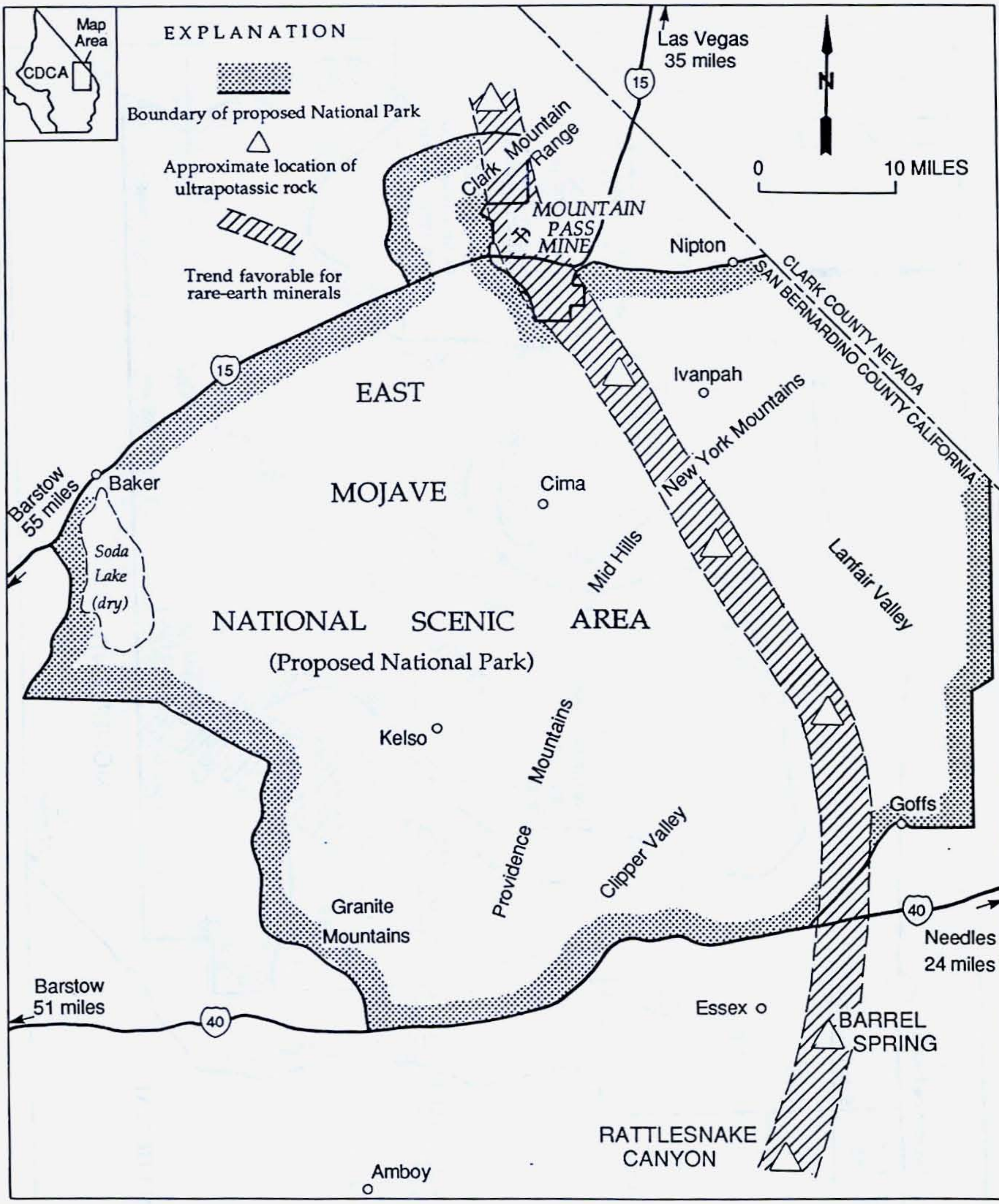


Figure 1.- Location of Mountain Pass rare-earth mine and favorable trend in San Bernardino County, California

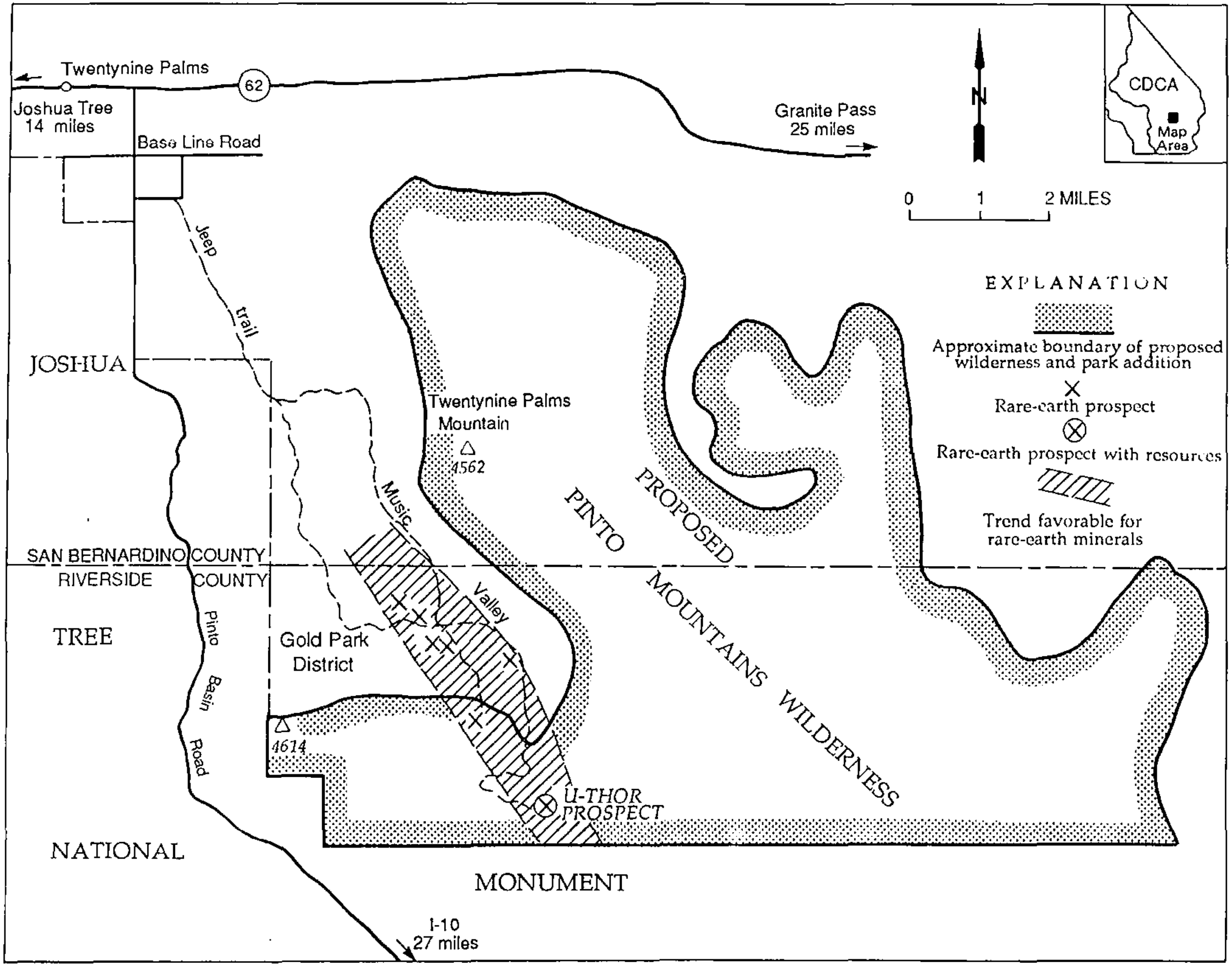


Figure 2.- Location of Music Valley rare-earth prospects and favorable trend in Riverside County, California

were made through the middle of the 20th century. Most of these applications used assemblages of REO's rather than individual elements, because the technology to separate most of these metals was lacking. Discovery of the deposit at Mountain Pass in the CDCA in 1949, and subsequent opening of the mine in 1954, represents a primary stimulus for the development of today's diverse, high-technology applications. Rare earths are produced for a wide range of applications. Intense research from 1930 into the 1960's resulted in many new and diverse markets; the best known being their use as red phosphor in color television. Table 2 lists the proportions of rare earths produced from bastnaesite at Mountain Pass mine and the major uses for each. Many of the applications were discovered after rare-earth production began. Although cerium-group REO's are most abundant, heavy REO's are also extracted from concentrates produced at the mine. Research into additional high-technology uses for rare earths continues, and new applications are discovered regularly. REO use in high-temperature superconductors is very promising and, if successful, could result in a significant increase in demand.

MOUNTAIN PASS - A RARE DEPOSIT

Two prospectors discovered the Mountain Pass deposit in the Clark mining district while searching for radioactive minerals in the Mojave Desert in 1949. The element that registered on their Geiger counter was thorium, a radioactive element commonly associated with rare-earth deposits. Their discovery, located as the Birthday claims, was subsequently acquired by Molycorp in 1950. It is noteworthy that the presence of rare earths had not been previously recognized despite the extensive exploration and mining which took place in the Clark Mining District since it was organized in 1865.

The carbonatite orebody which hosts the rare-earth-bearing mineral bastnaesite at Mountain Pass is steeply tilted and was intruded as a sill (slab-shaped body) 200 to 300 ft thick and about 2,300 ft long. It is estimated to contain over 30 million tons of ore.

PRODUCTION - A COMPLEX PROCESS/A WORLD LEADER

Mountain Pass operated intermittently from its opening in 1954 through 1964. Production of REO's has increased from approximately 2,200 short tons in 1964 to nearly 23,000 short tons in 1989; peak production was 27,900 short tons in 1984.

The flow sheet shown in figure 3 is a simplified graphic representation of the overall mining and processing system at the mine. An average of 2,000 short tons of ore are extracted each day with traditional open-pit methods of drilling and blasting. Currently, for each ton of ore mined, approximately 5 tons of waste rock must also be removed. This waste-to-ore ratio, 5 to 1, is called the "stripping ratio." As mining progresses to depth, this ratio may eventually reach 30 to 1 before mining becomes uneconomic.

Table 2.--Relative composition and major uses of rare-earth oxides produced from bastnaesite at Mountain Pass mine, California

ELEMENT	COMPOSITION (percent)	SELECT APPLICATIONS*
Cerium	49.0	Ceramic in automobile exhaust catalysts; lighter flints; glass polishing compound; alloy in cast iron to improve ductility; decolorizing glassware
Lanthanum	33.0	Increases gasoline yield in refineries; x-ray screens; enhances light transmission in lenses and optical fibers
Neodymium	13.0	Alloys for high-strength permanent magnets; increases temperature range in ceramic capacitors; enhances color television quality
Praseodymium	4.0	Alloys for high-strength permanent magnets; yellow glaze in ceramic tiles
Samarium	0.5	Alloys for high-strength permanent magnets
Gadolinium	0.2	Exposure reduction in x-ray screens
Europium	0.1	Fluorescent lamp energy reduction and natural light increase; red phosphor in color television and computer monitors
Yttrium/Terbium	0.1	Phosphors in color television and computer monitors; fluorescent lamps; lasers
Others	0.2	

*Data from Molycorp, Inc. and Industrial Minerals, May, 1990

Following traditional mining and milling, processing to concentrate and extract individual elements from the ore comprises one of the most complex and expensive procedures in the mineral industry (figure 3). Briefly, ore is concentrated by froth flotation and treated by leaching and calcining (heat) to reduce contaminants. Individual REO's are separated from the concentrate by counter-current solvent extraction, a complex chemical process pioneered by Molycorp. A thorough technical description of the process is beyond the scope of this paper.

In 1990, Molycorp employed 235 workers at the Mountain Pass operation with an annual payroll of approximately $9 million dollars. About 13,000 acres (20 square miles) are under mining claim, nearly 2,000 of which are in EMNSA. A series of exposures of rocks favorable for hosting rare-earth deposits defines a narrow 80-mile-long trend across the East Mojave desert; over 50 miles of this trend is in EMNSA, which is proposed for National Park status. Molycorp continues to conduct intensive exploration north and south of the active mine along portions of the favorable trend.

Molycorp's Mountain Pass mine is the sole U.S. source of bastnaesite and one of the world's largest producers of rare earths. World production has increased significantly, from about 6,500 short tons in 1964 to over 68,000 short tons in 1989. China is currently the world's largest REO producer having captured increasing portions of the world market, some of which belonged to the U.S., since 1985.

Mountain Pass mine is also unusual in that rare earths are its primary product. Other U.S. sources, and most mines in the world, produce monazite or xenotime as a byproduct. Rare-earth minerals were produced from three U.S. deposits in 1989, but operations at a byproduct monazite-xenotime producer in North Carolina closed at mid-year 1990. This leaves Mountain Pass and a producer of by-product monazite in Florida as the only domestic producers of rare earths.

Prices of rare-earth products vary widely depending on chemical state, purity, and end use. Prices quoted by Molycorp in October 1988 ranged from $6.75 per pound for 96.0-percent-pure neodymium to $745 per pound for 99.99-percent-pure europium. Other price quotes included cerium at $8.00 per pound for 99.0-percent-pure and $52.50 for 99.99-percent-pure yttrium. Prices are for product at the plant; shipments are made in lots of 25 to 300 pounds.

MUSIC VALLEY - ACTIVE EXPLORATION

As at Mountain Pass, the association of the radioactive element thorium with rare earths attracted attention to the area. Prospecting by the U.S. government in 1949 and subsequent private prospecting delineated the deposits in the Pinto Mountains, about 10 miles southeast of Twentynine Palms, California and 2 miles east of Gold Park Mining District. Xenotime and monazite, important yttrium-bearing rare-earth minerals, were first recognized in Music Valley in the late 1950's (figure 2). These rare-earth deposits

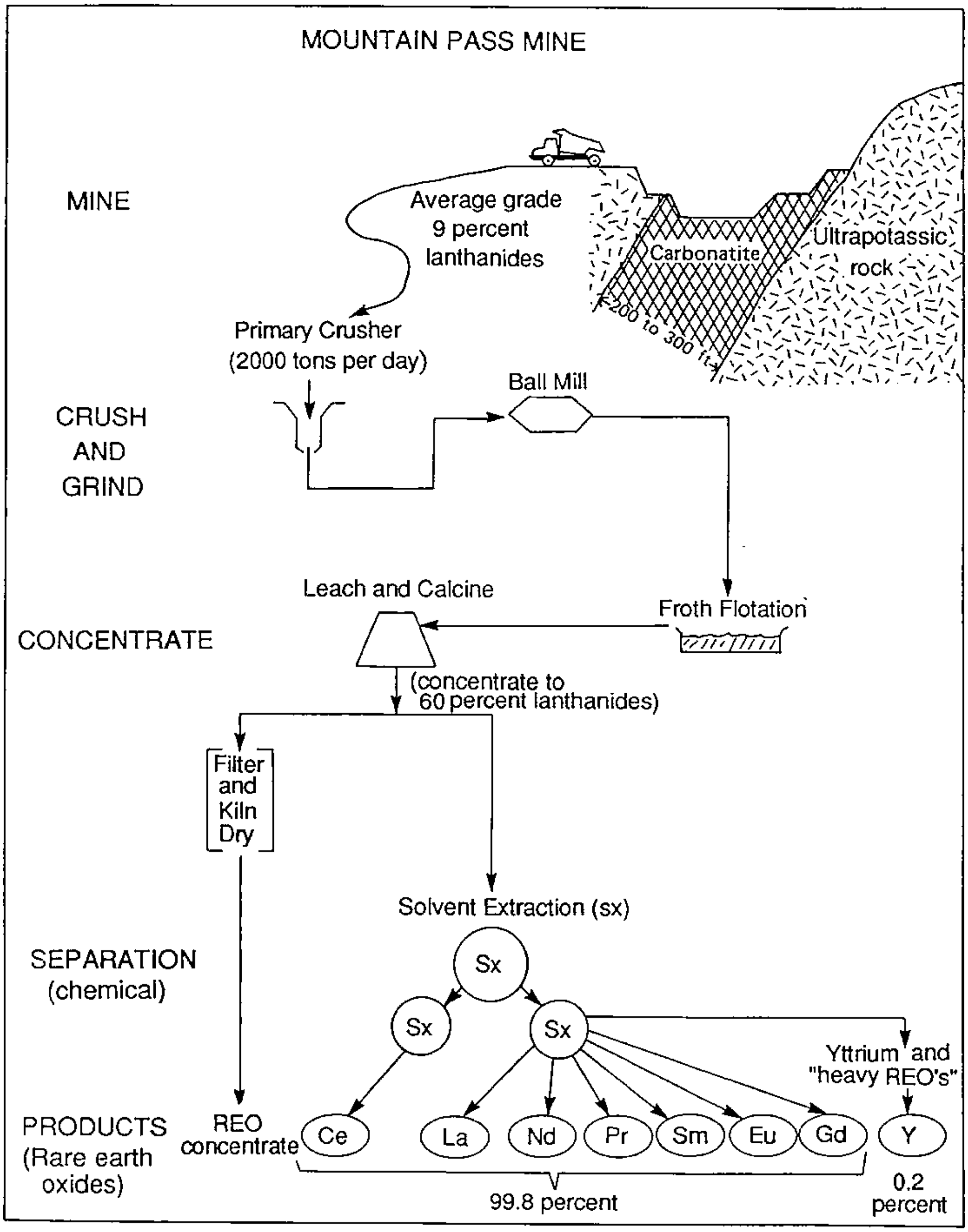


Figure 3.- Simplified flow diagram shows sequence from mine to end product for rare earths at Mountain Pass mine, San Bernardino County, California

were studied in detail in 1959 and 1960 by Jim Evans, then with the California Division of Mines and Geology. He determined that the deposits in the southern part of Music Valley would be of important economic interest with development of new uses and markets for yttrium.

In 1988 and 1989, Draco Exploration conducted a preliminary exploration drilling program consisting of 20 drill holes into the Music Valley prospects. Fifteen holes at the U-Thor prospect (figure 4) identified 330,000 short tons of resources containing over 700,000 pounds of yttrium oxide with nearly 1.2 million pounds of additional rare-earth oxides. Notable concentrations of the REO's cerium, ytterbium, neodymium, lanthanum, gadolinium, samarium, dysprosium, and erbium have been detected in laboratory analyses. The U-Thor and other prospects in Music Valley define a trend at least five miles long and more than one mile wide that is favorable for rare earths, principally yttrium. However, much of the area, especially to the south in the JTNM, has not been extensively explored. Although grades at the U-Thor prospect appear marginal, additional mapping and drilling along the Music Valley trend may define additional resources.

Figure 4.--View east of the U-Thor prospect in Music Valley, California. Joshua Tree National Monument lies less than one mile behind the site.

High-technology applications of yttrium have increased dramatically since Evans examined Music Valley in 1959. Despite the fact that small amounts of yttrium are produced by three American companies, the U.S. net import reliance (as a percent of apparent consumption) is 100 percent! Bureau of Mines Mineral Commodity Summaries, 1990, reports that "Of all the rare earths, yttrium continued to have the largest number of uses." Furthermore, "Substitutes for yttrium are available for some applications, but generally are much less effective. In most uses, especially phosphors, electronics, and ceramics, yttrium is not subject to substitution by other elements." The price for 99.99-percent-pure yttrium published in the Bureau of Mines Minerals Yearbook, 1989, was $52.50 per pound. Prices vary widely; refer to prices quoted for Mountain Pass.

OUTLOOK - TRENDS

The importance of rare earths to American high-technology industries is well demonstrated. Mountain Pass mine is a world-class source of REO, but both the Mountain Pass and Music Valley rare-earth trends also represent important areas for future exploration and possible development of these necessary commodities. Bills before the Congress could impact development of potential resources. Legislation known as the "California Desert Protection Act" proposes to include significant portions of both favorable rare earth trends in National Parks. This despite the fact that 14 years of study by the BLM has determined that these areas are not suitable for wilderness classification. Passage of the California Desert Protection Act will preclude future exploration and development in those areas affected.

It is clear that loss of access to the Mountain Pass and Music Valley trends will, 1) severely restrict the Nation in future exploration and possible development of these important resources, and 2) dramatically increase the reliance of American high-technology industry on foreign sources.

HUNTER MOUNTAIN WOLLASTONITE

There was little to suggest the presence of a mineral deposit at this particular spot north of Hunter Mountain in the Panamint Range of California (figure 1). In fact, a well-known geologist had walked over the area without giving it special note. However, in the late 1950's, Joe Ostrenger, a prospector who had roamed the region near Death Valley for years, was curious enough about an outcrop of white rock to have samples analyzed. Subsequent examination showed the white rock to be wollastonite, and the outcrop turned out to be a portion of one of the world's largest known deposits of the mineral.

Wollastonite is a calcium silicate mineral that has been marketed as a mineral commodity only since 1933, and it certainly isn't a household word. However, it has a variety of uses that take advantage of its several unique properties. The ceramic and refractory industries use wollastonite in fast-firing techniques to produce glazes and whiteware bodies at reduced energy costs. The high length-to-width ratio of wollastonite fibers helps ceramic products maintain their shape when fired and imparts high impact strength. The plastics and thermal insulation board industries use wollastonite fibers as filler to increase the mechanical strength of the product. Wollastonite can decrease acidity in some acrylic paints and so prevent can and lid corrosion. It also acts as a flattening agent and provides added durability to the paint. The mineral has replaced asbestos in cement formulations, ceiling and floor tiles, and brake linings.

Currently, domestic production is dominated by operations in New York State where NYCO, a subsidiary of the Canadian-based Processed Minerals Incorporated, and R.T. Vanderbilt supply the U.S. market, Europe, and Japan. Recent domestic production has totaled about 80,000 tons a year.

Early 1990 prices ranged from about $115 to $240 a ton, but actual costs of the wollastonite products vary with particle size: finer sizes command higher prices. As might be expected, a premium is paid for products with high length-to- width ratios.

The development of wollastonite markets in the western United States has been impeded by high transportation costs if the mineral is shipped from eastern sources and the poor quality and limited quantities of local sources. GSA Resources, a mineral consulting firm that investigated wollastonite market patterns in the western United States, estimated that during the mid-1980's, wollastonite consumption in the west for plastic fillers, paint fillers, and ceramics was only 10,000 to 11,000 tons a year. The company felt a western market that consumed 40,000 tons a year could be developed if a western source were available. A mine in the West would also be the most logical supplier to potentially large California and Japanese markets.

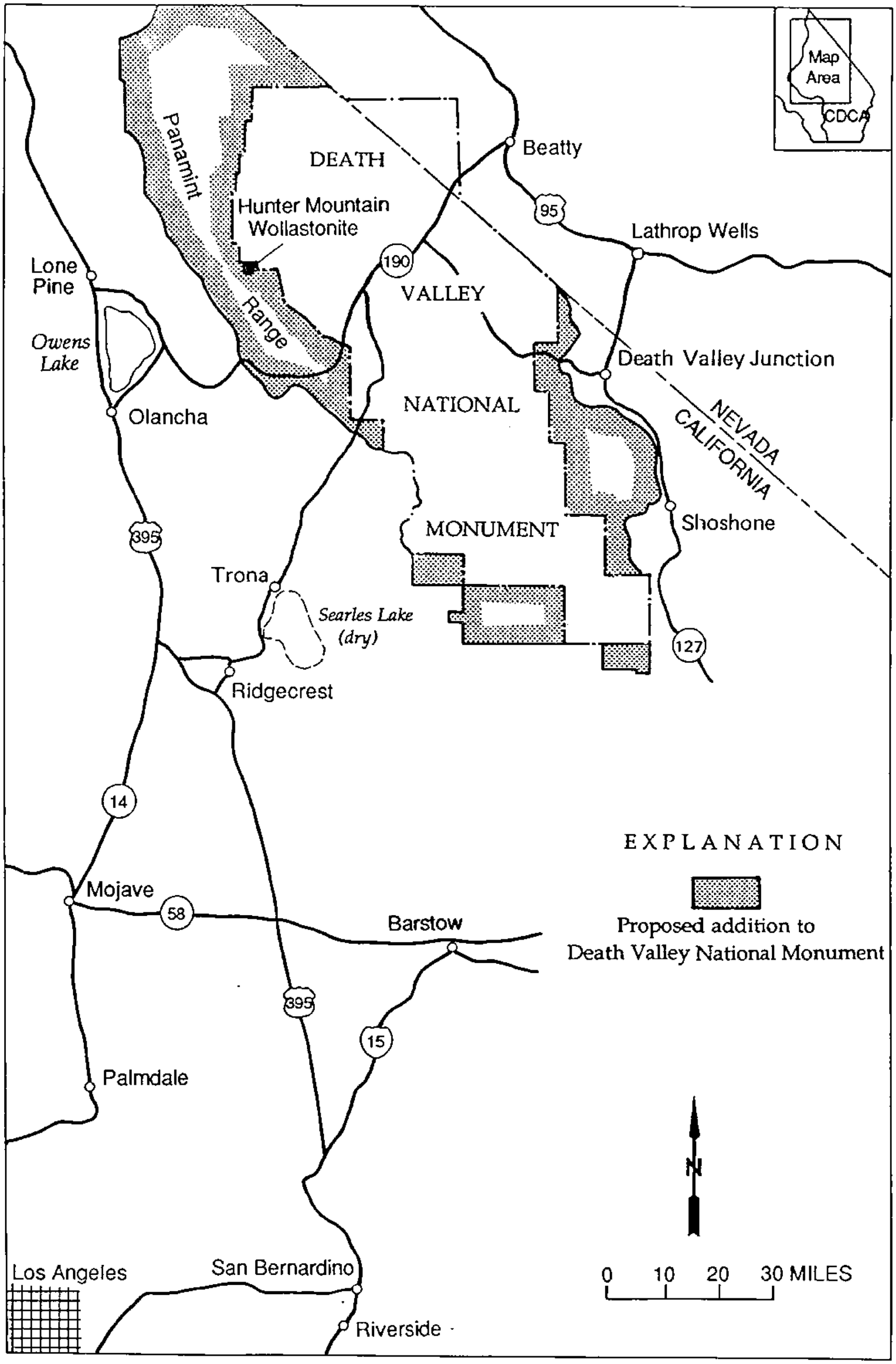


Figure 1.- Location of the Hunter Mountain Wollastonite deposit, Inyo County, California

In order to produce marketable products from wollastonite ore, it is generally necessary to separate the wollastonite from undesirable minerals before grinding it to final product size. Some operations use magnetic separation and froth flotation techniques; these techniques can also yield marketable garnet or calcite coproducts. Tests on material from the Hunter Mountain deposit reportedly indicated that a high-brightness, low-iron product could be produced by crushing, screening, grinding, and froth flotation. However, details of the tests are confidential, and it is not known if calcite or garnet coproducts could be produced.

Exposures of the wollastonite at the Hunter Mountain deposit can be traced intermittently for more than 5 miles along a zone that ranges from 300 to 1,000 feet wide for most of its length (figure 2). The entire deposit has been estimated to contain as much as 200 million tons of wollastonite-bearing rock, most of which lies in Death Valley National Monument. About 10,000 tons of ore was mined here during the early 1960's and required only crushing and screening to produce a product suitable for ceramics and for enamel coatings on stoves and ovens.

Figure 2: A portion of the Hunter Mountain wollastonite deposit.

However, the wollastonite claims within the Monument were ruled invalid by the National Park Service because Mr. Ostrenger apparently did not re-record the claims with the Park Service as required by Public Law 94-429 passed in 1976. As a result, only that portion of the deposit outside the Monument is now open to development.

Even this portion is still a large resource. In 1985, a Canadian-based exploration company outlined at least 18 million tons of material containing an average of 60 percent wollastonite. In 1986, the largest domestic wollastonite deposit in production was reported to have about 7.7 million tons of reserves containing from 55 to 65 percent wollastonite. Because the Hunter Mountain work was only a preliminary exploration effort, additional drilling would be required to determine the detailed geometry of the subsurface portions of the deposit.

However, there is danger that the Hunter Mountain deposit may never be mined. The California Desert Protection Act would expand Death Valley National Monument into a new Death Valley National Park that would encompass the entire deposit. This designation has been proposed in spite of the fact that no detailed studies have been done to determine the possible benefits of developing the deposit. Also, no studies have been done to determine the competitive advantage of lower costs and increased quality for wollastonite products produced in the western United States.

It is unlikely that additional money will be spent on exploration until the proposed national park boundary is determined. The lack of exploration and mineral data in turn precludes proposing a detailed development scenario for the Hunter Mountain deposit.

However, it is likely that if the wollastonite were developed, open-pit techniques would be used. To meet the potential 40,000 ton-a-year market, a plant capacity of about 100,000 tons a year would be required. This estimate assumes an average grade of 50 percent and recovery at 80 percent. Primary crushing and screening would probably be done at the mine site. Some of the calcite, which is softer and tends to concentrate in the undersized fraction, could then be discarded to produce an upgraded wollastonite product. Because supplies of water are limited at the site, this product would be hauled by truck to a more suitable mill location where froth flotation, grinding, and particle-size classification would produce marketable wollastonite.

There are many facts about the commercial feasibility of this deposit that detailed exploration, beneficiation tests, market surveys, and product development studies could determine. Without at least some of these studies, a rational land management decision on the Hunter Mountain deposit is impossible.

THE GOLD ENDOWMENT OF SOUTHEASTERN CALIFORNIA
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ELEPHANTS OF THE DESERT

A revolution in geologic thinking is providing new insight into the structure of the southeastern California desert. With this insight has come the ability to better assess the region's mineral endowment. Studies completed only a few years ago that are being used as a basis for managing this desert area may have grossly underestimated the area's mineral potential. Most recent investigations conclude that the gold endowment of the southeastern California desert is substantial and there is high likelihood that additional economically viable deposits will be found.

The Bureau of Land Management's California Desert Plan and the recently proposed California Desert Protection Act, are examples of current efforts to manage lands in the California desert. These acts would create wilderness areas and National Parks in the California desert resulting in new withdrawals of as much as 7.2 million acres from mineral exploration and development. The areas proposed for withdrawal were judged by the Bureau of Land Management and some members of Congress to have wilderness characteristics surpassing the value of any potential economic mineral endowment. Geologic and other lines of evidence strongly suggest that in the southeastern California desert this conclusion should be carefully reexamined.

CHANGING ESTIMATES OF MINERAL ENDOWMENT

"Mineral endowment" is defined as the estimated sum of the discovered and undiscovered mineral deposits in a region. It is an attribute that cannot be measured solely by totaling known mineral resources, but must include an estimation of those resources yet to be discovered. Estimates of mineral endowment are dynamic and change as increasing geologic knowledge allows explorationists to better assess potential for new mineral deposits.

A principal catalyst for the increased understanding of the geology of gold deposits in the western U.S. has been economic. Escalation in the price of gold, since it was allowed to rise to its free market value, has provided a tremendous incentive to improve gold ore mining and processing techniques. These improvements gave new life to many deposits that had had previous production and has spurred development of low-grade, bulk-tonnage gold deposits[1]. The current boom in gold production, especially in Nevada, is the result of these efforts. In addition, these improvements have resulted in increased exploration for new deposits by geologists armed with new geologic theories.

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[1]Low-grade, bulk-tonnage gold deposits are the usual targets of modern-day gold explorationists. They commonly have grades in the range of .02 to .2 ounces gold per ton, and may contain 1 to 25 million tons of ore.

An important example of the impact this exploration has had is the rebirth of the gold mining industry in the southeastern California desert. Three large gold operations, the Cargo Muchacho, Mesquite, and Picacho Mines (figure 1), are now producing over 270,000 ounces of gold per year in Imperial County where, as late as 1982, no gold was produced. The saying among exploration geologists is "to find an elephant you need to be in elephant country." In other words, if you want to find a mineral deposit you need to look in a geologic environment favorable for that particular type of deposit. Enormous amounts of geologic data collected by colleges and universities, mining companies, and government agencies have provided evidence that the same set of geologic conditions which resulted in the Cargo Muchacho, Mesquite, and Picacho gold deposits are also present elsewhere in southeastern California. Mining companies have responded by conducting detailed exploration of the region between the Mesquite and Picacho Mines. The resulting hundreds of mineral claims are evidence that these companies think that this is truly "elephant country."

THE MAKING OF ELEPHANT COUNTRY

Twenty-five years of evolution of modern plate tectonic theory has allowed reinterpretation of local geology in the context of its regional geologic framework. This has resulted in a better understanding of the processes affecting ore deposition. This reinterpretation has changed our estimates of mineral endowment in many areas of the U.S.

Most of the gold production in the western U.S. is from deposits formed by hydrothermal (hot water) solutions. An important factor controlling the location of gold deposits is rock permeability[2/]. Permeability can be provided by large fractures or by small-scale fractures and disrupted mineral grain boundaries. Known major gold mines in southeastern California are bulk-tonnage deposits which occur in crystalline rocks normally having very low permeability. Fortunately, the region has been periodically subjected to enormous geologic forces which, in places, have caused the rocks to fracture. The data suggest that at least three episodes of major faulting in southeastern California may have controlled gold deposition.

All three episodes of faulting resulted in increased permeability and porosity as brittle rocks broke not only along major fractures, but also along mineral grain boundaries and small-scale shears. These fractures provided the network of open spaces necessary for bulk-tonnage gold deposits. Opinions vary regarding which episode of faulting is responsible for providing the necessary permeability at each of the known gold deposits. Probably more than one faulting episode is responsible for some deposits.

[2/] "Permeability" is a measure of a material's ability to allow passage of fluids through it.

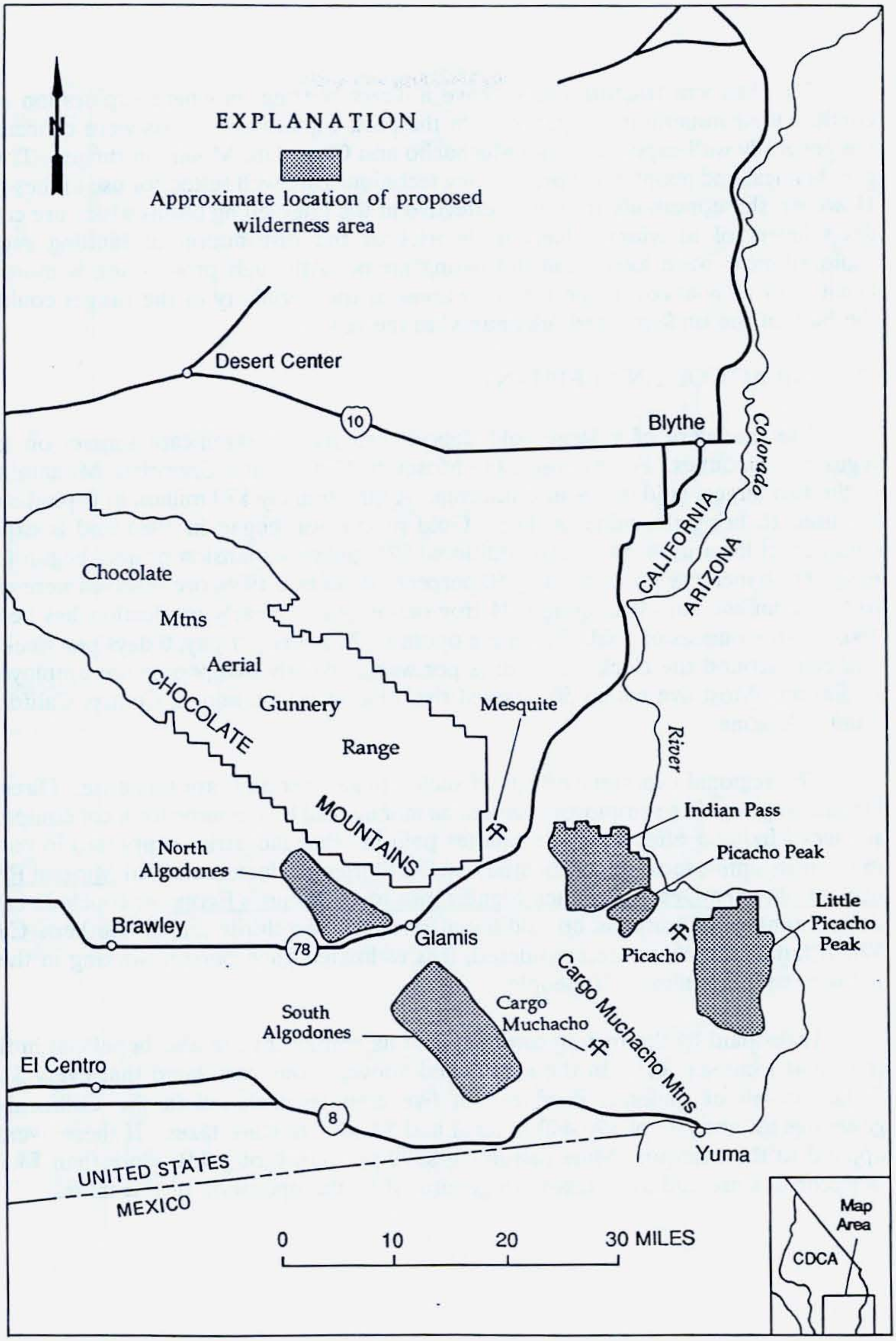

Figure 1.- Southeastern California

The different fracture modes have a direct bearing on where exploration geologists conduct their mineral investigations. In the past, exploration efforts were concentrated in the generally well-exposed Cargo Muchacho and Chocolate Mountain ranges. Traditional geochemical and geophysical prospecting techniques are well suited for use in these terrains. However, these methods are not as effective in the intervening basins which are covered by deep layers of alluvium. Recent theories of the distribution of faulting suggest the explorationists were looking in the wrong areas. Although prospecting is more difficult because of alluvial cover, the low-lying areas at the periphery of the ranges could contain the bulk of the undiscovered "elephants" in the region.

THE IMPACT OF AN ELEPHANT

The discovery of a large gold deposit can have a significant impact on local and regional economies. For example, the Mesquite Mine, in the Chocolate Mountains, is one of the two largest gold mines in California. Approximately $70 million in capital costs were required to bring the mine on line. Gold production began in 1986 and is expected to continue at least until 2003. An additional $21 million expansion project begun in 1987 is designed to increase production by 50 percent. As of mid 1989, ore reserves were estimated to be 53 million tons averaging 0.04 troy oz/ton gold. Yearly production has been about 180,000 troy ounces of gold. The mine operates 20 hours per day, 6 days per week and the mill runs around the clock, seven days per week. Nearly 340 people are employed at the operation. Most live within 50 miles of the mine at Blythe and El Centro, California, and Yuma, Arizona.

The regional economic effects of such a huge operation are immense. Direct effects include wages paid to employees, as well as money paid by the mine for local equipment and services. Indirect effects include salaries paid in other industries supported in part by the mine or its employees. A recent study by Dr. Shirley Anderson entitled Mineral Resources of the California Desert and their Significance to California's Economy concluded that each desert mining job sustains an additional one and two-thirds job in southern California. When family members are considered, it is estimated each person working in the mining industry supports almost 10 people.

Taxes paid by the mining company and its employees are also beneficial in financing state and local services. In the study cited above, it was calculated that every $1 million dollars worth of minerals produced in five counties included in the California desert generates an average of $26,440 in local and $41,877 in state taxes. If these averages are applied to the Mesquite Mine (assuming $370 per ounce of gold), more than $4.5 million per year in state and local taxes are generated by the operation of this mine.

ELEPHANTS AT RISK

If the BLM's recommendations are adopted for the California Desert Plan, three wilderness areas will be established in southeastern California: Indian Pass, Picacho Peak, and North Algodones Dunes. All were examined jointly by the U.S. Bureau of Mines and the U.S. Geological Survey and all were found to have a high potential for mineral resources. The Indian Pass and Picacho Peak areas virtually surround the Indian Rose, a gold prospect located along the Mesquite-Picacho trend. This prospect has been drilled by two large mining companies to determine its size and grade. Indications suggest another large low-grade gold deposit. Although sufficient non-wilderness land would remain to mine the Indian Rose, the proposed Indian Pass and Picacho Peak Wilderness Areas would preclude all but a small portion of the southern Chocolate Mountains from mineral development. Most of the Chocolate Mountains is already closed to mineral development because it is within the Chocolate Mountain Aerial Gunnery Range.

In addition to the BLM recommendations, the CDPA proposes creation of the Little Picacho Peak and South Algodones Dunes Wildernesses without the benefit of any field studies by the U.S. Bureau of Mines or the U.S. Geological Survey. Based on a survey of available geologic literature, both areas have high to moderate potential for mineral resources. Not only would the Indian Rose be lost to development, but the potential for future discoveries in these areas would also be lost.

The ability of the mining industry to respond to new geologic insights - and therefore realize our nation's mineral endowment - will depend on the land management decisions that are made in the future. Law that restricts a land management agency's ability to respond to changing economic, technical, and scientific conditions can only result in the inefficient use of the Nation's mineral endowment.