GL03037

GEOLOGY - Foundation of the present; key to California's future.

CALIFORNIA GEOLOGY

March 1978

35¢

"AIRFIELD FAULT" MESQUITE PLAYA, SAN BERNARDINO COUNTY, CALIFORNIA

State of California — EDMUND G. BROWN JR., *Governor*
The Resources Agency — HUEY D. JOHNSON, *Secretary for Resources*
Department of Conservation — PRISCILLA C. GREW, *Director*
Division of Mines & Geology — THOMAS E. GAY, JR., *State Geologist*

A PUBLICATION OF THE CALIFORNIA DIVISION OF MINES AND GEOLOGY

CALIFORNIA GEOLOGY

California Geology staff

Editor-in-chief: Mary C. Woods
Editors: William A. Bryant and William B. Clark
Editorial assistance: Margaret Turner
Graphics and design: Ron Morgan
Supervisor of publication: Merl Smith

Cartography: Richard Boylan, Dorothy Fong, Ed Foster, Betty Lindgren, Richard Moar, Jeffrey Tambert

Division Headquarters: 1416 Ninth Street, Room 1341, Sacramento 95814 (Phone 916–445–0514)
Los Angeles District Office: 107 South Broadway, Room 1065, Los Angeles 90012 (Phone 213–620–3560)
Sacramento District Office: 2815 "O" Street, Sacramento 95816 (Phone 916–445–5716)
San Francisco District Office: Ferry Building, Room 2022, San Francisco 94111 (Phone 415–557–0633)

California Geology reports monthly on the earth sciences in California. Articles of interest related to geology, mining, seismology, paleontology, mineralogy, and allied earth sciences are included. Subscription price for *California Geology*, January through December, is $3.00.
The Division also publishes Bulletins, Special Reports, County Reports, the Geologic Map of California, and other maps and information. A list of publications will be sent free upon request.
All orders for publications, changes of address, and subscriptions to *California Geology*, should be addressed to the Division at P.O. Box 2980, Sacramento 95812. Correspondence to the editors should be addressed to California Geology, 1416 Ninth Street, Room 1341, Sacramento 95814.

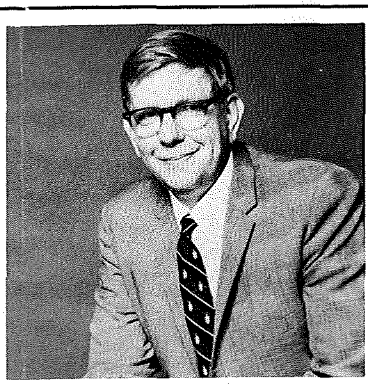
Typset: Department of Conservation, Word Processing Center; and Department of General Services, Office of State Printing

CGEOA 31 (3) 49 – 72 (1978) — March 1978/Volume 31/Number 3

IN THIS ISSUE

FRONT COVER. High altitude, oblique aerial photo of a portion of the Mojave Desert and Transverse Ranges, view north. Seen in the foreground in the Transverse Ranges are Precambrian and Mesozoic crystalline rocks of the Joshua Tree National Monument. The Pinto Mountain fault strikes east-west across the center of the photo. The Blue Cut fault strikes east-west and is located midway between the Pinto Mountain fault and the bottom edge of the photo. Northwest trending strike-slip faults characteristic of the Mojave Desert geomorphic province strike diagonally across the top half of the photo. The Mesquite Lake fault, marked by a concentration of vegetation in Quaternary alluvium, is located just left of the center of the photo. Mesquite Playa and the Marine Corps Training Center airfield are located between the Mesquite Lake fault and an unnamed fault marked by the northwest trending scarp in Mesozoic granitic rocks just east of the airfield; see article, p. 51. *USGS photograph USAF HA041L 112 taken by the U. S. Air Force, 1970.*

Memorial — Yvor H. Smitter 1926 - 1978



Yvor H. Smitter, geologist with the California Division of Mines and Geology since 1972, died January 6, 1978. Yvor's career was colorful and varied. He had a wide range of interest; besides being a geologist, he was an inventor and a musician.

Yvor was raised on a ranch in Owens Valley near Bishop, California. Growing up in the shadow of the Sierra Nevada, with surrounding mountains always in view, apparently was a great influence on him—he had a lifelong love and respect for the out of doors.

Yvor received a Bachelor's degree in geology and in chemistry from the University of California at Berkeley in 1948. He did graduate work in geology at the University of California at Berkeley and at the University of Southern California. He was a Fulbright Scholar and received his Doctorate in Geology in 1958 at the University of Witwatersrand in Johannesburg, South Africa.

During his career Yvor did geologic work in South Africa, Panama, Guatemala, the Philippines and various areas of the United States and published scientific as well as general interest articles. His work with the Division reflected his broad scientific knowledge. He was involved in Division projects in engineering geology, geohydrology, and economic minerals. He was a frequent contributor to CALIFORNIA GEOLOGY and was on the editorial staff at one time.

Yvor was keenly interested in his fellow man. His efforts to bring an understanding of earth science to the blind and handicapped and his willingness to share his knowledge with others were evidence of his dedication. He will be long remembered by his many friends and associates.

"AIRFIELD FAULT"

MESQUITE PLAYA, SAN BERNARDINO COUNTY, CALIFORNIA

By
DONALD L. FIFE, Geologist
P. O. Box 1054, Tustin, California 92680
This article was written while the author was a member of the CDMG staff.

In the latter part of 1976, giant fissures were reported at the Marine Corps Airfield near Twentynine Palms, San Bernardino County (figure 1). The two 5,000-foot runways, located on Mesquite Playa, were closed shortly after 12.5 inches of rain fell on the area during the tropical storms of September 1976 (de Becker, 1976). When the waters receded, large fissures were found trending under the runway fill (photo 1). Some fissures were up to 15 feet deep and 10 feet wide in the area of the runways.

DESCRIPTION OF FISSURES

The fissures at Mesquite Playa (photos 1 thru 4) are superficially similar to the giant desiccation cracks found on Lucerne Valley Playa (Fife, 1977), 50 miles west–northwest of the airfield (figure 1). The Mesquite Playa cracks, or fissures, trend north beneath the runway and form a zone of right–stepping *en echelon* breaks. The zone consists of essentially four separate fissures, each approximately ¼ mile in length. At the north end of the zone, the northerly fissure terminates near an evaporation pond; the southernmost fissure appears to enter a small dry wash with the same north–south trend. The zone of fissures may be the surface expression of a left–lateral fault lying between two northwest trending faults (figure 2).

The right–stepping zone of fissures is bounded on the west by the active (?) northwest trending Mesquite Lake fault and on the east by a concealed northwest trending fault (Dibblee, 1968). The predominate displacement on the Mesquite Lake fault is right lateral strike–slip. The Mesquite Lake fault, and the concealed northwest trending fault to the east, form a part of the dominant pattern of northwest trending strike–slip faults found in the Mojave Desert (Cummings, 1976) (figure 1).

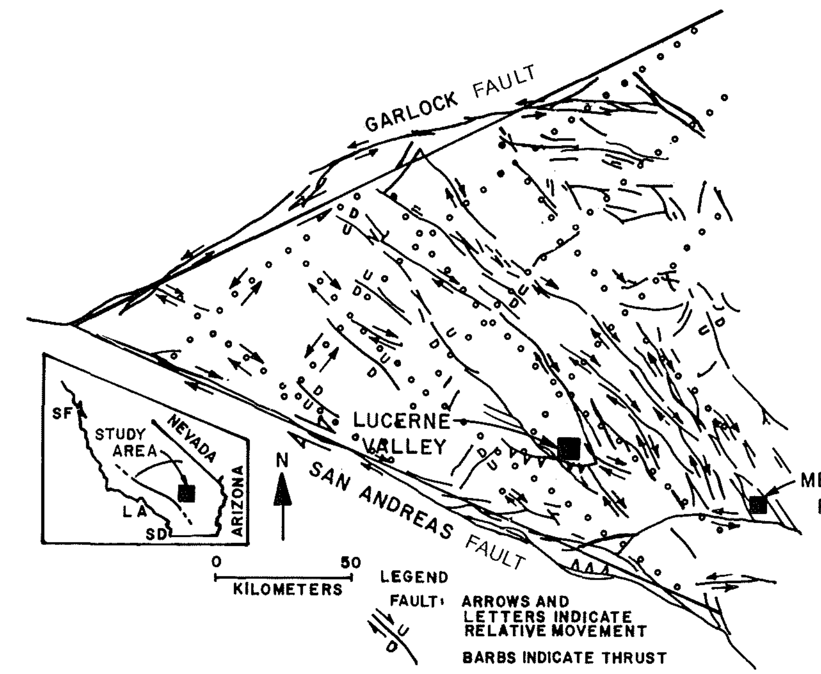


Figure 1. Map showing general location of Mesquite Playa (Marine Corps Airfield), Lucerne Valley, and the regional tectonic framework of the Mojave Desert region. *From Cummings, 1976.*

ORIGIN OF FISSURES

The fissures apparently formed due to stress or movement on one or both of the bounding northwest trending faults. At one location (photo 2; figure 3) evidence indicates that a fissure has been opened at least two times prior to the present breach: (1) The fissure was opened to a width of 2 feet and was subsequently filled with fine wind blown silt and sand, and ponded lake sediments; (2) Various storms contributed water to the playa and random open channels were exhumed and filled periodically.

The 12.5-inch rainfall of September 1976 in an area where the mean annual rainfall is less than 6 inches a year exhumed the spectacular cracks now visible. The fissures were enlarged by erosion as water percolated to lower levels, probably reaching the water table in some areas. Expansion and desiccation apparently were involved in the evolution of the feature after it was formed, as evidenced by the "healing" of some of the fissures in a manner similar to that of a typical desiccation crack (photo 3).

The fissures occur in an arid basin where ground–water pumpage exceeds ground–water recharge, and clay sediments similar to those found in other playas are present. The fact that the fissures disappear on the north end where the sewage treatment ponds saturate the playa sediments indicates that expansion and desiccation may be a component of the force that opens and closes the fissures. Another factor contributing to the movement may be subsidence related to ground–water withdrawal.

Photo 1. Fissure extending under runway mats. Looking south toward the beginning of another right-stepping fissure (arrow).

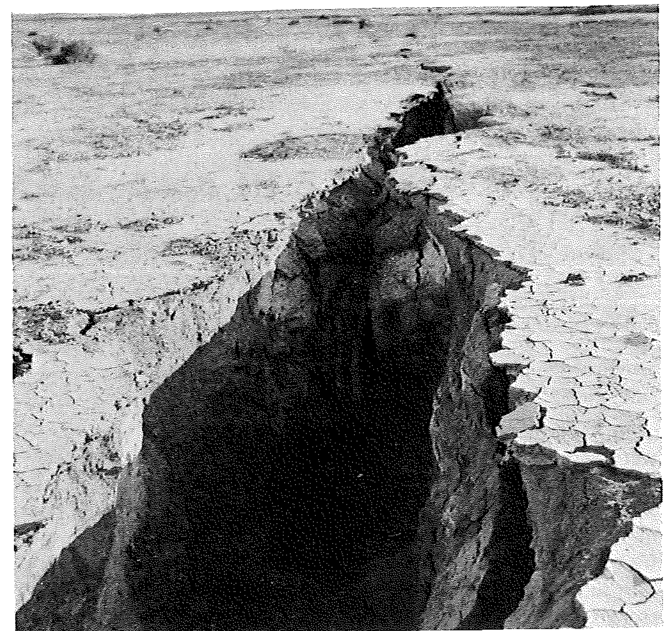


Photo 2. Fissure near south end. Looking north into site of lithologic log shown in figure 3.

Photo 3. Fissure "healing" in a manner similar to giant desiccation cracks. Looking north toward unnamed northwest trending fault.

Photo 4. Fissure trending south toward runway and northwest trending Mesquite Lake fault (Holocene ?). Maximum measured depth was about 15 feet.

AGE OF FISSURES

Portions of the cracks are at least several decades old and probably predate the construction of the Marine Training Center (1952) by several years. The relative age of the cracks was established during inspection of fill material along the runway, when it was observed that a small crack had been filled and covered by grading operations at the time the airfield was constructed.

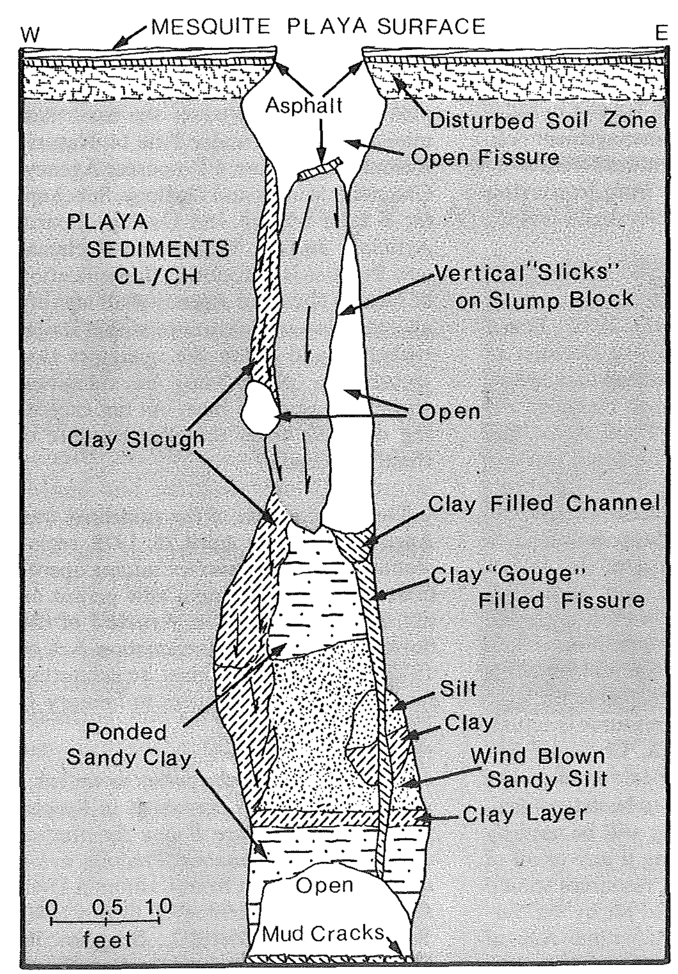
The most recent movement on the "airfield fault" has not been accurately determined. However, the U.S. Geological Survey has recently established benchmarks around the fault and survey data will be collected.

CONCLUSIONS

Based on observations to date, the Mesquite Playa fissures represent a north–south trending Holocene fault bounded by northwest–southeast trending right lateral strike–slip faults. The sense of displacement of the "airfield fault" is left lateral, as indicated by the right–stepping *en echelon* cracks. The open fissures are the result of erosion along and through the fault to a lower base level, which locally may be the ground–water table. Erosion will continue as long as ephemeral waters of the playa have access to a lower base level through the open fissures.

ACKNOWLEDGMENTS

Appreciation is extended to the Commanding General, Major General Edward J. Megarr, U.S. Marine Corps Training Center, Twentynine Palms and his Base G–4 and Public Works Officer and staff for access to the area and for discussion of the events leading up to the discovery of the fissures.



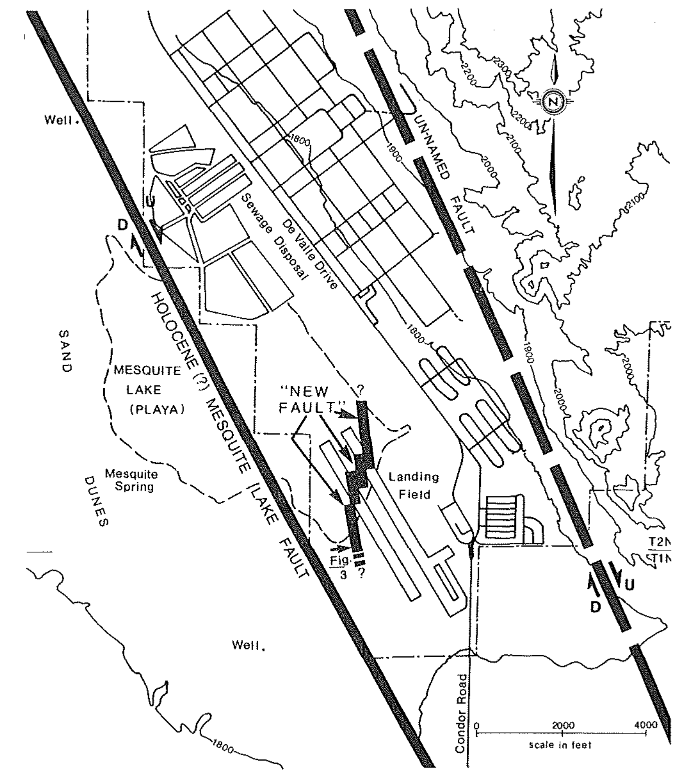


Figure 2. Approximate location of "airfield" fault, Mesquite Playa (dry lake) Twentynine Palms, San Bernardino County, California.

Figure 3. Lithologic log of fissure at the southernmost exposure (see photo 2 and location shown on map in figure 2).

REFERENCES

Cummings, D., 1976, Theory of placticity applied to faulting, Mojave Desert, southern California: Geological Society of America, Bulletin v. 87, no. 5, p. 720–724.

de Becker, J.A., 1976, Personal Communication, Soil Laboratory, U.S. Navy, San Bruno, California.

Dibblee, T.W., Jr., 1968, Geologic map of the Twentynine Palms quadrangle, San Bernardino and Riverside Counties, California: U.S. Geological Survey, Map I 561 (1:24,-000).

Fife, D.L., 1977, Engineering geologic significance of giant desiccation polygons, Lucerne Valley Playa, San Bernardino County, California (abstract): Geological Society of America Abstracts with Programs, April 6, 1977.

Board members Douglas W. Sprague, Return F. Moore, Ta–Liang Teng, Robert H. Twiss, Arthur Grantz (left to right back row), Eleanor Young and Alcides Freitas (left to right front row) in a lunch room at the 7800-foot level of the Pine Creek Tungsten Mine near Bishop, California.

STATE MINING AND GEOLOGY BOARD ACTIVITIES

The Special Representative to the State Mining and Geology Board in assisting the Board to carry out its public information responsibilities will begin providing, by this Report, a summary of the Board's activities. It is anticipated that the Report will be published semi–annually in CALIFORNIA GEOLOGY. Information on the Board's monthly meetings, field trips, or other information related to its responsibilities may be obtained by contacting the Board's Special Representative, Douglas W. Sprague, Department of Conservation, 1416 Ninth Street, Rm. 1335, Sacramento, California, 95814, (916)322-1082.

Classification Guidelines

The Mining Board adopted Guidelines for Classification of Mineral Lands on June 24, 1977, after a public hearing held in Sacramento on May 27, 1977. This action was taken in accordance with Section 2761(b) of the Surface Mining and Reclamation Act of 1975. These Guidelines provide direction to the State Geologist in identifying significant mineral resources through a process of land classification. Once classified these mineral resources may be considered for designation by the Board as of either regional or statewide significance. Designation requires local agencies to recognize the designated areas and to provide resource management policies to protect the mineral resources within the designated areas from irreversible land uses which would prevent their being mined.

Stanislaus River Project

At the November 18, 1977 Board meeting in Sacramento, the Division of Mines and Geology submitted to the Mining Board a mineral lands classification study of the Stanislaus River Area. The study was requested by the Board as a test case for its recently adopted Guidelines for Classification of Mineral Lands. The CDMG study by John Rapp, Ralph Loyd and Michael Silva delineated 1.2 billion tons of potential sand and gravel resources by using water well logs as the primary source of subsurface information, by testing selected surface and borehole samples, and by using available geologic data. How much of this resource is actually minable, due to U.S. Corps of Engineer's restrictions, local zoning and other regulations, is yet to be determined. The results of this study will be used by the Board in determining if any or all of these identified mineral resources should be designated as provided for by the Surface Mining and Reclamation Act of 1975.

Field Trips

In keeping with the Board's desire to be acquainted with California's diverse mineral extraction industry, it went underground in June to inspect the Pine Creek Tungsten Mine northwest of Bishop. This mine is operated by Union Carbide Corporation and provides about 65% of total U.S. tungsten production.

Other field trips were taken by the Board to inspect sand and gravel mining operations and reclamation practices in San Diego County and in the Central Valley area along the Stanislaus River. The Board also looked at instream aggregate extraction operations along the Russian River and Kelsey Creek in the Santa Rosa area. Local planners and industry representatives accompanied the Board so that related mining and reclamation practice issues could be discussed on site.

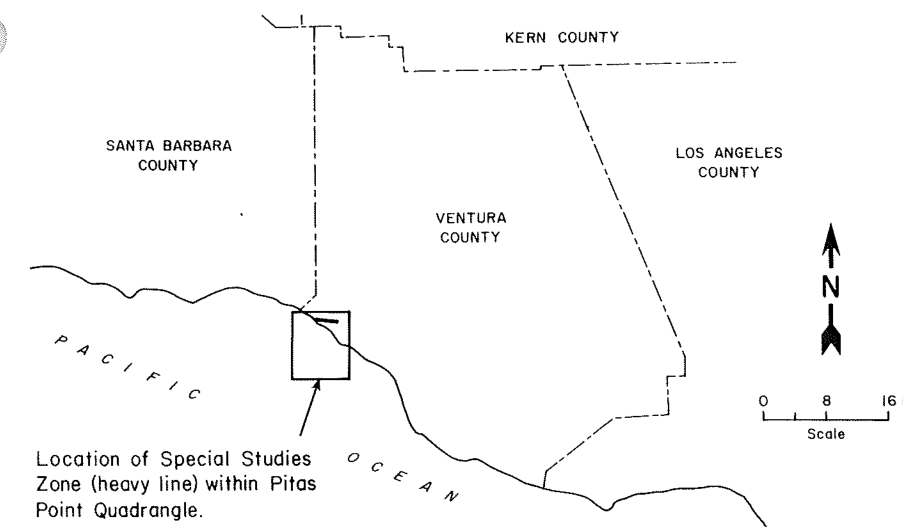
Reclamation Plans Due

Surface mine operators have only 1 month left to submit reclamation plans on land mined after January 1, 1976 to their local permitting authority (lead agency). Reclamation plans must also be submitted for surface mines operated after January 1, 1976, for which operators are claiming vested rights. Operations initiated after January 1, 1976, must have both permits to operate and an accepted reclamation plan. Section 3505(b) of the State Administrative Code under Title 14, Natural Resources, Division 6 Resources Agency, Chapter 8 Mining and Geology, Subchapter 1 State Mining and Geology Board, Article 1 Surface Mining and Reclamation Practice is as follows: "Identification of Mines. The Lead Agency shall identify all operating surface mines within its jurisdiction and notify the operators that reclamation plans must be submitted within a reasonable time, but not exceeding one year from the effective date of these guidelines."

The effective date of the guidelines was April 28, 1977. By April 28, 1978, reclamation plans for all surface mining operations whether requiring a new permit or not, under Section 2776, Article 5 of the Surface Mining and Reclamation Act of 1975 (vested rights), must be submitted for lands mined subsequent to January 1, 1976.

Complete text of the policy as well as a copy of the Act is contained in Special Publication 51, *State Policy for Surface Mining and Reclamation Practice,* available free on request from California Division of Mines and Geology, P.O. Box 2980, Sacramento, CA 95812 .... *Douglas W. Sprague, State Mining and Geology Board.*

NEW SPECIAL STUDIES ZONES MAP



Location of Special Studies Zone (heavy line) within Pitas Point Quadrangle.

On January 1, 1978, a new Official Map of Special Studies Zones was issued by the State Geologist in compliance with the Alquist–Priolo Special Studies Zones Act of 1972 (Chapter 7.5, Division 2, California Public Resources Code). As shown on the map, the newly established zone in the Pitas Point quadrangle, (see index map), lies entirely within the County of Ventura.

The purpose of a Special Studies Zone is to regulate development with regard to the hazard of surface fault rupture. The State Geologist has a continuing responsibility to revise existing zones and to delineate new zones based on new geologic information. Official maps of Special Studies Zones are delineated at a scale of one inch equals 2,000 feet (see below for availability).

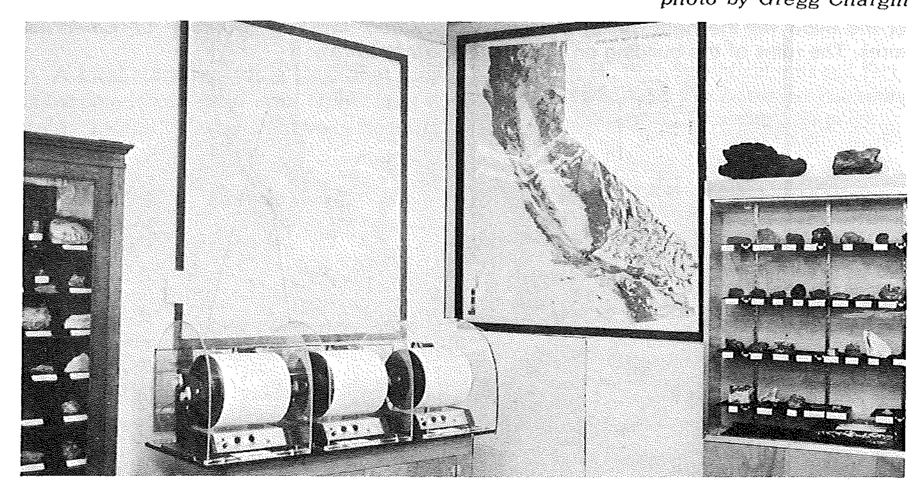
The release of the Pitas Point map brings to 261 the total number of Official Maps issued to date. A complete index of zone maps issued to date, as well as information on the Division's Fault Evaluation and Zoning Program and the Act are provided in Special Publication 42 (January 1977 Edition with Supplement No. 2). This reference may be purchased over the counter at any District office of the Division, or ordered by mail from the California Division of Mines and Geology, P.O. Box 2980, Sacramento, California 95812 for $1.00 plus tax.

Official Maps of Special Studies Zones may be consulted at any District Office of the Division of Mines and Geology or at the affected cities and counties (generally the Planning Department). Each city and county affected by Special Studies Zones has been provided with a reproducible copy of each zone map pertinent to that jurisdiction. Maps also may be purchased from Blue Print Service Company, 149 Second Street, San Francisco, California 94105 (415–497–8700).

Maps ordered from Blue Print Service Company *must be ordered by quadrangle name* (see Special Publication 42 for index map). Each map will cost approximately $0.54. The minimum order is $2.50, cash and carry only (if invoiced to account, minimum charge is $3.50). Handling charge will be $3.00 per order, regardless of the number of maps ordered. Five days must be allowed for processing. The order will be mailed C.O.D. Example: 5 maps will cost $2.70, plus $3.00 for handling, plus tax, plus C.O.D. charge....*Earl W. Hart, CDMG.*

SACRAMENTO DISTRICT EXHIBIT

photo by Gregg Chargin



The Sacramento District office of the California Division of Mines and Geology is now located at 2815 O Street. The District provides Division services to the people of 30 counties in central inland and northeastern California. All Division publications and maps that are in print may be purchased at the District Information and Sales Desk. Staff for seismological and geophysical studies, mineral resources and surface mining reclamation, and strong motion studies are located in the District office.

An economic rock and mineral exhibit, three seismographs, the fault map, and the new geologic map of California (both at scale 1:750,000) are on display in the Sacramento District office. The mineral display contains specimens of California's important economic minerals identified by name, source locality, and use. The seismograph units are connected by telephone line to seismometers located at Oroville dam (Butte County), San Luis dam (Merced County), and Iron Canyon (Los Angeles County). The continuous recordings monitor current seismicity throughout the state. The seismographs also record worldwide seismic events.

The Sacramento District office is open from 8 a.m. to 5 p.m., Monday through Friday. The phone number is 916-445-5716.

PRIVATE MINTS in California

By William B. Clark, Geologist

California Division of Mines and Geology

Soon after California's gold rush began, the production of gold from the rich surface placers and the rapid growth of the State's population resulted in a pressing need for a uniform medium of exchange. Gold dust and gold nuggets circulated freely in place of coinage and were accepted by most merchants, saloonkeepers, and gambling establishments. However, gold dust and gold nuggets were not accepted by the custom houses for payment of duties on merchandise because of the uncertain quality of the gold. The crude weighing devices and unrefined placer gold irked both the trader and the miner.

Within six months after Marshall's historic 1848 gold discovery at Sutter's Mill, continued pressure and letters from prominent citizens caused Colonel R.B. Mason of the First U.S. Dragoons and Military Governor of California, located at Monterey, to grant permission to "...wrought grain gold into convenient monetary shape to serve as substitute for gold and silver coin..."

PRIVATE MINTS

Colonel Mason's proclamation was issued on July 21, 1848 and was rescinded shortly afterward on August 8 because of its doubtful legality. Although private coinage may have been started in the latter part of 1848, the first known coin was issued on May 31, 1849. This coin was a $5 gold piece struck at Benicia City bearing the private mint stamp of Norris, Grieg, and Norris. Later, coins were made in San Francisco by this same firm.

On September 30, 1850 Congress passed an act authorizing private coinage. Soon afterwards about 20 private mints where gold coins were made were established in California, mainly in San Francisco. Private mints also were located in Sacramento, Stockton, Benicia, and Mount Ophir. The total value of gold coins manufactured at the mints was estimated to be between $10 million and $20 million (Clifford, 1961). Among those early-day private mints in San Francisco were the Adams and Company, Baldwin and Company, Bechtlers, Cincinnati Mining and Trading Company of San Francisco, Dunbar and Company, Kellog and Company, Miners Bank, Pacific Company, Templeton Reid, and the United States Assay Office; Moffat and Company in San Francisco and Mount Ophir; Blake and Company in Sacramento; and J.S. Ormsby in San Francisco and Sacramento. In addition, there was a mint at Lone Pine operated by C.H. Aaron where silver coins were made. (See CALIFORNIA GEOLOGY, December 1977).

The denominations of the gold coins produced by the mints were quarter dollars and half dollars, and one, two and one half, five, ten, twenty, twenty-five, and fifty dollars. The 50-dollar coins were known as "slugs" and the 25-dollar coins were called "half-slugs". The coins were either round or octagonal in shape, the octagonal-shaped coins being the most predominant in California. Small gold ingots for odd amounts were issued by several mints. For example, F.D. Kohler of San Francisco and Sacramento issued gold bars ranging from $36.55 to $150 in value.

Photo 1. Mount Ophir in 1886, view south. The town is on the left and the mine is on the right. The mint was located to the west of the mine (to the right out of the picture). The ruins of the building on the left (Trabuco store), walls of the mint (photo 2), and traces of building foundations are all that remain of the town today. *Photo by Carlton Watkins, Coutesy of California State Library.*

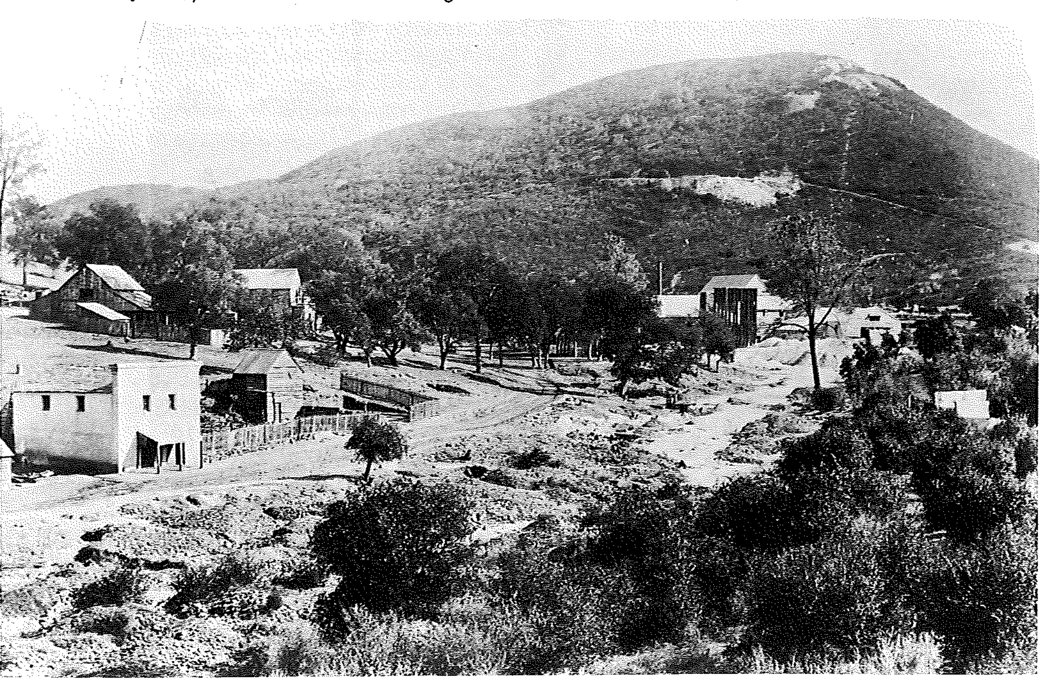


Figure 1. Drawing of octagonal gold slug (actual size) minted by the U.S. Assay Office (a private mint) in San Francisco in 1852. The fineness of the gold is 880.

Many of the privately minted coins resembled the U.S. money of that time with the liberty head and stars on one side of the coin and an eagle holding a shield on the reverse side. Other coins had the eagle on one side and the name of the mint or design on the reverse side. The 50-dollar slugs most commonly were octagonal in shape, but round ones were minted also. The octagonal slugs usually bore the name of the mint along the rim of the coin with the fineness of the gold ("880 or 900 thousand") imprinted on the coin (figure 1). Some of the smaller gold coins resembled tokens, merely giving the value and the name of the mint.

Workmanship of the coins ranged from crude to excellent. The craftsmen who made the coin stamps and dies were men who had worked at other mints, or assayers, goldsmiths, jewelers, or gunsmiths.

U.S. MINT ESTABLISHED

The Congressional Act of 1850 authorizing private coinage was repealed in 1852. The United States Mint was established in San Francisco in 1854. Soon afterward many of the privately minted coins in circulation were turned in for U.S. coins and melted down. After the middle 1850s only gold coins of small denominations (quarters, half dollars, and dollars) were issued by the private mints in California. Final legislation outlawing private coinage was enacted in 1882 (Yoeman, 1972, p. 231).

MOUNT OPHIR MINT

One of the private mints was located in the town of Mount Ophir in Mariposa County (photo 1) in the Mother Lode gold belt about 5 miles northwest of the town of Mariposa and 2 miles northwest of Mount Bullion. The Mount Ophir mint was erected in 1850 by John L. Moffat, (also spelled Moffatt) and was sometimes referred to as the Moffat mint (photo 2).

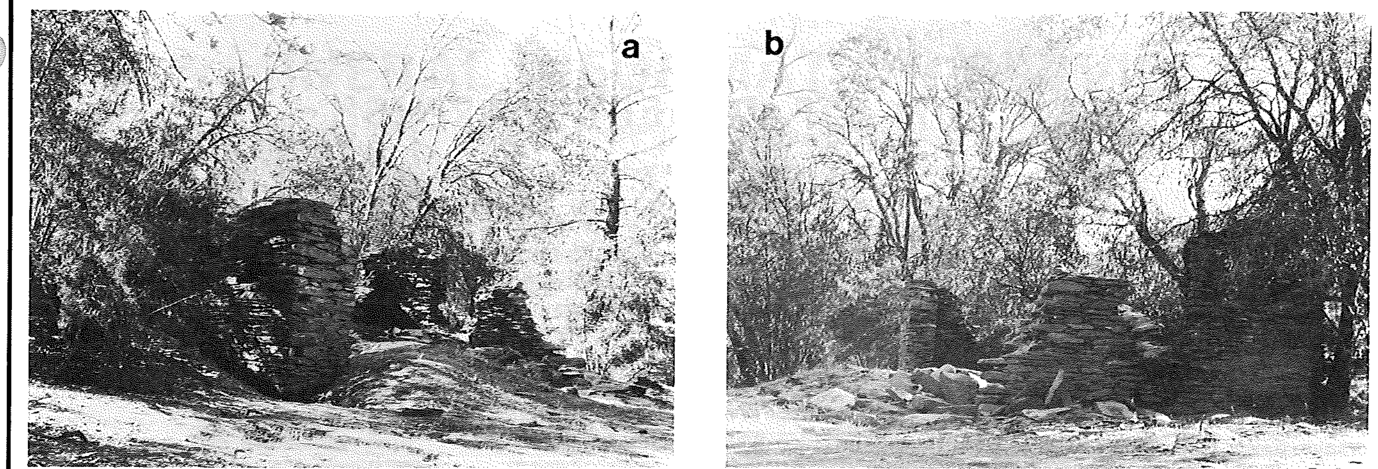


Photo 2. Ruins of Mount Ophir mint, 1977; view south (a) and view east (b). The mint was built of locally quarried amphibolite schist slabs set in mud mortar. The foundation and portions of walls 6 feet high can be seen (see hat on wall for scale).

John Moffat had previously worked as a miner and assayer in the gold fields of Georgia. In 1849 he located a claim near Mount Ophir and in 1851 he was appointed to the position of United States Assayer in San Francisco by President Zachary Taylor (Chamberlin, 1936, p. 32).

Gold for the octagonal slugs made at Mount Ophir mint was obtained from Moffat's mine and possibly from the Mount Ophir quartz mine on the ridge south of the mint. The total value of the coins minted at Mount Ophir is not known. Reportedly, some of the Mount Ophir coins were held by Mariposa County residents for many years. The mint was operated for only a short time; apparently after 1851 Moffat's main place of business was in San Francisco.

A local story regarding slugs that may have come from the Mount Ophir mint is told. Joseph Marre, Mariposa County Treasurer and Tax Collector in the early 1850s, was caught in a cloudburst as he was riding toward Mariposa, possibly coming in from Mount Bullion or Mount Ophir. It was known that he was carrying a bullhide bag containing 300 gold slugs ($15,000 possibly minted at Mount Ophir) to be deposited in the county treasury. Marre was drowned while attempting to cross a swollen creek. His body was found the next day; his horse survived with the empty saddle bags still in place. It was believed then that Marre had hidden the money for safekeeping before he attempted to ford the swollen stream. Needless to say, if any of those slugs were found today, there would be a "treasure" rush to this area.

Privately minted gold coins are collectors' items now, especially the 20 and 50-dollar pieces. Coins from some of the private California mints may be seen on display in San Francisco in the old United States Mint Building, 5th and Mission Streets, and in the history room of the Wells Fargo Bank, 420 Montgomery Street.

SELECTED REFERENCES

Adams, E.H., 1913, Private gold coinage of California, 1849–55, its history and its issues, Brooklyn, New York, 100 p.

Bowen, O.E., Jr., 1957, Mount Ophir gold mine *in* Mines and Mineral Deposits, Mariposa County; California Journal of Mines and Geology, Vol 53, nos 1 and 2, p. 139–140.

Burnie, R.H., 1955, Small California and Territorial gold coins: The Advertiser Publishing Co., Pascagoula, Mississippi, 96 p.

Chamberlin, Newell D., 1936, The call of gold: Gazette Press, Mariposa, California, p. 32.

Clifford, H.H., 1961, Pioneer gold coinage in the west – 1848–1861: Henry H. Clifford, Los Angeles, California, 52 p.

Friedberg, Robert, 1958, Gold coins of the world: The Coin and Currency Institute Inc., New York, 384 p.

Heizer, R.F., and Fenenga, F., 1948, Survey of building structures of the Sierran gold belt, 1848–70 – Mount Ophir, geologic guidebook along Highway 49 – Sierran gold belt: California Division of Mines Bulletin 141, p. 99.

Lee, E.M., 1932, California gold quarters, halves, dollars: Glendale, California, 94 p.

Yoeman, R.S., 1972, A guide book of United States coins (25th edition): Western Publishing Co., Racine, Wisconsin, 255 p.

ORIGIN OF DESERT VARNISH

Desert varnish, a smooth black coating that accumulates slowly on rock formations ranging from small boulders to cliffs hundreds of feet high, has puzzled naturalists for many years. On the underside, where it is not exposed to the air, a varnished rock often acquires a glossy red-orange finish through interaction with water and minerals in soil. Because of its striking appearance and widespread occurrence, the varnish frequently attracts attention, especially in national parks such as Grand Canyon and Zion where visitors query rangers about its cause.

For years scientists have assumed that desert varnish was composed primarily of manganese and iron oxides, precipitated out of the rock through weathering processes. However, the varnish structure eluded precise analysis because it is composed of particles too fine to be characterized by x-rays, the main diagnostic tool of mineralogical investigation.

Infrared spectroscopy, a technique which illuminates mineral samples with infrared light and records the pattern of absorbed wavelengths, was recently applied to the study of desert varnish by two Caltech scientists. George R. Rossman, associate professor of mineralogy, and Russel M. Potter, Caltech graduate student, used rock samples from 20 locations in California, New Mexico, and Arizona in the analysis of desert varnish. The samples included quartz, granite, basalt, rhyolite, quartzite, feldspar, and sandstone.

The results of the analysis revealed that the main constituent in desert varnish, totaling about 70%, is clay, not manganese and iron oxides. The oxides form the remaining 30%. The red coating on the underside of the varnished rocks, previously believed to be iron oxide, turned out to be 90% clay incorporating an iron oxide stain, similar to the iron in the black finish on the rocks' exposed portions. In addition it was found that all desert varnish, whether it formed on the side of a cliff or on a 10-inch boulder, shares a similar composition.

It was concluded that most of the coating collects from sources outside the rock rather than from material leached out of it, as many geologists had believed. One reason for this conclusion is that varnish is found covering non-manganese or iron bearing quartz crystals. Although some rocks may contribute oxides through weathering, the primary source seems to be wind deposited particles.

Fine, windblown clay particles are a critical ingredient in forming the varnish, which first forms on rough, porous surfaces. These surfaces allow dew and other moisture to collect, depositing a thin film of clay when the water evaporates. This film of sediment on the rock's surface encourages water to migrate through tiny pores inside the film, depositing traces of manganese and iron as the water evaporates.

The formation of desert varnish is interdependent upon the clay and oxides. The dry, fluffy clay particles depend on the oxides to form a resistant cementing agent. The oxides, in turn, require clay particles for transportation and deposition. This is the underlying reason why all desert varnish that was examined contained both clay and manganese and iron oxides – never one without the other.

...*Caltech.* ⚒

FRESH WATER UNDER THE SEA

— IN THE FAR EAST

Translated by NORMAN PRECODA
Santa Barbara, California

Geologists of the Primorye Territory are searching for fresh water under the sea. Nearly 60,000 years ago, according to their hypothesis, the sea advanced to inundate the lowland area between the mainland, and that area now called the Muravyev-Amur Peninsula, and along the channel of the Razdelnaya River which previously flowed to the Bosfor-Vostochnyy Strait. Squeezing the river, the sea formed a bay which now is called Amur Bay. The river gave way, but it survived under sea floor mud. There in the layers of conglomerate, the pure river water flowed. The fresh water source is almost in the center of the city—a gift to the Vladivostokians which is much desired.

But to find the river channel under the sea floor, is not an easy task. Geologists of the Primorye Geological Agency's Pacific Ocean Expedition are utilizing geophysical methods; special floating drilling installations have put out to search for the fresh water. ... From *OGONEK,* No. 22/ 1977, under the heading, "Vody...Pod Vody" USSR. ⚒

INDEX TO

MINERAL INFORMATION SERVICE

MINERAL INFORMATION SERVICE was changed to CALIFORNIA GEOLOGY in 1971 to emphasize the earth-sciences in California.

A PUBLICATION OF THE CALIFORNIA DIVISION OF MINES AND GEOLOGY

Volumes 21 – 23, 1968 – 1970

Compiled by Margaret W. Turner

Numbers following each entry indicate volume and page: v. 21, p.35.

A

B

C

THE ROLE OF RECYCLING IN CONSERVATION OF METALS AND ENERGY

Introductory Address at the 2nd Session on "Opportunities and Challenges in Metals Conservation and Substitution" held at the 1975 Materials Science Symposium, November 11–13 Cincinnati, Ohio.

By H. H. Kellogg

Stanley–Thompson Professor of Chemical Metallurgy
Henry Krumb School of Mines, Columbia Univ., N.Y.

This article is reprinted from the Journal of Metals (JOM), v. 28, no. 12, p. 29–32, by permission from the American Institute of Mining, Metallurgical and Petroleum Engineers, Inc.

Recycle of scrap is so often cited these days as a cure for the material and energy shortages that we face in the years to come that one is likely to picture recycle as a new idea, a new industry to be developed. In fact, scrap metal recycle has probably been practiced for as long as metals have been useful to man, and is now an established industry that handles millions of tons of scrap metal in the U.S. each year.

The recycle industry—or secondary metal industry, as it is frequently called—lacks the glamor of the primary metal industry. There are no dramatic discoveries of new ore–bodies, no huge mine pits, no mine disasters, no processing plants treating 100,000 tons per day of ore. For the most part, the metal recycle industry consists of many small operations, widely scattered throughout the country, with names that lack the familiarity of U.S. Steel, Alcoa, and Kennecott Copper Corp.*

The importance of metal recycle in the U.S. today can be understood by reference to Table 1 which shows the amount of scrap metal that was recycled in 1972, for eight major metals. We are dealing with an industry that recycles more than 45 million tons of metal each year. For lead, copper and silver, recycle accounts for about 41% of the total supply of metal to meet our consumption requirements. Almost one–third of our enormous requirement for raw steel is supplied by recycled scrap—excluding an additional large tonnage of "home" scrap recycled within the steel industry. The recycle rate for nickel, aluminum and magnesium is less but still represents a substantial contribution to total supply.

*Despite their concentration on production of primary metals from ore, these metal giants also play a significant role in scrap recycling.

NEW SCRAP

If the recycle industry already performs such an important part in our total metal supply, what lies behind the cry for greater scrap recycle? The data shown in Table II can help to answer this question. Here we see a split of total metal recycled into two categories—"new" or prompt industrial scrap, and obsolete scrap. "New" scrap is that resulting from metal fabricating industries in the form of trimmings, punchings, borings, imperfect products, drosses, sweepings, etc. Since such scrap is generated in large amounts in one location, it can usually be carefully segregated with respect to composition, and it finds a ready market for resale either to the primary or secondary metal industry. A recent study[2] estimates that recycle of most "new" scrap approaches 100% of that generated for most metals. Recycle of "new" scrap must be viewed, therefore, as a case where current economics and technology have combined to achieve a near to ideal conservation mechanism.†

†This probably overstates the case. There do exist examples of "new" scrap that is not recycled, or that is recycled only to degraded uses; the recycle industry does have problems with environmental pollution. In comparison with recycle of obsolete scrap, however, new scrap recycle offers little room for improvement.

Table I

CONTRIBUTION OF SCRAP RECYCLE TO TOTAL U.S. METAL
METAL CONSUMPTION 1972 *

METAL	U.S. CONSUMPTION TONS	RECYCLED SCRAP** TONS	SCRAP AS % OF TOTAL CONSUMPTION
LEAD	1,485,000	617,000	41.5
SILVER	5,258	2,157	41.0
COPPER (incl. Cu in Brass)	3,183,000	1,301,000	40.9
IRON and STEEL	133,200,000	42,200,000	31.7
ZINC (incl. Zn in Brass)	1,829,000	388,000	21.2
NICKEL	195,200	35,900	18.4
ALUMINUM	5,588,000	946,000	16.9
MAGNESIUM	115,100	15,700	13.6
TOTAL	145,600,000	45,506,000	31.2

* Based on Minerals Yearbook, 1972 (ref. 1).
** Sum of new and old scrap, but excludes "home" scrap.

OBSOLETE SCRAP

Obsolete scrap, or old scrap, consists of metal products (industrial or consumer) that have been in use, served their purpose and eventually are discarded. Such scrap runs the gamut from used rails, trucks, autos and heavy machinery to storage batteries, switchboards, and lamp–posts, to pots and pans, canoes and beer cans. As Table II shows, obsolete scrap recycle accounts for a much smaller amount of our total metal supply than the gross scrap recycle shown in Table I. Only 3–4% of our total supply of aluminum, magnesium and zinc, only 11–14% of our steel and copper, only 20% of our silver, comes from obsolete scrap. Lead and nickel seem to be special cases where the amount of recycled obsolete scrap considerably exceeds the recycle of new scrap, but the reverse case is more general.

It is the recycle of obsolete scrap that offers substantial new opportunities for conservation of material and energy resources. All of us know that our discarded beer can, or electric clock, or lawn chain, or washing machine is most likely to end in a not–so–sanitary landfill, provided it doesn't contribute to litter in backyards or along highways. Obsolete scrap recycle is the major theme of this paper—how it can be encouraged, and what contribution it could make to conservation.

Table II

"NEW" AND OBSOLETE SCRAP RECYCLE IN THE U.S., 1972*

METAL	"NEW" SCRAP RECYCLE TONS	OBSOLETE SCRAP RECYCLE TONS	OBS. SCRAP AS % OF TOTAL CONSUMPTION
LEAD	119,000	498,000	33.5
SILVER	1,091	1,066	20.3
NICKEL	5,500	30,400	15.6
COPPER	843,000	458,000	14.4
IRON and STEEL	27,200,000 (?)	15,000,000 (?)	11.3 (?)
ZINC	309,000	79,000	4.3
ALUMINUM	756,000	190,000	3.4
MAGNESIUM	12,500	3,200	2.8
TOTAL	29,246,000	16,260,000	11.2

* Based on Minerals Yearbook, 1972 (ref. 1).

OBSOLETE SCRAP THAT IS NOT RECYCLED

Any analysis of the potential for obsolete scrap recycle suffers from a lack of firm data on the amounts of such scrap generated each year. No one counts, weighs and analyses the metal going into landfills; no one counts the beverage cans that litter our highways. Estimates can be made, based on samples of municipal refuse. I have used, in Table III, estimates of yearly obsolete scrap availability made by Battelle.[2] Their methodology was to first estimate the average lifetime for the various uses to which metal is put (e.g. for lead: the average life cycle is 2.3 years for storage batteries, 0.2 years for tetra-ethyl lead, 20 years for oxide, 40 years for cable sheathing, 20 years for solder, 2 years for type metal, etc.) Next they found how much metal was used for each purpose at the time in the past equal to the average lifetime. If X tons of lead was used to make cablesheathing 40 years ago, than X tons of lead should become available as obsolete scrap this year. Certainly, such estimates are subject to uncertainty, but they are probably as reliable as can be obtained without a very costly inventory analysis.

Table III, which compares these estimates of total obsolete scrap generated to the actual recycle, tells the story of what still needs to be done to improve this mechanism of conservation. Only for stainless steel does the actual recycle of obsolete scrap exceed one–half of the total scrap generated. Only 4% of the available zinc and 13% of the available aluminum scrap was recycled. Even for lead, which placed No. 1 in Tables I and II as showing the largest contribution of scrap recycle to total metal supply, we find that 62% of the total available scrap was not recycled. Clearly, Table III shows that we have a long way to go to achieve optimum recycle of used metal products.

ENERGY REQUIREMENT FOR METAL PRODUCTION

One positive result of the recent concern over dwindling energy resources is the existence of a number of studies of the energy requirements for metal production. We have come to know that magnesium and aluminum, produced from ore, are very energy intensive on a unit weight basis. Fortunately, the low density of these metals renders them less energy intensive on a unit volume basis, but even on this basis they require considerably more energy for production than do steel or lead. Copper is the most energy intensive of the major metals (steel, aluminum, copper, lead, zinc) on a unit volume basis, mainly because of the heavy expenditure of energy in mining and concentration of very low–grade ore (average about 0.6% Cu). The energy requirements (unit weight basis) for production of primary metals from ore are shown in column 2 of Table IV, as determined in a new study by Battelle for the U.S. Bureau of Mines.[3]

To properly understand the role of metal recycle in conservation of energy resources we need a comprehensive and critical study of the energy used by the recycling industry similar to that for primary metals.* In the absence of such data, I have shown in column 3 of Table IV some crude estimates of my own. Even if my estimates err by 50%, which is possible, the data of Table IV will tell the same story—*it requires far less energy to produce secondary metal compared to primary metal.* The ratio of energy for production of primary metal to energy for production of secondary metal is of the order of 36/1 for magnesium, 20/1 for aluminum, and 6.2/1 for copper.

The recycling of scrap can take on various degrees of complexity, depending on the quality of the scrap. Processing of copper and brass scrap can be used to illustrate the spectrum of processing employed and the unit energy requirements. No. 1 grade uninsulated copper wire scrap requires only remelting and casting to wire bar. The energy for melting and casting is of the order of 3 million BTU/ton. Collection, sorting and transportation may add another 2 million BTU/ton. Well–segregated brass scrap also requires only cleaning, remelting and casting for recycle. The total energy use may be about 8–10 million BTU/ton of brass ingot recovered.

*Such a study is now being made by A. D. Little, Inc., under contract with U.S. Bur. Mines.

Table III

POTENTIAL AND ACTUAL RECYCLE OF OBSOLETE SCRAP*-U.S.,1969

METAL	ESTIMATE OF AVAILABLE OBSOLETE SCRAP, TONS	ACTUAL RECYCLE OF OBSOLETE SCRAP, TONS	% OBSOLETE SCRAP RECYCLED
STAINLESS STEEL	210,000	159,000	76
SILVER	2,620	1,100	42
COPPER (incl. Cu in Brass)	1,620,000	657,000	41
LEAD	1,320,000	497,000	38
NICKEL (excl. Stainless Steel)	84,500	25,000	30
ALUMINUM	1,330,000	175,000	13
ZINC (incl. Zn in Brass)	1,200,000	50,000	4.2

* Based on reference 2.

No. 2 grade copper wire scrap is lower in quality and contains some impurities that must be removed. It is melted and cast into anodes, electrolytically refined to cathodes, and then melted and cast into wire–bars. The total energy consumed is of the order of 15 million BTU/ton.

Finally, low–grade copper scrap, called "copper–bearing material," will consist of drosses, sweepings, old motors, telephone receivers, whole switchboards, mixed borings and trimmings and an unbelievable assortment of other junk. It will contain much iron, zinc, lead, tin, nickel, and precious metals. Processing begins with smelting in a cupola furnace to produce black copper, slag, and a fume rich in Zn, Pb and Sn. The black copper is next converted to blister copper, slag which is returned to the cupola, and more fume. The blister copper is partly refined in an anode furnace and cast into anodes. The anodes are electrolytically refined to cathodes, which are then melted and cast into wire–bars. The total energy requirement for this more intensive processing probably amounts to about 40 million BTU/ton. The value of 18 million BTU/ton used in Table IV is a weighted average for the various methods of copper scrap recycle.

EFFECT OF METAL NOBILITY ON SCRAP PROCESSING

The ability to recycle low-grade "copper–bearing material" and produce refined copper of a quality indistinguishable from primary refined copper is linked to the relatively noble nature of copper (i.e. copper forms oxides and other compounds that are weaker than the compounds of most of the impurities associated with the scrap—iron, lead, tin, nickel, zinc, aluminum, etc.). It is because of this noble nature that most of the iron, zinc, etc. can be selectively removed in the cupola and black–copper converter. Electrolytic refining is also made possible by the nobility of copper, and serves to separate the even more noble precious metals (gold, silver and platinum group) in the anode slime. Refining of low–grade scrap of silver and lead is similarly facilitated by the nobility of these metals.

At the other end of the spectrum, magnesium and aluminum are very reactive metals, selective oxidation cannot be used to remove impurities from scrap, and electrolytic refining in aqueous media cannot be employed. Processing of scrap of these metals is generally limited to clean, well segregated scrap, and impurities are controlled by dilution of the charge with pure primary metal.* Despite the use of segregated scrap and dilution with pure metal, secondary aluminum ingots are generally limited to special casting alloys and don't enjoy the unlimited market of primary aluminum.

Table IV

UNIT ENERGY FOR PRODUCTION OF PRIMARY AND SECONDARY METALS

METAL	10^6 BTU PER TON METAL: PRIMARY* FROM ORE	SECONDARY** FROM SCRAP	ENERGY SAVING FROM RECYCLE
MAGNESIUM	358	10	348
ALUMINUM	244	12	232
NICKEL	144	15	129
COPPER	112	18	94
ZINC	65	18	47
STEEL	32▲	13	19
LEAD	27	10	17

* From Battelle study for USBM, 1975 (ref. 3).
** Crude estimates by the author.
▲ Adjusted to basis of "home" scrap only.

We need new technology capable of removing impurities from low–grade aluminum scrap. Electrolytic refining in fused–salt media has been shown to be feasible, but it would be very costly, compared to current technology for remelting of clean scrap, and it would be very energy intensive, thereby reducing the energy advantage of scrap recycle shown in Table IV.

Iron is intermediate in reactivity between copper and aluminum. Selective oxidation is capable of removal of most impurities except copper and nickel. The build–up of the copper content of steel, scrap with this element, is a cause of concern and represents another example

*Magnesium is the only metallic impurity that can be removed from scrap aluminum by simple selective oxidation.

Table V

CURRENT YEARLY SAVING IN ENERGY FROM SCRAP RECYCLE-U.S., 1972

METAL	TOTAL SCRAP RECYCLE TONS	UNIT ENERGY SAVING 10^6 BTU/TON	ENERGY SAVED 10^{12} BTU
STEEL	42,200,000	19	802
ALUMINUM	946,000	232	219
COPPER	1,301,000	94	122
ZINC	388,000	47	18.2
LEAD	617,000	17	10.5
MAGNESIUM	15,700	348	5.5
NICKEL	35,900	129	4.6

TOTAL ENERGY SAVED 1182 x 10^{12} BTU

Energy Saving is 23 % of total energy actually used for production of these metals.

where new technology will be needed in order to recycle larger quantities of contaminated scrap.

CONSERVATION THROUGH SCRAP RECYCLE

The estimated energy saved in scrap recycle, from Table IV, has been applied in Table V to the total tons of scrap recycled in 1972. There results an estimate of 1.18 x 10^{15} BTU saved by recycle of the seven metals listed. This amounts to 23% of the total energy used for production of these metals (primary and secondary) for U.S. consumption. We find, therefore, that the saving of energy due to scrap recycle is only slightly less than the 31% saving in material resources indicated in Table I.

There remains the question of the potential for further conservation of material and energy resources through improved recycle of obsolete scrap. A crude approach to this problem is illustrated in Table VI, which simply lists the unrecovered obsolete scrap indicated by the data of Table III, and applies the unit energy savings from Table IV to these amounts of scrap. The totals show that complete recovery of scrap could add material amounting to 20% of our consumption of these seven metals, and save energy amounting to 18% of the energy now used to produce these metals.

These estimates contain many shortcomings. In the first place the estimates of unrecovered scrap are uncertain and apply to 1969 data. The unit energy savings are also uncertain estimates, and the assumption is made that the energy requirements for recycle of the additional scrap will be the same as that currently used for recycle. Finally, the unrecovered scrap amounts include many forms of scrap that are never likely to be recovered—lead used as tetra-ethyl lead and ammunition, zinc and lead used as oxide pigments, copper used as chemicals, etc.—because they have become so widely dispersed in the environment.

Table VI

POTENTIAL ADDITIONAL YEARLY SAVING IN ENERGY FROM "COMPLETE" OBSOLETE SCRAP RECYCLE

METAL	ADDITIONAL SCRAP RECYCLE TONS	UNIT ENERGY SAVING 10^6 BTU/TON	ENERGY SAVED 10^{12} BTU
STEEL	25,000,000	19	475
ALUMINUM	1,155,000	232	268
COPPER	963,000	94	90.5
ZINC	1,150,000	47	54
LEAD	823,000	17	14
NICKEL	59,500	129	7.7
MAGNESIUM	20,000	348	7

TOTAL ENERGY SAVED 916 x 10^{12} BTU

Saving is 18 % of total energy now used.

Despite these shortcomings, the estimates of Table VI provide a rough idea of what more efficient obsolete scrap recycle can hope to achieve. It can save a significant fraction of the material and energy resources that we now use. It cannot free us from dependence on primary resources —unless the day comes when our total demand for metals drops far below what it is today.

FACTORS THAT HELP OR HINDER INCREASED SCRAP RECYCLE

I conclude this brief discussion of conservation through scrap recycle by consideration of the factors that will help or hinder a greater degree of recycle than we now practice. Some of these are economic, some technical, and some involve social attitudes. Tables VII and VIII summarize these considerations. These are briefly discussed here, but the subject could easily result in a paper of this length for each of the metals considered.

The estimated percentage for current obsolete scrap recycle, shown in Table III, can be explained qualitatively by a balance among the factors listed in Tables VII and VIII.

Stainless steel heads the list because it combines a high price, easy recognition for collection and sorting purposes, and uses which are not (or were not in the period 1947–1958, when the metal which became obsolete in 1969 was put into service) highly dispersive. Large amounts of the metal were used by industry (aero-

Table VII

FACTORS THAT ENCOURAGE SCRAP RECYCLE

1. HIGH METAL PRICE:

	\$/lb
‣ SILVER	65.6
‣ NICKEL	2.0
‣ COPPER	0.64

2. EASE OF COLLECTION AND SORTING:
   - LEAD IN STORAGE BATTERIES, CABLE COVERING, TYPE METAL.
   - STEEL IN HEAVY MACHINERY, STRUCTURAL, RAILS, ETC.
   - COPPER AND BRASS BY COLOR.
3. EASE OF REFINING TO "PRIMARY" SPECIFICATIONS:
   ‣ SILVER ‣ COPPER ‣ STEEL ‣ LEAD

Table VIII

FACTORS THAT DISCOURAGE SCRAP RECYCLE

1. HIGHLY DISPERSED USES THAT INHIBIT COLLECTION AND SORTING:
   - COPPER WIRE IN SMALL MAGNETS, CARTRIDGE BRASS AND OTHER BRASS ITEMS.
   - ALUMINUM IN PACKAGING (CANS, FOIL, ETC.).
   - LEAD IN SOLDER, BEARING METAL, TEL, OXIDE AND CHEMICALS.
   - ZINC IN SMALL DIE CASTINGS, GALVANIZED IRON, OXIDE AND CHEMICALS.
   - NICKEL IN LOW-ALLOY STEELS, ELECTROPLATE.
   - SILVER IN PHOTOGRAPHIC MATERIALS, ELECTRICAL CONTACTS, JEWELRY.
2. REMOVAL OF IMPURITIES IS DIFFICULT (SCRAP MUST BE CLEAN AND SORTED):
   - ALUMINUM: ONLY Mg CAN BE EASILY REMOVED BY REFINING.
   - MAGNESIUM: CAN'T REMOVE BASER METALS, EXCEPT BY DISTILLATION OF Mg.
   - STEEL: Cu, Ni, S VERY DIFFICULT TO REMOVE.
3. ABANDONMENT OF THE PURITAN "THRIFT ETHIC":
   - DESIGN FOR CONVENIENCE AND APPEARANCE.
   - THE "DISPOSABLE" PRODUCT.
   - THE AFFLUENT SOCIETY.

space, construction and machinery, chemical, marine, trucks) from which obsolete scrap is easier to collect than from consumer uses. Finally, reprocessing of stainless steel scrap offers no unusual difficulties with respect to precise material specification, since small amounts of scrap can be added to melts that predominantly consist of primary materials.

Based on price alone we might expect silver recycle to far exceed that of copper. But Table III shows that they are recycled to about the same extent. Recycle of obsolete silver is undoubtedly restricted by the uses of this metal—photographic supplies, contacts in electrical devices, and jewelry—that disperse the metal so widely that collection, particularly of consumer scrap, is very difficult. Both copper and silver are readily reprocessed, once collected, and are easily refined to any desired specification.

Obsolete lead is recycled to almost the same extent as copper, despite a price which is only 25% of the price of copper. This certainly results from the major uses of lead in several massive forms (storage batteries, cable sheath and type metal) that are easy to collect. These three forms of lead scrap account for almost 85% of obsolete lead recycle. Reprocessing of lead offers no serious technical problems.

Substantial increase in obsolete lead recycle is likely to be limited by the near–to–impossible problems associated with collection of lead used as tetra–ethyl lead, lead oxide pigments, and ammunition. Probably the only effective means to save this metal is not to use tetra–ethyl lead or lead pigments in the first place, although we should carefully examine the conservation and environmental aspects of alternatives before deciding against lead use.

As far as ammunition is concerned, most of us could agree that the world would be a better place to live for both man and beast, if fewer arms were discharged except on firing ranges, and recovery of spent lead shot from ranges is both feasible and practical.

The very low recycle rate for zinc, shown in Table III, is associated both with low price and highly dispersive uses. All major uses of zinc are dispersive (small die castings, galvanizing and oxide pigments). About 20% of total obsolete die cast scrap is apparently recycled, but there is no recovery of zinc from galvanized scrap or pigment. Granted that pigment recycle is unlikely, it is by no means hopeless to recover zinc from galvanized scrap and to greatly increase the recycle rate for die castings.

The low recycle rate for obsolete aluminum is partly a problem of dispersive uses (cans, packaging, small consumer items) but also relates to technical difficulties associated with recycle of contaminated scrap referred to above. The fact that aluminum is our most used non–ferrous metal and that the primary metal is energy–intensive are sufficient justification for a thorough search for new refining technology for this metal.

As the years pass metal prices are likely to rise relative to other commodities and this should encourage scrap recycle. But even more important would be revival of "thrift" in our social consciousness. Children of my generation saved tin and lead foils in balls, and sold them to "junkies" (a different sort than the name now implies) who plied the street with pushcarts or an old horse and wagon. Our post World War II affluent society has promoted the opposite—the "disposable" bottle, can, turkey roaster, tablecloth, etc. Even our so–called durable consumer commodities are more often designed for appearance and convenience than for long life and ease of repair, with the result that they are converted to unrecycled scrap after an all–too–short lifetime. Not being a sociologist I can't offer suggestions on how these attitudes can be reversed, but reversed they must be if we are to have a viable future for materials and energy in the 21st Century.

REFERENCES

[1] *Minerals Yearbook.* 1972. U.S. Bureau Mines, 1974.

[2] *A Study to Identify Opportunities for Increased Solid Waste Utilization,"* researched by Battelle Institute for NASMI and EPA. Nat. Tech. Inf. Service PB–212730 1972.

[3] *"Energy Use Patterns in Metallurgical and Nonmentallic Mineral Processing,"* Phase 4 report, June 27, 1975, NTIS PB 245 759/AS; Phase 5 report, Sept. 16, 1975, NTIS PB 246 357/AS, researched by Battelle Institute for U.S. Bur. Mines.

BOOK REVIEWS

All books reviewed in this section are on file in the California Division of Mines and Geology library in San Francisco, Room 2022, Ferry Building.

Rambles in King's River country. By John Muir, with a foreward by Alan Ross. Published by and available from Lewis Osborne Limited Editions, Post Office Box 647, Ashland, OR 97520. 64 p. $25; hard cover.

This limited edition (600 copies) presents the writings of John Muir as he recounts his explorations of the region south of Yosemite during the 1890s. An introduction to the text presents a biographical sketch of Muir, including his childhood in Scotland, his youth in rural Wisconsin, and his rise to regional fame as an inventor of machinery in the midwest.

The book has fourteen wood-engraved illustrations of Sierra scenes, a portrait of Muir as a young man, and a map of the Kings River environs drawn about 1891.

Advanced mechanics of materials, second edition. By Sir Hugh Ford and J.M. Alexander. 1977. Available from the Halsted Press, a Division of John Wiley and Sons, Inc., 605 Third Avenue, New York, NY 10016. 672 p. $27.50, hard cover.

This revised edition of a text first published in 1963 presents a thorough treatment of the stresses in, and the deformations of, engineering materials. Emphasis is placed on stress and strain analysis, the former as a branch of statics and the latter as the geometrical relationships between displacement and strains. Other general topics covered in the text include the application of the theory of elasticity and the theory of plasticity to engineering problems. The text offers a comprehensive course for advanced undergraduate and graduate study, and a systematic coverage for professional engineers in research and development.

The Tertiary gravels of the Sierra Nevada of California. By W. Lindgren. 1911 (reprinted 1977). Reprint of U.S. Geological Survey Professional Paper 73. Reprinted by and available from American Trading Company, P.O. Box 1312, Bellevue, WA 98009. 226 p. Paperback. Write to publisher for price list and catalog.

Tertiary gravels of the Sierra Nevada of California was first published in 1911 and copies from the original printing have become rare. This classic of California geological literature describes the Tertiary formations of the Sierra Nevada with emphasis on the origin and distribution of the gold-bearing gravels. The printed pages, maps, and illustrations have been reproduced consistent with the original copy.

This professional paper reprint will appeal to anyone interested in the gold mining history of the Sierra.

Manual of Mineralogy (after James D. Dana); 19th edition. By Cornelius S. Hurlbut, Jr., and Cornelis Klein. 1977. Published by and available from John Wiley and Sons, Inc., 605 Third Avenue, New York, NY 10016. 532 p. $19.95; hard cover.

The *Manual of mineralogy* was written in 1848 by James D. Dana and has had more than 19 editions, since some reprintings in the 1880s and 1890s were not given an edition number.

This revised edition of the work known as *Dana's Manual of Mineralogy,* is designed for the beginning course in mineralogy and as a permanent mineralogic reference. Topics discussed in the text include the symmetry of ordered patterns, morphological crystallography, crystal chemistry and crystal structure, x-ray crystallography, chemical composition of minerals, physical and optical properties of minerals, systematic mineralogy of the major mineral groups, and an introduction to petrology.

Story of the great American West. 1977. Published by and available from The Reader's Digest Association, Inc., Pleasantville, NY 10570. 384 p. $12.99; hard cover.

This book presents a well illustrated one-volume history of the West. In addition to many paintings by artists of the early West—Bierstadt, Bodmer, Catlin, Lesueur, Miller, Remington, and Russell—the volume contains some of the first photographs ever taken of the West and its homesteaders. Some of the topics, with both text and appropriate illustrations, include: The beckoning of the West; To the Mississippi and beyond; Texas and the Great Southwest; The California Gold Rush; Civil War and Indian Wars; Building of the Transcontinental Railroad; The Plains; and The Coming of Age of the West.

Ores in sediments. Edited by G.C. Amstutz and A.J. Bernard. 1977 (reprint; original copyright 1973). Published by and available from Springer-Verlag New York, Inc., 44 Hartz Way, Secaucus, NJ 07094. 350 p. $23.80; soft cover.

The book contains papers presented at the VIII International Sedimentological Congress held in Heidelberg, Germany in 1971. The main theme of the articles discusses the diagenetic behavior or role of ore minerals. Most of the papers also refer to the facies and paleogeographic relations of ore mineral formation. Main topics presented in the text include reduzate deposits, oxidate deposits, sulphate and phosphate deposits, and detrital deposits (placers, sands).

Mining and mineral operations in the Pacific states: a visitor guide. By U. S. Bureau of Mines, State Liaison Officers. 1976. Published by U. S. Printing Office. Order from Public Documents Distribution Center, Department 25-P, Pueblo, CO 81009. Specify S/N 024-004-01872. 80 p. $2.15; booklet.

This illustrated guide book is one of six visitor guides covering mining operations in the U. S. The booklet presents highlights about mines and mineral operations in Alaska, California, Hawaii, Oregon, and Washington that travelers can see along highways. Selected references are included.

Geochemistry and the environment; volume II, the relation of other selected trace elements to health and disease. 1977. Published by and available from the National Academy of Sciences, 2101 Constitution Avenue, Washington, D.C. 20418. 163 p. $12.00; soft cover.

This volume, the second in a three part series concerning geochemistry and the environment, considers the possible relationships between the geographic distribution of certain elements and patterns of disease. This report is the result of a workshop at Capon Spring and Farms, Capon Springs, West Virginia held during May, 1973. Topics discussed by the contributing authors include trace elements related to health and disease, and the geochemical environment and man.

Annual review of energy, volume 2. Edited by Jack M. Hollander, Melvin K. Simmons, and David O. Wood. 1977. Published by and available from Annual Reviews, Inc., 4139 El Camino Way, Palo Alto, CA 94306. 522 p. $17.00; hard cover.

Volume 2 of *Annual Review of Energy* presents 20 papers by 28 authors. The first part of the book contains analyses of issues that define the international and global aspects of energy. Topics include world energy resources, the role of multinational oil companies in world energy trade, and the impact of the production and use of energy in the global climate. The second part of the volume presents articles on regional perspectives in such countries as China, India, Japan, U.S.S.R., Sweden, and regional organizations such as the European Community, and the Organization of Arab Petroleum Exporting Countries.

The origin of sediments and sedimentary rocks. By Wolf v. Engelhardt. 1977. Available from John Wiley and Sons, Inc., 605 Third Avenue, New York, NY 10016. 359 p. $49.50; hard cover.

This revised second edition is part III in a series on sedimentary petrology. The text, which presumes an understanding of the petrographic description of sedimentary rocks, attempts to explain what happens in the sedimentary domain by relating the extremely complex natural processes to simple models.

Topics discussed in the text include parent materials, weathering, transport and deposition of clastic constituents, formation of chemical sediments, and diagenesis. The book is designed for advanced students of geoscience and researchers in sedimentary petrology.

Staff reviews.

CDMG OPEN-FILE REPORTS

The following open-file reports have been released by the California Division of Mines and Geology.

OFR 77-11 SAC

A microearthquake survey of the Rocklin-Penryn pluton in the Sierra Nevada foothills west of Auburn, California. By Chris H. Cramer, Roger W. Sherburne, Tousson R. Toppozada, and David L. Parke. October, 1977. 29 p., 3 tables, 8 figures.

This report presents the detailed results of seismic monitoring conducted in the autumn of 1976 and briefly covered in previous CALIFORNIA GEOLOGY articles (January 1977, p. 16; June 1977, p. 140). Besides covering current seismic activity in the vicinity of the pluton, the results of a shallow refraction study and a review of historical earthquake activity are also presented.

OFR 77-16 SAC

A mineral land classification study of the Stanislaus River area, San Joaquin and Stanislaus Counties, California. By John S. Rapp, Ralph C. Loyd, and Michael Silva. November 1977. 93 p., 4 plates, scale 1:48,000.

The California Division of Mines and Geology (CDMG), pursuant to Resolution No. 16 of the State Mining and Geology Board, has conducted a pilot study to classify the sand and gravel resources along the lower Stanislaus River. This pilot study was designed to develop and test methodology, investigative techniques, and staff time requirements to classify land based on its content of mineral deposits following the State Mining and Geology Board's "Guidelines for Classification and Designation of Mineral Lands."

The study area lies along the Stanislaus River From Goodwin Dam to the Junction with the San Joaquin River. The study area is underlain by a series of terrace and alluvial fan deposits which were deposited by the Stanislaus River during Pleistocene time. Sand and gravel deposits contained in the Pleistocene units and the Holocene stream channel deposits are potential aggregate resources, depending on rock quality and depth of occurrence.

Water well logs were the primary sources of subsurface information for the study. Where sufficient well log data existed, computer analysis of the data identified the distribution of potential aggregate material. This information was combined with geologic data and laboratory test results of rock material to assign Mineral Resources Zone Classifications.

A maximum of 1.2 billion tons of potential aggregate resources was delineated in the Stanislaus River study area.

OFR 77-17 SAC

Principal facts and sources for 1,820 gravity stations on the Alturas $1° \times 2°$ quadrangle, California. By R. H. Chapman, C. C. Bishop, and G. W. Chase. September, 1977. 53 p., 1 figure (A-H).

Basic data for 1,820 gravity stations on the Alturas $1° \times 2°$ quadrangle, California, are given in 5 separate tables. Also included in the report are a brief summary of the format used, information on the individual data sets including sources, station location plots at a scale of 1:250,000, and information on 14 base stations. Complete Bouguer anomalies have been computed for all stations using reduction densities of 2.67 g/cm^3 and 2.50 g/cm^3.

OFR 77-18 SAC

Principal facts and sources for 666 gravity stations on the Needles $1° \times 2°$ quadrangle, California. By R. H. Chapman, J. D. Rietman, and S. H. Biehler. December, 1977. 34 p., 1 figure (A-H).

Basic data for 666 gravity stations on the Needles $1° \times 2°$ quadrangle, California, are given in three separate tables. Also included in the report are a brief summary of the format used, information on the individual data sets including sources, station location plots at a scale of 1:250,000, and information on seven base stations. Complete Bouguer anomalies have been computed for all stations using reduction densities of 2.67 g/cm^3 and 2.50 g/cm^3.

These reports are available for reference at the Sacramento, San Francisco, and Los Angeles District Offices. The reports may be purchased through a bonded blueprint or reproduction service. The reproducible masters are available in the Sacramento District Office only.

GEOLOGIC MAP OF CALIFORNIA

A new GEOLOGIC MAP OF CALIFORNIA (Map No. 2 in the Geologic Data Map series) has been published by the California Division of Mines and Geology. The map was compiled by Charles W. Jennings with assistance from R. G. Strand and T. H. Rogers. Preparation of this comprehensive map culminates nearly 10 years of careful and extensive research which involved the cooperation of numerous State and Federal agencies, academic institutions, private geological firms, and consultants.

Published as a single sheet at 1:750,000 scale (1 inch = 12 miles), this 4 1/2 x 5 foot map is an ideal size for wall display. Its bright colors permit easy recognition, even at a distance, of the most prominent rocks and structures found in the state.

This map was created as a ready reference tool of high quality for use by public officials, industry, libraries, consultants, students, and educational institutions seeking information on the geology of California.

Besides information as to the types of rocks and their distribution in the state, the map clearly depicts faults, folds, volcanoes, and for the first time on a state geologic map of this relatively large scale, offshore geologic structure.

The 1977 edition of the GEOLOGIC MAP OF CALIFORNIA (Geologic Data Map No. 2) is a companion to the FAULT MAP OF CALIFORNIA (Geologic Data Map No. 1) published in 1975.

The Geologic Map of California (scale 1:750,000) is available with topographic contours (500-foot intervals) or without contours.

Map prices are:

Colored, with or without topography	
Over the counter, rolled	$8.00
By U.S. mail, rolled in a tube	$9.50
Uncolored	
Over the counter, rolled	$4.00
By U.S. mail, rolled in a tube	$5.50

Order from California Division of Mines and Geology, P.O. Box 2980, Sacramento CA 95812. Make checks payable to the California Division of Mines and Geology. Over the counter purchases can be made at CDMG District offices in Sacramento, San Francisco, and Los Angeles. California residents add 6% sales tax for orders sent to a California address.

CDMG LIST OF AVAILABLE PUBLICATIONS UPDATED

The following list of additions and out of print items is printed here to update the 1977 CDMG List of Available Publications. Please refer to this list before ordering publications from CDMG. Additional copies of the list are available free from all district offices and from the mail order address (see p. 71).

ADDITIONS

SPECIAL REPORT

SR134 EROSION ALONG DRY CREEK SONOMA COUNTY, CALIFORNIA $3.00
By G.B. Cleveland and F.R. Kelley.

COUNTY REPORT

CR8 ALPINE COUNTY, MINES AND MINERAL RESOURCES OF. *(with map)* $3.50
By William B. Clark. 1977.

COUNTY MAP

ALPINE 1977. Mines and mineral deposits *(included in CR8)* $1.00

SPECIAL PUBLICATION

SP51 STATE POLICY FOR SURFACE MINING AND RECLAMATION PRACTICE ..... FREE
Prepared by the California State Mining and Geology Board

MAP SHEET

MS29 GEOLOGY OF THE NATIONAL CITY, IMPERIAL BEACH AND OTAY MESA QUADRANGLES, SOUTHERN SAN DIEGO METROPOLITAN AREA, CALIFORNIA $6.00
By M. P. Kennedy and S. S. Tan. 1977

BOUGUER GRAVITY ATLAS OF CALIFORNIA, SCALE 1:250,000

SAN JOSE. By S.L. Robbins, H.W. Oliver, and K. Holden. 1975 ..... $4.00

GEOLOGIC ATLAS OF CALIFORNIA, SCALE 1:250,000

SAN DIEGO—EL CENTRO. Compiled by R.G. Strand. 1962
flat or folded colored $2.50
flat only, uncolored $1.50

GEOLOGIC MAP OF CALIFORNIA, SCALE 1:750,000

Geologic Data Map #2 Compiled by C.W. Jennings. Assisted by R.G. Strand and T.H. Rogers.
Colored edition, with or without topography:
Over the counter, rolled $8.00
By U.S. mail, rolled in a tube $9.50
Uncolored edition:
Over the counter, flat only $4.00
By U.S. mail, rolled in a tube $5.50

OUT OF PRINT

B189 MINERALS OF CALIFORNIA
B190 GEOLOGY OF NORTHERN CALIFORNIA
SR4 GEOLOGY OF THE SAN DIEGUITO PYROPHYLLITE AREA, SAN DIEGO COUNTY, CALIFORNIA.
SR8 TALC DEPOSITS OF STEATITE GRADE, INYO COUNTY, CALIFORNIA
SR43 GEOLOGY OF A PORTION OF THE ELSINORE FAULT ZONE (RIVERSIDE AND SAN DIEGO COUNTIES), CALIFORNIA.
SR74 INDEX TO GRADUATE THESES ON CALIFORNIA GEOLOGY TO DECEMBER 31, 1961.
CR1 KERN COUNTY, CALIFORNIA, MINES AND MINERAL RESOURCES

COUNTY MAPS: ► FRESNO ► MARIPOSA ► NAPA ► SISKIYOU

QUADRANGLE MAPS: ► BARSTOW 30' QUADRANGLE ► BIG PINE 15' QUADRANGLE

CALIFORNIA EARTHQUAKE CATALOG

A catalog of information on 40,000 earthquakes that have shaken California between 1900 - 1974 has been released by the California Division of Mines and Geology. The new catalog in the form of a magnetic tape (7- or 9-track, BCD, 800 bpi, even parity) with a short text gives the earthquake history of all areas in the state. It is useful to seismologists for research and for assessing the severity of future earthquake damage at any specific locality.

For the period 1900 through 1931, before statewide seismographic coverage was established, only earthquakes of magnitude about 4 or greater are included. The 517 earthquakes that fall in this category were studied by CDMG and are described in Special Report 135 (in press). For the period 1932 through 1974, the catalog combines information on events of all recorded magnitudes from the University of California Berkeley, the California Institute of Technology, and the U.S. Geological Survey records.

For each earthquake the catalog has the date, time, epicenter location, focal depth, magnitude, maximum intensity, felt area, and source of information. Records of destructive earthquakes also include the number of lives lost and estimated damage in dollars. Updated editions of the catalog will be released about once a year and will include new information that is being collected continuously by Division seismologists.

For users without a digital computer, and for library use, a microfiche version of the earthquake catalog will be available. All future editions of the earthquake catalog will be announced in CALIFORNIA GEOLOGY.

The Earthquake catalog of California 1900 - 1974 — Magnetic Tape, on either 7- or 9-track tape, can be obtained by mail or in person from California Division of Mines and Geology, Sacramento District 2815 "O" Street, Sacramento, CA 95816. It costs $45.00 (plus 6% tax for California orders) prepaid for U.S. orders, and $80.00 prepaid for foreign orders.

MAIL ORDER FORM

PLEASE NOTE: Orders for all books and maps to be sent to a California address must include 6% sales tax.

PRICE CORRECTION FOR CR5, misquoted in the December 1977 order form. CR5 Monterey County mines and mineral resources is $5.00 plus tax.

BULLETIN
_____B193 Gold districts of California $6.50

SPECIAL REPORT
_____SR81 Geology of the Lockwood Valley area, Kern and Ventura Counties, California $2.00
_____SR113 Geologic hazards in southwestern San Bernardino County, California $15.00

SPECIAL PUBLICATION
_____SP38 Site characteristics of southern California strong-motion earthquake stations $2.00
_____SP42 Fault hazard zones in California $1.00
_____SP47 Active fault mapping and evaluation program—10-year program to implement Alquist–Priolo Special Studies Zones Act $2.00

PRELIMINARY REPORT
_____PR14 Geology and mineral resource study of southern Ventura County, California $7.00

GEOLOGIC ATLAS OF CALIFORNIA. Scale 1:250,000
_____Needles Sheet. Colored $2.50. Uncolored $1.50.

GEOLOGIC MAP OF CALIFORNIA. Scale 1:750,000
Map #1 Geologic Data Map. Fault map of California with locations of volcanoes, thermal springs, and thermal wells.
_____Folded $5.00, Rolled $6.50.
Map #2 Geologic Data Map. Companion to the Fault map of California.
Colored edition, with ☐ or without ☐ topography.
_____By U.S. mail, rolled in a tube $9.50

Uncolored edition
_____By U.S. mail, rolled in a tube $5.50

_____CALIFORNIA GEOLOGY $3.00 per calendar year, no tax.
☐ New ☐ Renewal
Maximum subscription is 2 years
☐ $3.00 for 1 year ☐ $6.00 for 2 years

$_____Total amount enclosed
NAME _____
ADDRESS _____
CITY _____
STATE _____ ZIP _____

Address all orders to the California Division of Mines and Geology, P.O. Box 2980, Sacramento, California 95812. **NO CASH.** Checks and money orders should be made payable to the Division. Your order/subscription can not be processed unless correct amount is remitted. ALL *FOREIGN* AND *CANADIAN* ORDERS MUST BE PROCESSED BY AN INTERNATIONAL MONEY ORDER OR DRAFT PAYABLE ON/AGAINST A UNITED STATES BANK.

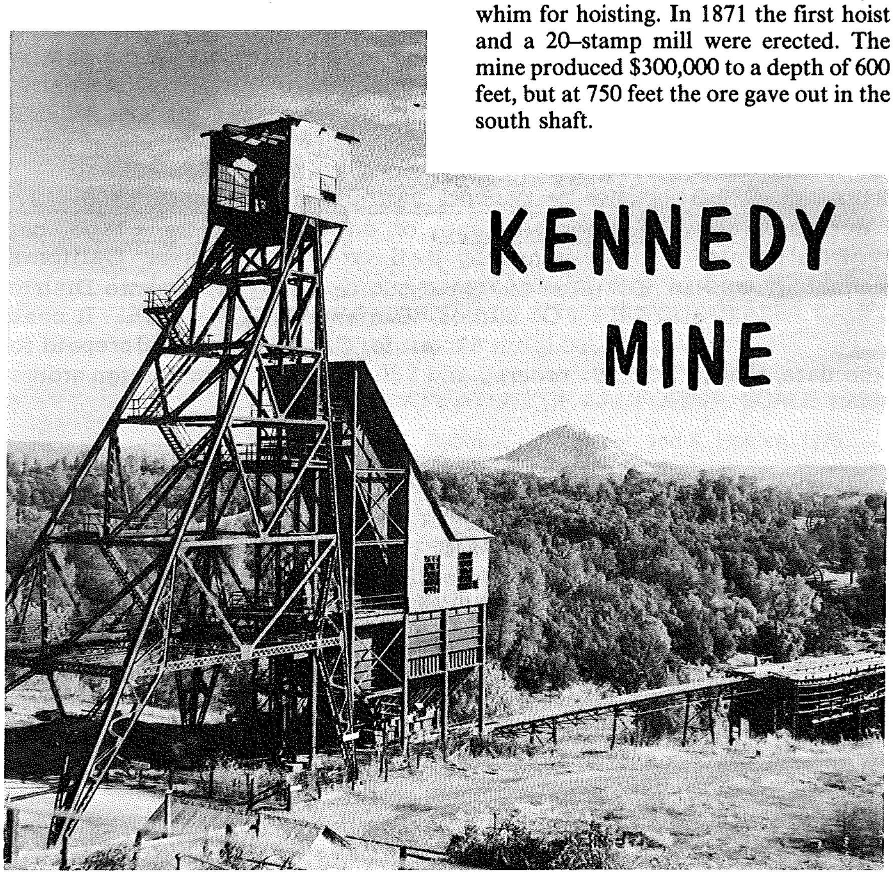
76164-650 2-78 16M

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF CONSERVATION

CALIFORNIA DIVISION OF
MINES AND GEOLOGY
P. O. BOX 2980
SACRAMENTO, CALIFORNIA, 95812

RETURN POSTAGE GUARANTEED

KENNEDY MINE



Located in the Mother Lode county of Amador, the Kennedy Mine was, at one time, considered the deepest vertical shaft gold mine in the country. The Kennedy was opened around 1856 but until 1871 was worked on a small scale, with only a whim for hoisting. In 1871 the first hoist and a 20–stamp mill were erected. The mine produced $300,000 to a depth of 600 feet, but at 750 feet the ore gave out in the south shaft.

The mine was reopened in 1885, the south shaft was sunk 200 feet deeper, ore was found, and this shaft was continued on the incline to a depth of 2276 feet. The results were so satisfactory that a new vertical shaft was started 1950 feet east of the north shaft to cut the vein at great depth. It struck the east vein at 3680 feet, the west vein at 4000 feet, and was continued to 4764 feet. It is claimed that the shaft was constructed with such craftsmanship, that a plumb–bob would not indicate an error in alignment of over one–quarter of an inch. Later an inclined winze was extended from the 4650–foot level to a depth of 5912 feet vertically.

Geology of the Kennedy indicates the best ore, taken as a whole, is the banded or ribbon rock, consisting of hard white quartz with numerous ribbons of finely ground slate and often ribbons of pyrite and galena, showing building up of the vein by repeated opening of the fissure and deposition of successive layers of quartz with 1% to 2% pyrite and galena.

There are 150 miles of underground workings in the Kennedy from which 75,000 gallons of water was hoisted every 24 hours, in special bailing skips.

Records show the mine, closed in 1942, produced $34.28 million in gold but since production records were not kept prior to 1880 this figure could be much higher....From *AMERICAN GOLD NEWS*. February 1976 ⚒

NEW STATE GEOLOGIST . . .

The appointment of Dr. James F. Davis as the new State Geologist of California has been announced by Dr. Priscilla C. Grew, Director of Conservation. Dr. Davis will assume the position in mid-March. Thomas E. Gay, Jr., who has been interim State Geologist, will return to his former position as Chief Deputy State Geologist. ⚒