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October 1974

Man-made Diversion of Furnace Creek Wash
Zabriskie Point, Death Valley, California

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California Geology, the monthly publication of the California Division of Mines and Geology, reports on the progress of earth science, especially in California, and informs the public of discoveries of interest and concern to their lives and livelihood in geology, mining, seismology, paleontology, mineralogy, and allied earth sciences. Correspondence to the editors should be addressed to *California Geology*, 1416 Ninth Street, Room 1341, Sacramento 95814.

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IN THIS ISSUE **October 1974 / Volume 27 / Number 10**

CDMG NAMES NEW DEPUTY

Thomas E. Gay, Jr., has assumed new duties as chief deputy state geologist, the second-ranking executive position for the California Division of Mines and Geology.

Gay previously was Sacramento district geologist. He obtained his master's degree in geology from the University of California, Berkeley, and also has a master's degree in public administration from Golden Gate College, San Francisco.

A native Californian, Gay has been with the division since 1950. During that time, he has served in all division offices. In San Francisco, he was the Program Manager of the Information and Education Program.

In the Sacramento headquarters office he was a member of the Planning Group. From 1969-71, he was on temporary assignment to the Interagency Council for Ocean Research, working on the comprehensive ocean area plan.

Gay is one of the authors of the *Urban Geology Master Plan for California*, recently issued as CDMG Bulletin 198. He has performed field mapping for the Geologic Map of California project, and has worked extensively on economic mineral deposits.

He is presently on the Aggregate Resources Management Technical Advisory Committee for Sacramento County. ⚒

Figure 1. Oblique aerial photograph oriented west-southwest, showing most of drainage area of Furnace Creek Wash (foreground). Dashed line bounds approximate area of drainage onto Furnace Creek fan (FF) since the diversion. Zabriskie Point (Z), Black Mountains (B), Funeral Mountains (F). Death Valley (D), Panamint Range (P), Furnace Creek Wash (FW). Gower Gulch, too small to indicate, extends between (Z) and a very small fan on south (left) edge of Furnace Creek fan. *Photo courtesy of U.S. Geological Survey – U.S. Air Force.*

Man-made Diversion of Furnace Creek Wash

Zabriskie Point, Death Valley, California

By Bennie W. Troxel
Geological Society of America
Boulder, Colorado 80301

INTRODUCTION

Furnace Creek Wash enters the floor of Death Valley at the head of a large alluvial fan near Furnace Creek Inn, a resort at the north tip of the Black Mountains. Until a major portion of the surface flow from the normally dry creek was diverted into Gower Gulch three decades ago, it drained some 200 square miles of land (figure 1) that ranges in elevation from sea level, at Furnace Creek Inn to 6,700 feet in the Funeral Mountains. Gower Gulch originally drained about 2 square miles. Annual precipitation ranges from probably more than 10 inches in the higher area to about 1.8 to 2 inches at Furnace Creek Inn. Much of the precipitation falls during short periods of heavy rainfall.

Most of the mountainous part of the drainage area contains barren rock that is moderately impermeable and readily produces runoff during storms. The channels in the canyons and washes contain coarse gravel that is usually several feet to a few tens of feet thick and nearly everywhere is dry and loose. Slopes of many of the mountains contain appreciable amounts of debris that is easily eroded.

The combination of occasional rapid, heavy runoff, abundant loose material, and moderately steep gradients in the stream beds affords a high potential for erosion and debris transport during the heavy flows of runoff events.

Diversion of Furnace Creek into Gower Gulch reportedly was made in 1941 as a flood-control measure. It was accomplished by making a small cut into the soft, fine-grained sediments of the Pliocene Furnace Creek Formation, which crop out along the low, narrow divide along the southwest side of Furnace Creek Wash at the upstream base of Zabriskie Point. A gravel barrier was placed diagonally across Furnace Creek Wash at the downstream side of the cut, and waters from the wash were thus diverted into a tributary channel of Gower Gulch.

Before the diversion, Furnace Creek Wash carried intermittent flood waters to the floor of Death

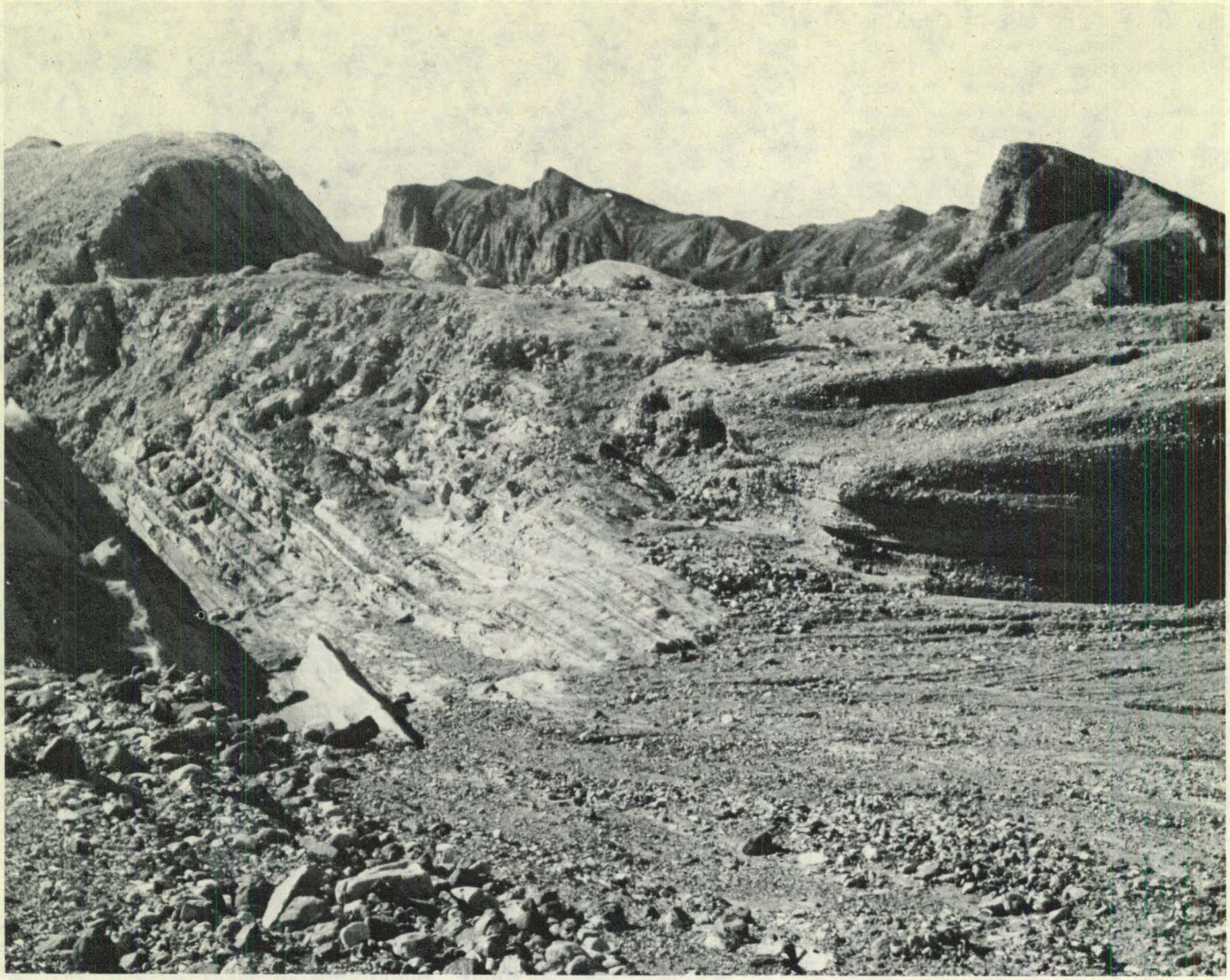

Figure 2. Incised channel of Gower Gulch at the diversion point on southwest side of Furnace Creek Wash. Channel is about 15 feet deep at edge of wash in foreground.

Valley in a stream system that appeared to be in balance. By gradual growth, the fan at the mouth of the wash accommodated the material that was being carried along the stream, and the channel system was well integrated so that no areas of unusual erosion or deposition were obvious in the drainage system. Tributary streams entered the wash at grade throughout the system except in local areas where recent flash floods had downcut a local segment of the main channel, thus leaving the channels of tributary streams temporarily at a higher level than the main channel.

Gower Gulch, too, in spite of its much smaller size, was apparently in balance throughout its channel, which flows onto a very small alluvial fan in Death Valley.

Gower Gulch and Furnace Creek Wash have the same ultimate base level (-282 feet at Badwater), but because of the elevation of the head of the fans, Gower Gulch debouches onto the apex of its fan at about - 100 feet elevation, and Furnace Creek drains onto its fan at about sea level. The channel of Gower Gulch is a few tens of feet lower in elevation than Furnace Creek Wash at Zabriskie Point. The large, through-going Furnace Creek channel was at grade at a higher elevation than the small Gower Gulch. The result of a diversion from a higher and larger channel into the lower channel resulted essentially in the development of the equivalent of a waterfall that concentrated strong erosive force on the point of diversion (figure 2).

Thus the diversion at Zabriskie Point was done by man in a setting where stream capture would occur within a geologically short time, and the system was ready to respond immediately and strongly to the change. The magnitude of the changes in stream regimen is a function of the size of floods and their frequency. Several floods have occurred since the diversion, some with peak flows of several thousand cubic feet per second.

A

B

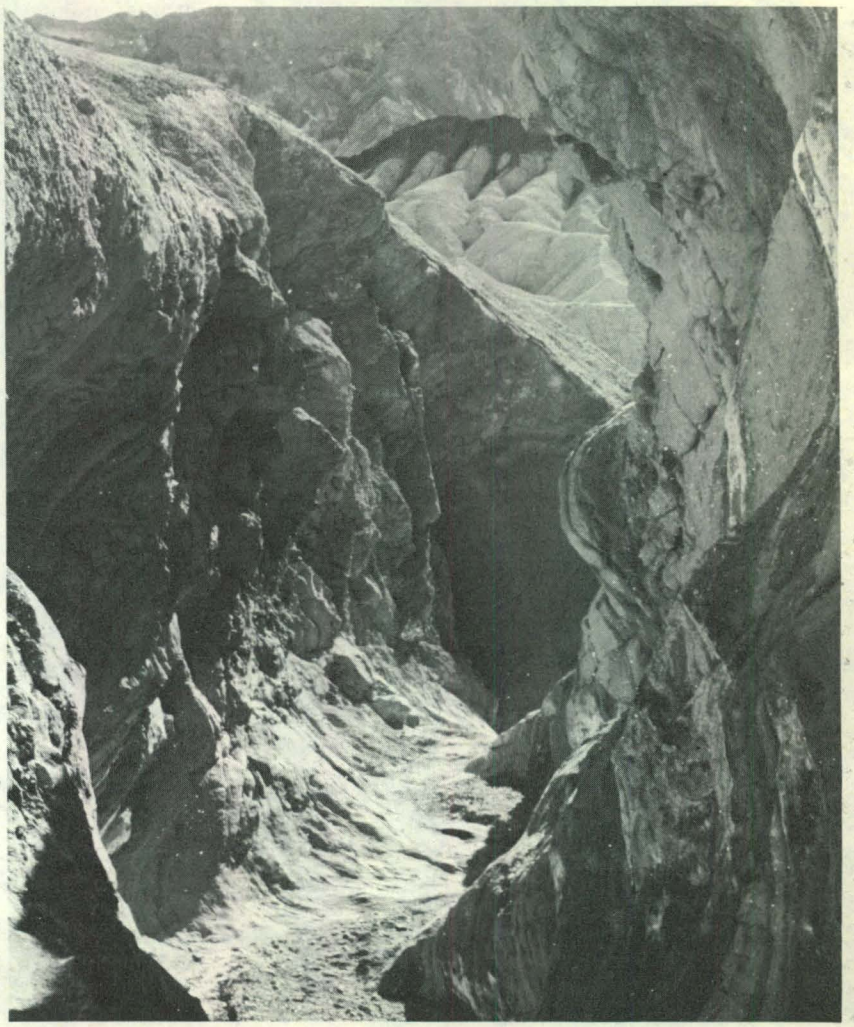

Figure 3. A. Incised channel at mouth of Gower Gulch (view downstream). B. Steep-walled channel in Gower Gulch a few feet downstream from diversion point (view downstream). Rocks are steeply inclined fine-grained sediments of Furnace Creek Formation.

EFFECTS

By abruptly increasing its drainage area from about 2 square miles at low altitude to about 170 square miles at altitudes as great as 6,700 feet, the diversion has placed an extraordinary burden on Gower Gulch. The effect of this sudden influx of large volumes of water and debris during flood periods has, in only the 30 years or so since the diversion, resulted in significant erosion and deposition. The erosion appears to be accelerating, but this may be illusionary because of the occurrence of some floods of larger-than-usual magnitude during the past few years. For example, during July 1968, a local storm centered in the southern part of the Furnace Creek drainage produced a peak flow of 7,000 to 10,000 cubic feet per second, which deepened the channel at the diversion several feet and caused appreciable scour (figure 3) in the channel.

Figure 4. Hanging tributary channels in Gower Gulch at southeast base of Zabriskie Point.

The floor of Gower Gulch has been lowered (figure 4) and widened by the accelerated erosion; the fan at the mouth of Gower Gulch has been incised 10 to 15 feet (figure 5) in what appears to be an extension of the stream channel across the fan (none of the adjacent fans shows such deep channeling); gravel from Furnace Creek Wash now coats the channel of Gower Gulch (figure 4); tributary stream channels in Gower Gulch are hanging 1 or more feet above the level of the main channel (figure 4); lateral erosion of stream walls in Gower Gulch is accelerating by collapse after they have been undercut; and the lower reach of the Gower Gulch fan is growing more rapidly because of the increased volume of debris now being contributed to it.

Furnace Creek Wash Furnace Creek Wash has become deeply incised at the point of diversion (figure 6) and headward erosion has migrated 1.7 miles upstream, as evidenced by hanging tributary stream channels; headward erosion is cutting a new drainage system into the floor of Furnace Creek Wash (figure 6); headward erosion is vigorously attacking State Highway 190 at a point across Furnace Creek Wash from the diversion (figure 6A), and at several points for some distance upstream.

The segment of Furnace Creek Wash below Zabriskie Point is receiving much less flood water, and as a result, the channel and fan will receive less debris.

Ground water. The diversion is conceivably causing adjustments in ground-water storage and movement but the changes are apt to be slow and certainly cannot be detected without careful monitoring.

One obvious change that probably is occurring because of the loss of 80 percent of the drainage area is the reduction of recharge to the Furnace Creek fan by seepage losses during floods and by postflood underground flow in the lower part of Furnace Creek Wash. If the recharge is reduced significantly, the water table beneath the fan will be lowered. This could reduce the water available for plants in the wash and near the toe of the fan and some plants would die. Without recharge, salt water beneath Death Valley may intrude the fresh ground water that underlies the Furnace Creek fan.

More surface water will be lost to evaporation on the saline floor of Death Valley. The shorter channel, moderately impervious rocks in Gower Gulch, and lack of a large fan in which to spread the water near the mountain front are other significant deterrents to ground-water recharge and storage.

Figure 5. Incised channel on fan below mouth of Gower Gulch. Undercut and vertical walls collapse into channel during intervals between floods. A. View upstream (east). B. View downstream (west).

A

B

A

B

C

Figure 6. Gullies cut into gravel of Furnace Creek Wash. A. View from highway toward diversion point. Edge of roadbed is actively eroded each time running water flows through. B. View downstream from center of wash toward diversion point (left of center). C. View upstream from northeast side of wash. Wash is incised 1.7 miles upstream from diversion point (to right of photo edge).

SUMMARY

The diversion of Furnace Creek Wash into Gower Gulch at Zabriskie Point has made significant changes in the environment. However, the magnitude of these changes can be assessed only by careful measurement of the changes to date and a program of monitoring future changes. The principal benefit of the diversion has been to lessen flood damage to (1) the highway in Furnace Creek Wash downstream from Zabriskie Point, (2) the water-supply collection and conveyance system from springs in the wash to Furnace Creek Inn and to users on Furnace Creek fan, and (3) to structures at the Inn and on the fan. To some degree the benefit is offset by jeopardizing a long segment of the highway upstream from the diversion point and a short segment of the paved highway from Furnace Creek to Badwater where it crosses Gower Gulch in Death Valley. The diminished ground-water recharge, intrusion of salt water, and transfer of flood damage from the Furnace Creek fan to the Gower Gulch fan are factors that are less easy to predict, measure, or evaluate.

What, in hindsight, appears to have been an ill-conceived action to remedy a local problem may cost much to rectify. The cost of plugging the diversion point (figure 2) so that the flow is returned to the original channel and thus to a more balanced condition would seem to be a small price to pay if it proved to be the best corrective measure. Upper Furnace Creek Wash probably would return to near its pre-diversion condition within several years or a few decades. The incised channel and secondary fan on the Gower Gulch fan will retain evidence of the diversion for a much longer time. If the diversion remains permanent, should the name Gower Gulch give way to Furnace Creek Wash or vice versa? Should lower Furnace Creek Wash be renamed Echo Wash?

ACKNOWLEDGMENT

I thank Glen Miller and Peter Sanchez for occasional interesting discussions over a period of years and the late Charles Hansen for corresponding with me about the matter. ⚒

Loellingite and Black Vesuvianite from Tulare County, California

by
Jack A. Crowley
Fair Oaks, California

Loellingite ($FeAs_2$) has recently been reported occurring with an unusual black vesuvianite in a contact metasomatic replacement deposit at the Bill Waley Indian Allotment tungsten mine in Drum Valley, Tulare County, California. Although loellingite has been found in six other localities in California, this is the first known report of its existence in Tulare County.

The presently inactive Bill Waley Allotment tungsten mine, located on private property in the Dunlap quadrangle (Section 2, Township 15 South, Range 26 East), was described by Krauskopf in 1953 and by Goodwin in 1957. Since the completion of Goodwin's report, another adit was added approximately 150 feet south of and below the crest of the hill where the original workings are located. This adit extends about 100 feet in a northern direction into the hill. Beyond that distance, the adit is inaccessible. Approximately 60 feet from the entrance to the adit, a contact between granodiorite and marble runs in an east-west direction. Metasomatic replacement in the contact zone has resulted in extensive silicate and calc-silicate mineralization. In several areas, the marble has been removed by the dissolving action of ground water, leaving various sized solution cavities. Extensive brecciation along the contact zone makes this part of the mine susceptible to cave-in and extremely dangerous.

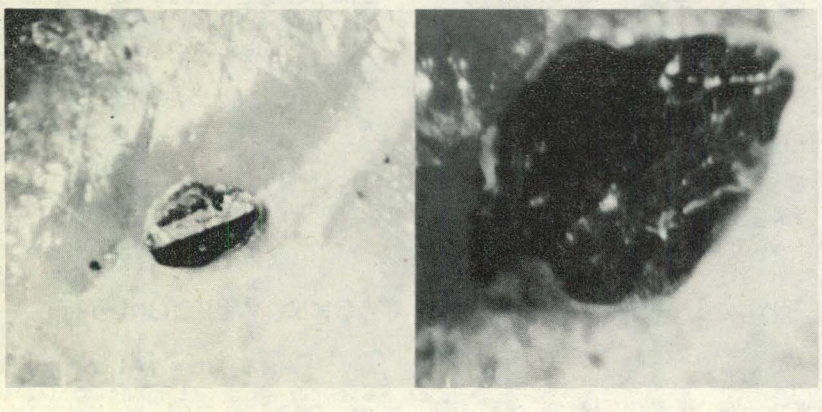

Figure 1: Loellingite on calcite. Crystal size approximately 2.5 millimeters.

Figure 2: Two loellingite crystals on calcite and wollastonite. An acicular crystal of loellingite is present in the lower right hand portion of the figure. Crystals approximately 1.5 millimeters in length.

LOELLINGITE

Loellingite is found in the contact zone in association with vesuvianite, calcite, wollastonite, epidote, a greenish clay, pyrrhotite, and minor chalcopyrite. The loellingite occurs as brilliant silvery white subhedral to euhedral crystals, seldom larger than 1 millimeter in size, although one crystal was found that measured 4 millimeters in length by 2 millimeters in width. The loellingite is enclosed by blue calcite or is perched on crystals of black vesuvianite and corroded wollastonite. Crystals from this Tulare County locality resemble those from Franklin, New Jersey, as shown by Palache, et al (1944). Loellingite also occurs as long thin prismatic crystals usually less than 1 millimeter in diameter and as much as 5 millimeters in length. The loellingite is associated only with black vesuvianite and is not found with vesuvianite of other colors found elsewhere in the mine.

Figure 3. Black vesuvianite. A large black crystal 3 centimeters in diameter is situated in a matrix of pale green calcite.

VESUVIANITE

Vesuvianite, $Ca_{10}Al_4(Mg,Fe)_2(SiO_4)_5(Si_2O_7)_2(OH)_4$, is present throughout the contact zone between the granodiorite and the marble and varies both in crystal form and in color. Vesuvianite associated with loellingite is jet black in color. The black vesuvianite occurs as a band 4 feet by 3 feet and runs parallel to the marble-granodiorite contact, which is approximately 10 feet distant. Between the black vesuvianite zone and the contact with the granodiorite is coarse-grained marble. The vesuvianite is masive and contains numerous vugs lined with euhedral brilliant black vesuvianite crystals. The crystals vary in size from a few millimeters to several centimeters. Vugs are usually filled with coarse-grained blue calcite that formed after the vesuvianite.

Along the edges of the vesuvianite zone, crystals are larger and enclosed in the calcite rather than occurring in vugs completely surrounded by vesuvianite. When a thin fragment of black vesuvianite is held up to the light it is a translucent brownish green. The crystals are tetragonal, generally equidimensional, highly modified forms of the first and second order prism, first order pyramid, and first order pyramid and base as illustrated on page 97 of Ford (1949). In other areas of the contact zone colors range from dark pistachio green to cinnamon brown.

Crystals of brown or green vesuvianite as much as 6 centimeters in size also have been found in the mine. The brown vesuvianite occurs as crystals of the first order pyramid and first and second order prisms as illustrated by Ford. Groups of small vesuvianite crystals held loosely together by massive vesuvianite as well as larger loose crystals are found in the brecciated part of the contact zone in the mine. The larger crystals are commonly misshapen, probably due to the confining walls of the pockets in which they are formed. The green vesuvianite crystals are similar to the black crystals, although usually less modified and more prismatic in shape. Crystal size is comparable to other vesuvianite in the mine.

A number of minerals are associated with both the brown and green vesuvianite. Andradite garnet occurs as crystals embedded in quartz and in rock composed of alternating bands of quartz and garnet. The usually sharp, distinct dodecahedral crystals of andradite garnet vary in color from a pale yellow to a brownish olive green. Grossularite garnet, which forms aggregates of poorly developed dodecahedral crystals with pale green corroded prisms of epidote, ranges in color from tan to cinnamon brown. Wollastonite occurs as tabular crystals and is usually corroded; loellingite occurs as crystals within corrosion cavities and on the surface of wollastonite crystals; epidote occurs as prismatic, fractured crystals lying across vesuvianite crystals; and pyrrhotite occurs as blebs scattered through the massive vesuvianite. In some areas pyrrhotite has been completely removed by oxidation, leaving small irregular cavities filled with iron oxides.

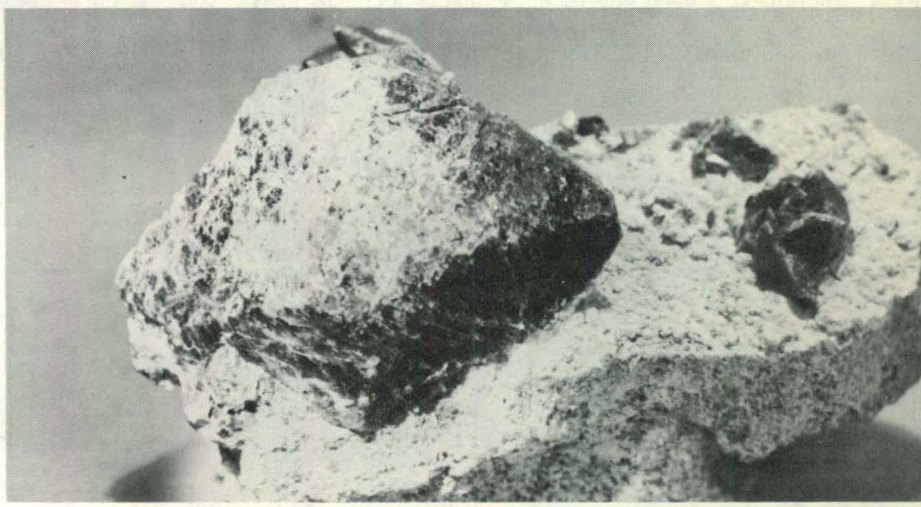

Figure 4. Brown vesuvianite. This flattened bipyramidal form, 5 centimeters in diameter, is uncommon in Tulare County. The matrix is a whitish gray feldspar that has been altered to a hard clay.

TABLE 1: SUMMARY OF THE X—RAY DIFFRACTION DATA

(d-spacing of the ten most intense peaks in decreasing order)

LOELLINGITE	2.557	2.607	2.421	1.865	1.641	2.421	1.648	1.692	1.983	1.949
	10	9	9	6	3	3	3	2	1	1
VESUVIANITE, CRESTMORE	2.767	2.611	2.968	2.471	1.631	1.671	2.134	3.502	2.139	3.025
	10	8	4	3	3	2	1	1	1	1
GREEN VESUVIANITE, DRUM VALLEY	2.777	2.617	2.488	2.598	2.938	1.638	1.567	1.634	2.145	2.225
	10	7	4	3	3	2	2	2	2	1
BLACK VESUVIANITE, DRUM VALLEY	2.781	2.620	2.496	1.643	2.596	2.931	2.996	3.533	2.955	1.639
	10	8	3	3	2	2	2	2	1	1

LABORATORY ANALYSIS

Calcite containing loellingite was dissolved in hydrochloric acid. The insoluable residue was washed, dried, and then run through a magnetic separator. After vesuvianite and iron bearing pyroxenes and sulfides were separated from the loellingite, which is non-magnetic, other non-magnetic minerals were separated from the loellingite using heavy liquids. Loellingite crystals were then verified by X-ray diffraction. A summary of the ten highest diffraction peaks for the loellingite is given in table 1. A quantitative analysis of the loellingite and a fluorescence check of non-loellingite-bearing separates showed less than .5 percent cobalt to be present.

An X-ray diffraction pattern also was run for three samples of vesuvianite: one for pale brownish green vesuvianite in blue calcite from Crestmore, Riverside County, California, and one each for dark green vesuvianite and for black vesuvianite from Drum Valley. The three patterns varied from one another in d-spacings and intensity of peaks. The largest difference in intensity and peak shift can be seen by comparing the black vesuvianite peaks to the brownish green and dark green vesuvianite.

A preliminary fluorescence analysis (table 2) was made for CaO, $FeO + Fe_2O_3$, TiO, K_2O, and Cu to determine additions and losses of elements from the green to the black vesuvianite. The K_2O value is considerably higher than would be expected. This may be attributable to enhancement by the fluorescence apparatus. The increase in K_2O value should be treated as a relative increase. The actual K_2O percentage value is undoubtedly less than that indicated. Co, Mo, Ni, V, and Zr were sought in the vesuvianite from Drum Valley, but were not present in sufficient quantity to be detectable by fluorescence techniques. Further analysis for these and other elements may yield an explanation for the very dark color in the black vesuvianite.

TABLE 2: SUMMARY OF THE X—RAY FLUORESCENCE DATA

ELEMENT	*GREEN VESUVIANITE*	*BLACK VESUVIANITE*	*GAIN OR LOSS*
CaO (%)	41.13	38.54	- 2.59
$FeO + Fe_2O_3$ (%)	4.25	5.96	+ 1.71
TiO (%)	.25	.39	+ .14
K_2O (%)	5.74	8.05	+ 2.31
Cu (PPM)	36	42	+ 6

No quantitative results could be obtained for Mn and Cr because of limitations of the equipment.

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ZONING FOR SURFACE FAULT HAZARDS IN CALIFORNIA: THE NEW SPECIAL STUDIES ZONES MAPS

by Earl W. Hart, Geologist, California Division of Mines and Geology

In compliance with the Alquist-Priolo Geologic Hazard Zones Act of 1972, official maps of Special Studies Zones, delineated by the State Geologist, were released 1 July 1974 to the cities and counties affected by the zones. The Special Studies Zones were drawn to encompass potentially hazardous traces of the San Andreas, Calaveras, Hayward, San Jacinto and other faults.

The Alquist-Priolo Act (also known as Chapter 7.5, Division 2 of the California Public Resources Code) provides cities and counties with a means of reducing personal and property damage from fault rupture. The Act applies to all "new real estate developments and structures for human occupancy" within the zones established. Contemplated structures are to be so located as to avoid "undue hazards" that may be created by "surface faulting and fault creep."

The State Geologist, the State Mining and Geology Board, and those cities, counties, and state agencies affected by the Special Studies Zones (table 1) are responsible for the implementation of the Act. The State Mining and Geology Board has the responsibility of providing "policies and criteria" to carry out the law (table 2). Affected cities and counties (table 3) also may impose more restrictive or additional rules and regulations to satisfy their local needs.

The effectiveness of the new legislation will depend on (1) local implementation of ordinances, and (2) geological evaluation of potential surface fault displacement. Given the general guidelines set forth by the State, each city and county affected by the new zones will have to adopt additional special guidelines, or at least make specific interpretations that will enable them to make decisions regarding proposed developments. According to the State Mining and Geology Board, an active fault is defined as one which has had displacement during Holocene time (last 11,000 years) and therefore constitutes a potential hazard. In evaluating a fault with respect to a given proposed development site, the geologist has considerable responsibility. In cases where the existence of a fault hazard is unclear, the local jurisdiction must decide on the basis of the geologic evaluation whether or not the proposed development is an acceptable risk.

Table 1.

Summary of official responsibilities and functions required under the Alquist-Priolo Geologic Hazard Zones Act.

State Geologist (Chief, California Division of Mines and Geology)

1. Delineates Special Studies Zones; compiles and issues maps.
   a. Preliminary Review maps.
   b. Official Maps.
2. Reviews new data.
   a. Revises existing maps.
   b. Compiles new maps.
3. Approves requests for waivers by cities and counties.

State Mining and Geology Board

1. Formulates policies and criteria to guide cities and counties.
2. Serves as Appeal Board for appeals that cannot be coped with locally.
3. Advises State Geologist.

Cities and counties

1. Responsible for local implementation of Act within the delineated Special Studies Zones.
2. Approves permits for development.
3. Collects fees for building and development permits to cover administrative costs.

State agencies

Implied responsibility for siting State structures safely within Special Studies Zones.

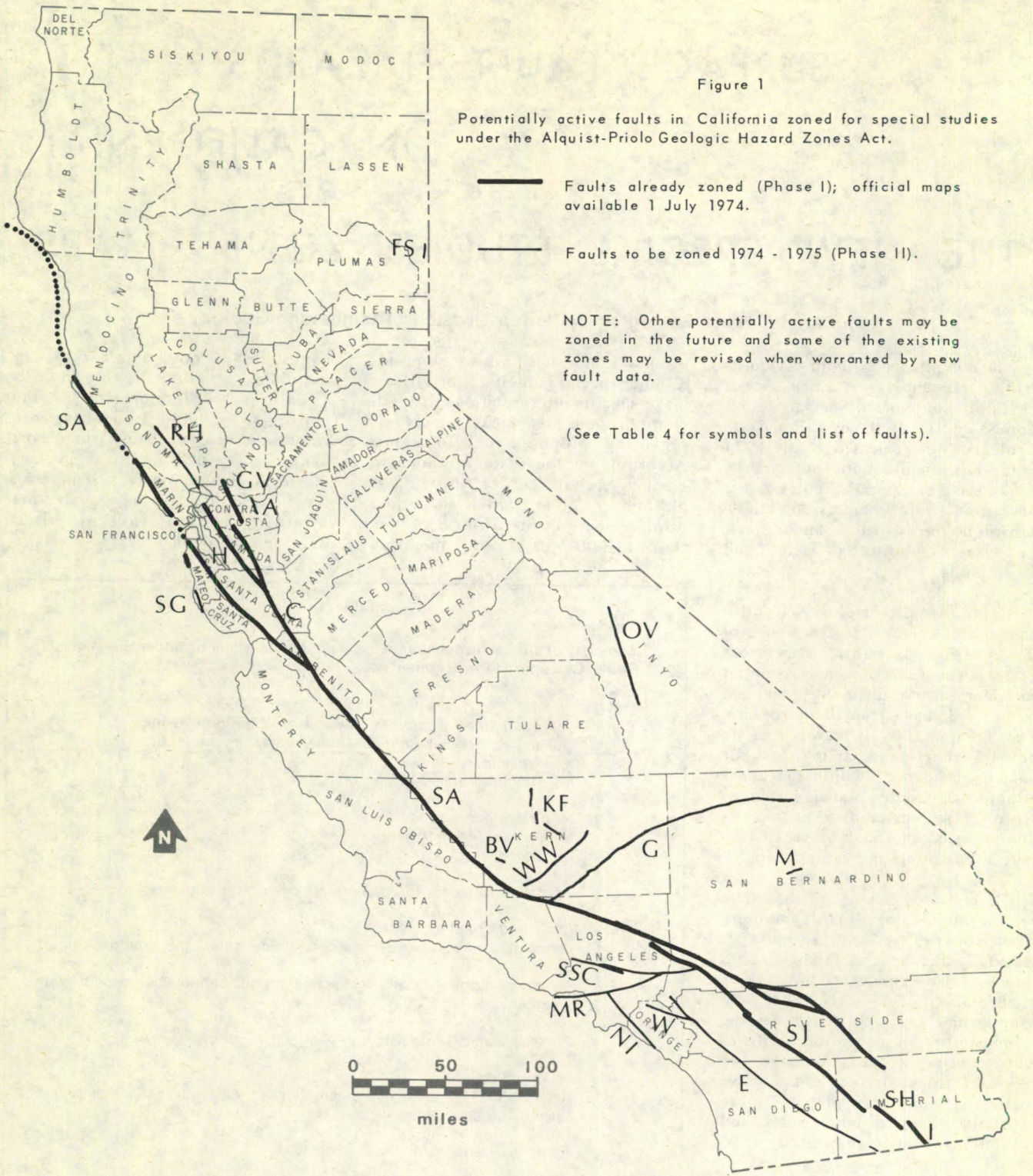


Figure 1

Potentially active faults in California zoned for special studies under the Alquist-Priolo Geologic Hazard Zones Act.

Faults already zoned (Phase I); official maps available 1 July 1974.

Faults to be zoned 1974 - 1975 (Phase II).

NOTE: Other potentially active faults may be zoned in the future and some of the existing zones may be revised when warranted by new fault data.

(See Table 4 for symbols and list of faults).

The CDMG program

Under the Alquist-Priolo Act, the State Geologist (who is also Chief of the State Division of Mines and Geology) is required to delineate the Special Studies Zones and to compile and distribute maps of these zones. A project team, headed by staff geologist Earl Hart, was established within the Division to develop a program for delineation of the zones.

It was determined that the faults named in the Act--the San Andreas, Calaveras, Hayward, San Jacinto--could be zoned by 31 December 1973 with the available funds and staff. The zones were delineated on U. S. Geological Survey topographic maps at a scale of 1 inch equals 2000 feet (1:24,000). This initial phase, whereby Preliminary Review maps were compiled in 1973 and subsequently reviewed and revised for issue as Official Maps on 1 July 1974, is known as Phase I (see map, figure 1; and table 4).

Phase II of the Division program, the delineation of Special Studies Zones for other potentially active faults (table 4), will be accomplished in Fiscal Year 1974-1975 and the Preliminary Review maps issued around mid-1975. Following the prescribed review and revision periods of 90 days each, Offcial Maps will be issued at the end of 1975. At that time, any newly established or revised zoning will become effective and the affected cities and counties will be required to implement the Act within the zoned areas.

Table 2.

Summary of policies and criteria adopted by the State Mining and Geology Board, effective 1 July 1974

Policies

1. Specifies that the Act is not retroactive.
2. Suggests methods relating to review of Preliminary Maps prior to issuance of Official Maps.
3. Policies and criteria apply only to area within the Special Studies Zones.
4. Defines *active fault* (equals potential hazard) as a fault that has had surface displacement during Holocene time (last 11,000 years).

Specific criteria

1. No structures for human occupancy are permitted on the trace of an active fault. (Unless proven otherwise, the area within 50 feet of an active fault is presumed to be underlain by an active fault).
2. Requires geologic report directed at the problem of potential surface faulting for all real estate developments and structures for human occupancy.
3. Requires that geologic reports be placed on open file by the State Geologist.
4. Requires cities and counties to review adequacy of geologic reports submitted with requests for development permits.
5. Permits cities and counties to establish standards more restrictive than the policies and criteria.
6. Sets fees for building permits at 0.1 percent of estimated assessed valuation of proposed structure.
7. Defines a) structure for human occupancy, b) technically qualified geologist, and c) new real estate development.

Although there are many other potentially active faults in California that could be zoned, the faults listed under Phase II in table 4 include (1) all of the known historically active faults not zoned under Phase I, and (2) major potentially active faults, especially those situated in areas of

Table 3.

Cities and counties affected by Special Studies Zones

Incorporated cities

Banning	El Cerrito	Martinez	Pleasanton	San Juan Bautista
Benicia	Fairfield	Millbrae	Portola Valley	San Leandro
Berkeley	Fremont	Milpitas	Redlands	San Pablo
Burlingame	Hayward	Morgan Hill	Redwood City	South San Francisco
Coachella	Hemet	Oakland	Rialto	Union City
Colton	Hercules	Pacifica	Richmond	Walnut Creek
Concord	Hollister	Palmdale	San Bernardino	Woodside
Daly City	Indio	Palo Alto	San Bruno	
Desert Hot Springs	Loma Linda	Pinole	San Jose	

Counties

Alameda	Kern	Monterey	San Diego	Santa Cruz
Contra Costa	Los Angeles	Riverside	San Luis Obispo	Solano
Humboldt	Marin	San Benito	San Mateo	Sonoma
Imperial	Mendocino	San Bernardino	Santa Clara	Ventura

current development. The zoning of faults in Phase II will be done on a priority basis according to the manpower and funds available, and existing data.

In the meantime, the State Geologist will continue to review new information and revise existing Special Studies Zones as necessary. It is planned that copies of all geologic reports submitted to the cities and counties for the purpose of obtaining permits for development will be kept on open file at the Division's San Francisco office in Room 1016, Ferry Building.

Table 4.

Faults to be zoned for special studies (on priority basis), under Alquist-Priolo Act; CDMG program through 1975. See figure 1 for location of faults.

Fault	*Map symbol*
Phase I (zoning complete):	
Calaveras	C
(includes Green Valley and Concord)	GV
Hayward	H
San Andreas	SA
San Jacinto	SJ
(includes: Imperial	I
Superstition Hills)	SH
Phase II (1974-1975):	
Antioch	A
Buena Vista	BV
Elsinore-Chino	E
Fort Sage	FS
Garlock	G
Kern Front	KF
Manix	M
Malibu Coast-Raymond	MR
Newport-Inglewood	NI
Owens Valley	OV
Rogers Creek-Healdsburg	RH
San Gregorio	SG
Sierra Madre-Santa Susana-Cucamonga (includes "San Fernando")	SSC
Whittier	W
White Wolf	WW

Available information

For those readers interested in obtaining more detailed information on the Alquist-Priolo Act and the Division's program, the following references are available:

1. *Index to maps of Special Studies Zones* (containing supplementary text of the Alquist-Priolo Act, Policies and Criteria of the State Mining and Geology Board, and a list of cities and counties affected by the Special Studies Zones), California Division of Mines and Geology Special Publication 42. Price: $1.00, plus tax.

2. *Maps of Special Studies Zones* (see Index map). Full scale maps (1 inch equals 2000 feet) may be consulted at offices of the cities and counties affected by the zones (table 3) or at any district office of the California Division of Mines and Geology. Individual copies may be obtained from many local jurisdictions or they may be purchased commercially from Blue Print Service Company, 149 Second Street, San Francisco 94105 (attention: Ellen Schermerhorn; phone: 415-495-8700).

3. Explanation of Special Studies Zones Maps. Free.

4. *Guidelines to geologic and seismic reports.* CDMG Note 37. Free.

5. *Model ordinance for cities and counties to implement the Alquist-Priolo Act.* This is an informal set of regulations for quidance purposes only. Price: $0.25.

Items 1, 3, 4, and 5 can be obtained at CDMG district offices or by mail from California Division of Mines and Geology, P. O. Box 2980, Sacramento, California 95812.

MINERAL AND ENERGY CONFERENCE

The Pacific Southwest Mineral and Energy Conference will be held 11, 12, and 13 November 1974 at the Hilton Hotel, Los Angeles, California. The American Institute of Mining, Metallurgical and Petroleum Engineers, and the Western Oil and Gas Association, join the U.S. Bureau of Land Management and the California Mine Operators Association in sponsoring the event.

The program will be geared principally to energy minerals, covering geology, mining, environmental considerations and management. Speakers are nationally recognized authorities in their field from top management in industry and government. This biennial conference will provide government and industry with a meeting ground for the exchange of ideas and information regarding mineral production and management.

For further information contact: G. W. Nielsen, U.S. Bureau of Land Management, 2800 Cottage Way, Room E-2841, Sacramento, California 95825.

MODEL ORDINANCE FOR SEISMIC SAFETY

An ordinance for use by local governments to implement the provisions of the Alquist-Priolo Geologic Hazards Act has been drafted by the California Division of Mines and Geology. The Alquist-Priolo Act declares that it is the intent of the legislature "to provide policies and criteria to assist cities, counties, and state agencies in the exercise of their responsibility to provide for the public safety in hazardous fault zones."

The Division of Mines and Geology prepared the model ordinance at the request of Senator Alfred E. Alquist and the California Legislative Joint Committee on Seismic Safety.

The Alquist-Priolo Geologic Hazards Act requires the Division of Mines and Geology to prepare maps which delineate zones around active or potentially active faults throughout the State. The Act provides that "cities and counties shall not approve the location of such [real estate] development or structure [for human occupancy] within a delineated special studies zone if an undue hazard would be created...pending geologic and engineering studies to more adequately define the zone of hazard." According to State Geologist James E. Slosson, "The model ordinance is a suggested method for local governments to meet the requirements of the Alquist-Priolo Act."

If adopted by local governments, the ordinance would prohibit construction of structures for human occupancy"...over the trace of an active fault. Furthermore, the area within 50 feet of an active fault shall be assumed to be underlain by active branches of the fault..."until proven otherwise by an appropriate geologic investigation. Such an investigation will require that a qualified geologist use standard or "state of the art" methods to determine the location or absence of an active fault.

Slosson stated that the model ordinance can also be used as a part of the seismic safety element and geologic hazards element of the general plan.

The ordinance provides for an appeals board to arbitrate in cases of disagreement between a developer and the county or city staff. In addition, developers always have the right of appeal to the city council, the board of supervisors, or eventually, the courts.

Copies of the model ordinance may be obtained by sending 25 cents to California Division of Mines and Geology, P. O. Box 2980, Sacramento, California, 95812.

NEW WORLD EARTHQUAKE MAP

A new *World seismicity map* showing the location and depth of about 23,000 earthquakes around the world and their relationship to major physical features of the land and ocean has been prepared by the U.S. Geological Survey, Department of the Interior, and is available for purchase.

The four-color wall-sized (48x36-inch) map, shows land surface features in shaded relief, ocean depths at 500-fathom contours, and the polar ice caps. In addition to color-coding three major depths of earthquake activity, the map lists the date and magnitude of the 121 major earthquakes of magnitude 8 or greater that occurred from 1897-1972, as well as spotting 22,895 earthquakes of magnitude 4.5 or greater that occurred from mid-1963 through 1972.

Since 1897, the world's two most severe earthquakes, with a magnitude of 8.9, occurred off the coasts of Ecuador (1906) and Japan (1933). Earthquake magnitudes are measured on a logarithmic scale so that a magnitude 8 earthquake is 10 times as large as a magnitude 7 earthquake. By comparison, a magnitude 2 earthquake is the smallest normally felt by humans.

Arthur C. Tarr, Acting Chief of the USGS National Earthquake Information Service, Boulder, Colorado, and compiler of the World Seismicity Map, said that the new map, based on earthquake data collected by the National Oceanic and Atmospheric Administration, should provide a much better picture of where the world's earthquakes have occurred and how they are related to the major continental and oceanic mountain ranges and trenches. For example, the mid-Atlantic Ridge—a chain of undersea mountain ranges that stretches from Spitsbergen to south of Africa—is clearly outlined by a pattern of shallow (0-70 km deep) earthquake epicenters. Similarly, the seismically active circum-Pacific belt, sometimes called the "Ring of Fire" because of its many volcanoes and earthquakes, is almost girded by a solid pattern of red, blue, and green dots denoting earthquake activity at all depths. Such a visual presentation of the earth's seismically active zones should be of particular interest to the many scientists studying the theories of continental drift and sea-floor spreading.

The new *World seismicity map*, published in a Mercator projection with a scale at the Equator of 1:39,000,000, may be purchased for $1.50 per copy from the USGS Distribution Section, 1200 South Eads Street, Arlington, VA 22202.

CDMG RELEASES NEW PUBLICATIONS

The following publications have recently been released by the California Division of Mines and Geology. They are available over-the-counter at each of the district offices or by mail.

⚔

Preliminary reports

PR 14. *Geology and mineral resources study of southern Ventura County, California.* By F. Harold Weber, Jr. and George B. Cleveland, James E. Kahle, Edmund F. Kiessling, Russell V. Miller, Michael F. Mills, and Douglas M. Morton of the California Division of Mines and Geology and Blase A. Cilweck, County of Ventura, Department of Public Works. Price $7.00 plus tax.

The report was prepared in cooperation with the County of Ventura and the U.S. Geological Survey (July 1972). This study includes a geologic map and a reconnaissance landslide map, both at a scale of 1:48,000, an inventory of the mineral resources, and a preliminary investigation of late Quaternary sedimentation and seismicity.

⚔

PR 19. *Geological and geophysical investigations for tri-cities seismic safety and environmental resources study.* By Charles C. Bishop, Richard D. Knox, Rodger H. Chapman, Donald A. Rodgers, and Gordon B. Chase. Price $4.00 plus tax.

This report was prepared in cooperation with the cities of El Cerrito, Richmond, and San Pablo (1973). The study provides the geologic basis for the seismic safety element of the general plan for each of these cities.

⚔

PR 20. *Geology for planning on the Sonoma County coast between the Russian River and Estero Americano.* By Michael E. Huffman, assisted in geophysical studies by Gordon B. Chase and Theodore C. Smith; assisted in seismic risk evaluation by Roger W. Greensfelder. Price $4.00 plus tax.

This report was prepared in cooperation with the Sonoma County Planning Department (1973). The purpose of this geologic study was to identify, map, and interpret slope stability, seismic risk, and related factors that should be considered in land use planning and development.

⚔

PR 21. *Geology and geologic hazards of the Novato area, Marin County, California.* By Salem J. Rice, assisted in geophysical studies by Gordon W. Chase. Price $4.00 plus tax.

This report was prepared in cooperation with Marin County and the City of Novato (1973). The study was made to identify and map geologic factors that might affect land use planning within uplands (hills and ridges), bay plains, and marshlands. ⚒

OFFSHORE OIL

The step up in the search for oil on the floors of the world's oceans and seas adjacent to the continents during the last decade marks the beginning of one of the most massive oil-hunting eras in history, according to a U. S. Geological Survey, Department of the Interior report. The 27-page report, *The worldwide search for petroleum offshore - status report for the quarter century, 1947-72,* by Henry Berryhill, Jr., a marine geologist of the Survey's Corpus Christi, Texas, office, notes that:

* At the end of 1972, offshore petroleum exploration was in progress on the submerged continental margins of 80 countries, with about 780 oil and gas fields having been discovered.

* Estimated worldwide volume of oil discovered offshore as of 1 January 1973, is 172.8 billion barrels, or about 26 percent of the world total. About 90 percent of the oil discovered has been found in 60 giant fields having reserves of 500 million or more barrels each.

* Present reserves of oil are 135.5 billion barrels, of which 70 percent is in the Persian Gulf.

Noting that the petroleum industry moved to the offshore in response to increased consumer demands which no longer could be met adequately by onshore source, the report describes the year 1947 as "significant," not only as the beginning of the "modern era" of offshore exploration, but also as the last year in which the United States was a net exporter of petroleum. The year 1948 was the first full year in which the U.S. reversed its historical position as a net exporter, and became a net importer of oil. The trend, has not been reversed, and the U.S. now imports nearly 40 percent of its total petroleum consumption, with worldwide demand for petroleum and its products now doubling about every 10 years. Over the next 15 years, man is expected to consume as much or more petroleum than in the entire previous 116-year history of the industry.

Though land areas will continue to attract exploration for years to come, current emphasis is on the offshore areas for substantial new sources of petroleum.

Published as USGS Circular 694, and available free upon request to the U. S. Geological Survey, National Center, Reston, Virginia 22092, the report reviews the scope of the offshore petroleum search now in progress around the world, presents the geographic distribution and magnitude of the petroleum found to date, reviews the time factors involved in the exploration and development of offshore fields, and summarizes the geologic characteristics of major offshore producing areas. Maps, graphs, and tables are used to summarize data. ⚒

SAN JOAQUIN GEOLOGICAL SOCIETY SHORT COURSE

The Continuing Education Committee of the San Joaquin Geological Society (Pacific Section-AAPG) plans to conduct a short course for industry geologists and geophysicists. The short course, entitled *Current concepts of depositional systems with applications for petroleum geology,* will be held on 21 and 22 February 1975 at the West High School Student Center in Bakersfield, California. Professor William R. Dickinson of Stanford University will serve as course moderator and editor. Four other distinguished scholars will present papers and hold discussions at the short course.

For more detailed information as to lecturers names, specific topics, course costs, and scheduling contact: H.J. Briscoe, Jr., Short Course Meeting Chairman, San Jaoquin Geological Society, P.O. Box 1056, Bakersfield, CA 93302. ⚒

REGISTERED GEOLOGISTS

As of 19 July 1974 there were 2960 geologists and 298 geophysicists registered in California. 884 of the geologists are certified engineering geologists. ⚒

LAND SUBSIDENCE

Land subsidence due to ground-water withdrawal, Arvin-Maricopa area, California. By Ben E. Lofgren. 1973. U.S. Geological Survey open-file report, 192 pp., 63 figures, 7 tables.

This report, prepared in cooperation with the California Department of Water Resources, covers pertinent geologic and hydrologic features of the Arvin-Maricopa area which is the southernmost of three principal subsidence areas in the San Joaquin Valley. The analysis, based on data collected over an extended period by state, federal, and local organizations, indicates that maximum subsidence exceeds 9 feet and the total volume of subsidence (1926-1970) is about 1 million acre-feet.

Before extensive development of ground water for irrigation, natural discharge occurred from the ground-water basin by upward percolation from the confined and semiconfined aquifers to the land surface, and by phreatophytes. All ground-water levels were more or less uniform.

The use of ground water in the Arvin-Maricopa area greatly increased during the late 1940s and 1950s, causing the rapid decline of water levels in all producing zones. This was also a period of below-normal precipitation and severely deficient ground-water recharge. As a result of overdraft (pumpage in excess of ground-water replenishment), subsidence developed, causing significant economic and environmental problems.

In 1959 compaction and water-level recorders were installed in three unused irrigation wells and one shallow test hole. In 1963, a 1480 foot observation well was drilled near the center of maximum subsidence, to measure compaction and water-level change. These recorders have been maintained continuously, and have provided definitive data on the direct relationship between water-level changes and compaction, which results in subsidence of the land surface. Results are interpreted through records for 1970.

The continued overdraft or "mining" of water for irrigation has caused the compaction of water yielding deposits as intergranular stresses are increased by water-level decline.

In addition to intensive pumping of ground water, subsidence in scattered localities of the Arvin-Maricopa area has resulted from hydrocompaction, and the extraction of fluids from producing zones in some oil fields.

Recently tectonic adjustments — slow uplift of some mountainous areas and very slow settlement of the valley floor — have been recognized in the southern and western parts of the San Joaquin Valley.

Subsidence can be slowed or stopped by (1) reduction of ground-water pumpage, (2) increase in ground-water recharge, (3) spacing withdrawal wells to reduce centers of large drawdown, or (4) a combination of these methods.

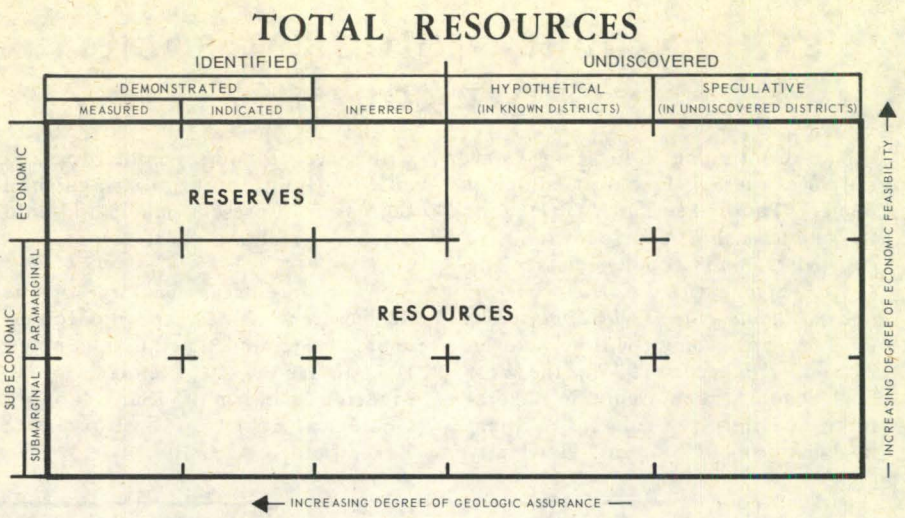
Importation of surface water from the Friant Kern Canal, and the California Aqueduct, has offset the ground-water over draft in the area. In 1970 water level decline in key observation wells decreased, and compaction recorders indicated a flattening of the subsidence trend. By 1972 measured compaction at Lakeview in the center of the area was less than 1/4 the rate of three years earlier. Water levels must be raised in all producing zones to stop the subsidence trend.

The magnitude and extent of subsidence and the natural and man-made causes must be understood to successfully manage the ground-water basin and to construct and maintain water service facilities and other engineering structures in the area.

Results of this study provide answers to some water management problems in the San Joaquin Valley and will be applicable also to subsidence problems in other areas.

Copies of the open-file report are available for inspection (not for sale) at the following U.S. Geological Survey addresses in California: 555 Battery Street, San Francisco; 345 Middlefield Road, Menlo Park; Room 7638, 300 North Los Angeles Street, Los Angeles; and the California Division of Mines and Geology, Room 118, 1416 Ninth Street, Sacramento, California. ⚒

NEW MINERAL RESOURCE TERMINOLOGY ADOPTED



New definitions for such crucial mineral terms as "reserves" and "resources" have been jointly adopted by the Interior Department's Bureau of Mines and Geological Survey. The new definitions more accurately describe the estimated production potential of mineral deposits, including fuels. Adoption of the nomenclature is expected to clear up the confusion of these terms—especially between "mineral resources" and "mineral reserves," the agencies said.

Because the Bureau and the Geological Survey both collect important information about minerals, a common terminology is essential to evaluate the data for governmental planning. The new definitions extend those officially adopted in 1943 and later used by the Paley Commission to assess the nation's mineral resources.

The classification system agreed upon by the Bureau and the Survey is based on two key criteria: the extent of geologic knowledge about the resource; and the economic feasibility of its recovery.

For example "mineral resources" are defined as concentrations of naturally occurring solids, liquids, or gases, discovered or only surmised, that are or might become economic sources of mineral raw materials. "Mineral reserves" are that portion of "mineral resources" that have actually been identified, and can be legally and economically extracted. (The term "ore" is used for the reserves of some minerals).

GLOSSARY OF RESOURCE TERMS

Resource—A concentration of naturally occurring solid, liquid, or gaseous materials in or on the earth's crust in such form that economic extraction of a commodity is currently or potentially feasible.

Identified resources—Specific bodies of mineral-bearing material whose location, quality, and quantity are known from geologic evidence supported by engineering measurements with respect to the demonstrated category.

Undiscovered resources—Unspecified bodies of mineral-bearing material surmised to exist on the basis of broad geologic knowledge and theory.

Reserve—That portion of the identified resource from which a usable mineral and energy commodity can be economically and legally extracted at the time of determination. The term *ore* is also used for reserves of some minerals.

The following definitions for measured, indicated, and inferred are applicable to both the reserve identified-subeconomic resource components.

Measured—Material for which estimates of the quality and quantity have been computed, within a margin of error of less than 20 percent, from analyses and measurements from closely spaced and geologically well-known sample sites.

Measured—Material for which estimates of the quality and quantity have been computed, within a margin of error of less than 20 percent, from analyses and measurements and partly from reasonable geologic projections.

Demonstrated—A collective term for the sum of materials in both measured and indicated resources.

Inferred—Material in unexplored but identified deposits for which estimates of the quality and size are based on geologic evidence and projection.

Identified-subeconomic resources—Known deposits not now minable economically.

Paramarginal—The portion of subeconomic resources that (a) borders on being economically producible or (b) is not commercially available solely because of legal or political circumstances.

Submarginal—The portion of subeconomic resources which would require a substantially higher price (more than 1.5 times the price at the time of determination) or a major cost reducing advance in technology.

Hypothetical resources—Undiscovered materials that may reasonably be expected to exist in a known mining district under known geologic conditions. Exploration that confirms their existence and reveals quantity and quality will permit their reclassification as a reserve or identified-subeconomic resource.

Speculative resources—Undiscovered materials that may occur either in known types of deposits in a favorable geologic setting where no discoveries have been made, or in as yet unknown types of deposits that remain to be recognized. Exploration that confirms their existence and reveals quantity and quality will permit their reclassification as reserves or identified-subeconomic resources. ⚒

National Cartographic Information Center

The nucleus of a National Cartographic Information Center (NCIC)—which will eventually provide "one-stop" access to cartographic and survey data for all users—has been established by the U.S. Geological Survey.

In a paper presented on 14 March 1974 before an annual joint convention of the American Congress on Surveying and Mapping and the American Society of Photogrammetry at St. Louis, Missouri, Rupert B. Southard, Associate Chief of the USGS Topographic Division, reported that a new cartographic information center now exists at the Survey's national headquarters facility in Reston, Virginia, "not full-grown yet, but active and growing."

"The need for a truly central source of information about maps, charts, aerial photography, space imagery, geodetic control, and related data available for the United States has long been recognized by federal and state agencies," Southard noted, adding that "even experienced users of maps face a bewildering task in locating data to suit their needs. No longer will the customer have to contact four or five different agencies to gather the aerial photos, survey control, topographic quads, geologic maps, soil maps, highway maps, or nautical charts that he may need."

The new NCIC is being built around the U. S. Geological Survey Map Information Office which was established by an Executive Order of 1919 "for the purpose of collecting, classifying and furnishing information to the public concerning all map and survey data available in the several government departments and from other sources." A 1973 report of the Federal Mapping Task Force sponsored by the Office of Management and Budget recommended formation of such a central cartographic center.

"With the complex problems of resource and energy development, land use, and preservation of our environment being pursued with increasing urgency, the demand for maps and survey data continues to increase," Southard said, noting that "the demand for cartographic information has increased to the point where the USGS Map Information Office alone was receiving 80,000 requests annually with other major mapping, charting, and geodesy agencies reporting similar growth in data demand."

The new center, Southard emphasized, "is highly dependent on the cooperation of the agencies that produce and hold cartographic data to make their data or information about their data and their data information systems available to NCIC."

"NCIC does not intend to take over the functions of other organizations furnishing cartographic and survey information and products to users, or to make the actions of those organizations subordinate to NCIC," Southard said, adding that "NCIC wants only to act as a catalyst in cartographic information activities by providing vital links to expedite the flow of information, requests and orders, and the exchange of funds and, most important of all, to provide an organizational element that can implement policy and make standardization effective in the field of cartographic information."

Southard added that "this concept is illustrated by the cooperative approach being taken by NOAA and USGS toward the establishment of a harmonious working relationship in providing survey control data to customers. Since NOAA has the basic responsibility for geodetic control, NCIC will not operate a separate system for this data but needs only to provide information on and accept orders for survey control data to meet needs of NCIC customers. The Geological Survey plans to make use of an Advisory Committee to provide coordination support and guidance to NCIC."

One of the new features of NCIC is a terminal connected directly to the Interior/Geological Survey's EROS (Earth Resources Observation Systems) Data Center at Sioux Falls, South Dakota. Orders for space imagery and aerial photography will be transmitted from Reston, Virginia and later from other NCIC offices in Denver, Colorado; Menlo Park, California; and Rolla, Missouri; directly into the computer at Sioux Falls where they will become part of computer-produced work orders to the photo lab holding the film. Many of the participating information centers will be equipped with microfilm readers and reader-printers. All data files and indexes are in the process of being converted from cumbersome paper files to small microfilm files or catalogs. The customer will be able to research the cartographic and survey data on the microfilm reader to determine if the information meets his needs. The customer can then either obtain a hard copy print directly from the microfilm, or place an order for a map or map product that is currently available for distribution.

The NCIC, Southard said, "is not just a simple change of names. New technology, new user needs, and new interagency requirements for coordination placed such burdens on the old and accepted ways of doing business that drastic change was needed. We hope by the successful establishment of NCIC to bring data dissemination up to date and at long last give users of cartographic data effective and timely service." ⚒

Tahoma Glacier on the west slope of Mount Rainier, Washington, is one of eight active glaciers on Rainier being studied by scientists of the U.S. Geological Survey for clues to past climates.

The USGS scientists note that 60 years ago, the glacier stretched down to the present tree line. This and other evidence of advances and declines of the glacier during the last 350 years may help produce a better understanding of how present glaciers can be expected to respond to future climatic changes. Such an understanding is particularly important in Alaska and the Pacific Northwest where glacial meltwater produces much of the summertime streamflow that is vital for water supplies, irrigation, and hydroelectric power. *U.S. Geological Survey Photo*

MOUNT RAINIER GLACIERS

HOLD "CLUES" TO PAST CLIMATES

Tree-ring dating of past advances and retreats of the glaciers on Mount Rainier in west-central Washington is uncovering clues to past climates and may aid management of future water supplies, according to a new report by the U.S. Geological Survey.

Designed primarily as a scientific investigation of recent glacier activity, the 24-page report and accompanying maps should also prove useful to hikers and naturalists interested in the constantly changing scenic environment of Mount Rainier volcano.

Robert S. Sigafoos, botanist, USGS, National Center, Reston, Virginia, and senior author of the report, said: "Because glaciers advance and retreat in response to climatic changes, our detailed studies of past glacier movement on Mount Rainier are designed to produce a better understanding of how present glaciers will respond to any future climatic changes. Such an understanding is particularly important in Alaska and the Pacific Northwest where glacial meltwater produces much of the summertime streamflow that is vital for water supplies, irrigation, and hydroelectric power.

"Based on tree-ring dating of more than 1,300 trees now growing on the ridges of gravel and rock rubble deposited at the margins of eight active glaciers, we can peg the dying stages of at least eight periods of glacial advance since 1525. These separate advances apparently terminated in 1525, 1550, 1625-60, 1715, 1730-65, 1820-60, 1875, and 1910, which must have marked periods of increased streamflow as more and more meltwater was released from glacial storage.

"Apparently, these glaciers have not always advanced and retreated at the same time, indicating that there are some subtle controls of glacier movement that we still do not understand. However, 125-130 years ago, all eight glaciers did extend considerably farther down the sides of Mount Rainier than they do now, and the mountain must have looked much different than it does today. The upper slopes, heavily weighted with ice, would have exposed little bedrock to view and the valleys would have been filled with long tongues of ice protruding between the dark forested slopes.

"We may, in fact, be returning to that earlier appearance, because after more than 100 years of retreating, many of the Mount Rainier glaciers have been advancing for the past 10-15 years," the spokesman said. "For example, the front of Nisqually glacier has advanced about 1,200 feet since July 1960."

In addition to using the tree-rings to date the end of glacial advances, the scientists have been trying to use the thickness of the tree-rings as an indication of climatic conditions during the growth of the tree, with thicker rings corresponding to periods of greater growth under more favorable conditions. Using such information, the scientists hope to determine the approximate climatic conditions of past years and how they relate to glacier activity and meltwater runoff.

"We've hit a lot of rough spots in trying to develop an accurate method of relating climate, glacial activity, and meltwater runoff," Dr. Sigafoos said, "but we feel confident that despite the various problems and quirks of the individual glaciers, we are moving closer towards determining and anticipating the vital role of meltwater in the overall water supply of the Pacific Northwest."

The 24-page report, complete with 17 illustrations and tables and seven desk-size maps, is titled "Recent activity of glaciers of Mount Rainier, Washington," and is written by R.S. Sigafoos and E.L. Hendricks. Published as USGS Professional Paper 387-B, copies of the report may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 for $5.70 (stock number 2401-2179).

AEC ADOPTS RULES CHANGE

The Atomic Energy Commission has adopted a new regulation requiring that all plutonium shipments in excess of 20 curies per package be shipped in solid form and in double containment as a safety precaution.

The new requirement is designed to minimize the likelihood of leakage during transport. Current regulations provide adequate protection for present shipments. However, both quantity and specific activity of plutonium recovered from power reactor fuel will increase considerably in the private sector over the next several years. The amount of plutonium currently available for recovery is estimated at 500 kilograms and the amount forecast for 1980 is approximately 21,000 kilograms. No significant change is expected in the quantity or characteristics of plutonium shipped in the next 4 years.

The amendment requires that plutonium be doubly contained with both levels of containment able to withstand the effects of the normal and accident conditions described in the Regulations. Solidification is necessary because of the inherent susceptibility of liquids to leakage. Exempt from the double containment requirements are reactor fuel elements, metal or metal alloy, and other plutonium bearing solids which are essentially forms of plutonium which cannot be inhaled.

Effective date of the new requirement will be 4 years from the adoption date of the amendment which was 30 days from the date of publication in the Federal Register scheduled for 17 June 1974. The amendment, to Part 71 of AEC Regulations, as proposed, was published for comment in the Federal Register on 1 August 1973. The adopted amendment takes into account the comments received. ⚒

ALTERNATIVES FOR HIGH-LEVEL RADIOACTIVE WASTE DISPOSAL

The Atomic Energy Commission has issued a four-volume study on advanced alternative methods for disposal of high-level radioactive waste conducted for the AEC by the Battelle Pacific Northwest Laboratories in Richland, Washington.

The comprehensive study, *Advanced waste management studies, high-level radioactive waste disposal alternatives,* BNWL-1900, is available for $36.40 from the National Technical Information Service, U. S. Department of Commerce, Springfield, Virginia 22151.

Volume 1 ($10.60) contains summary, background and methodology of the study; Volume 2 ($7.60) deals with geologic disposal, Volume 3 ($7.60) with disposal in ice sheets or seabeds, Volume 4 ($10.60) with waste partitioning, extra-terrestrial disposal and transmutation. A summary of this four-volume study, *High-level radioactive waste management alternatives,* WASH-1297, was issued in May and is also available at NTIS for $5.45.

Sets of the four-volume study will be sent within the next few weeks to all 50 state libraries and more than 100 major university, college, and city libraries. The study will also be available for public inspection at the AEC Public Document Rooms at 1717 H Street, N.W., Washington, D.C.; AEC San Francisco Operations Office, 1333 Broadway, Oakland, California; AEC Savannah River Operations Office, Aiken, South Carolina; AEC Idaho Operations Office, 550 Second Street, Idaho Falls, Idaho; AEC Richland Operations Office, Federal Building, Richland, Washington, and at the Cook County Law Library, 2900 Chicago Civic Center, Chicago, Illinois. ⚒

URANIUM MARKETING ACTIVITY

The U.S. Atomic Energy Commission has issued its annual report on commercial marketing arrangements for the supply of uranium fuel to nuclear power plants. During 1973 new uranium commitments totaled 52,000 tons which, after reductions in earlier contracts, resulted in a net increase of 45, 800 tons U_3O_8. The amount contracted for in 1973 was roughly three times that during 1972. This is the largest commercial activity for a single year.

The report, *Survey of United States uranium marketing activity, WASH-1196 (74), April 1974,* reflects data as of 1 January 1974. Information was furnished by 64 utilities, 5 reactor manufacturers and 20 uranium producers or companies with definite plans for future uranium production. Data on 195 power reactors were included. The report also includes data on buyer uranium inventories, unfilled needs for uranium in the years 1974 through 1980, outstanding invitations to bid on 1 January 1974 and the degree to which first core and reloads for reactors have been procured.

Domestic commercial deliveries prior to 1 January 1974 plus future commitments now total 175,600 tons of U_3O_8. In addition, domestic producers have contracted with foreign users for delivery of 6700 tons of U_3O_8, of which 5500 tons were delivered prior to 1 January 1974.

A copy of the report may be obtained by writing to Elmo G. Knutson, Supply Evaluation Branch, Division of Production and Materials Management, U.S. Atomic Energy Commission, Washington, D.C. 10545, or J. C. Westbrook, Grand Junction Office, U.S. Atomic Energy Commission, P.O. Bx 2567, Grand Junction, Colorado 81501. It is also available at the AEC Visitor's Aid Desk in the lobby of the Matomic Building, 1717 H Street, N. W., Washington, D.C. ⚒

INTERNATIONAL GEODYNAMICS PROJECT

Formation of an ad hoc committee to coordinate U.S. federal activities in the International Geodynamics Project (IGP) was announced recently by H. Guyford Stever, Chairman of the Federal Council for Science and Technology (FCST). The IGP is a research program designed to learn more about the driving forces within the earth based on the theory of plate tectonics. The theory states that the earth's outer shell consists of a small number of very large plates that move slowly in relation to each other, constantly being renewed by upper movement of material along the mid-ocean ridges and depleted by downward movement of the ocean floor along continental margins and trenches. The IGP has major implications for improving our understanding of such geological phenomena as mountain building, earthquakes, volcanoes and the formation and location of petroleum and ore deposits.

The objectives of the project are to bring together coordinated research in all parts of the world to bear on details of the plate tectonic theory, with particular attention to those movements seemingly unrelated or not in accordance with present theories, and to determine the driving forces within the solid earth. The ad hoc committee will identify the areas of studies considered appropriate and will review annually the federal geodynamics programs and budget. It also will serve as the focal point for liaison with the U.S. Geodynamics Committee of the National Academy of Sciences and other agencies. Each Federal agency with programs in or closely related to the IGP will have members on the ad hoc committee. The agencies include the Department of the Interior, the Department of Commerce, the Department of Defense, the National Aeronautics and Space Administration, the Atomic Energy Commission, the Department of State, and the National Science Foundation. Other agencies may appoint observers as appropriate. ⚒

COASTAL ZONE GRANTS AWARDED

Grants totalling $1,152,050 have been awarded California, Michigan, and Mississippi to assist the three states in developing programs to manage their coastal lands and adjoining waters.

The grants are made by NOAA as part of its responsibilities under the Coastal Zone Management Act of 1972, to encourage effective management, beneficial use, protection and development along America's sea coasts and Great Lakes shores.

The grants made available $720,000 to California, $330,486 to Michigan, and $101,564 to Mississippi. Each state is contributing a matching share of the coastal zone management funds, which by law must amount to at least one-third of the total program cost. The first three grants in this program were made 14 March 1974 to Rhode Island, Maine, and Oregon.

The California grant will be administered by the California Coastal Zone Conservation Commission (CCZCC), which was designated by Governor Ronald Reagan as the applicant agency. The CCZCC, which comprises one state and six regional commissions, was created by the California Coastal Zone Conservation Act of 1972, and the commission is required to adopt by 1 December 1975, a comprehensive plan for the long-range conservation and use of California's coastal zone resources. While the planning program—which must be submitted to the state legislature is under way, the CCZCC has regulated development along the coastline through a permit system. California's 1 year work program involves five state departments, two universities, and seven other commissions and councils. ⚒

REVIEWS

Guidebook: Death Valley Region, California and Nevada. 1974. Prepared for the 70th Annual Meeting of the Cordilleran Section of the Geological Society of America as Field Trip Number 1. Published by and available from the Death Valley Publishing Company, Shoshone, California 92384. Price $7.50 plus tax for California residents.

This guidebook was prepared for use on a 3-day bus trip of the Death Valley region, that starts and ends in Las Vegas, Nevada. The second and third day's trips begin in Shoshone, California. The guide may be useful to those who wish to follow selected segments of the trip or to review in more detail some of the geologic features of part of the Death Valley region which are highlighted in this guide. The guidebook can and should be supplemented by additional reports and maps. General papers and selected papers pertaining to areas along the route are included in the references.

The guidebook consists of a general guide (Part I) and preprints of several new papers, as well as reprints of others, that pertain to the Death Valley and Las Vegas regions (Part II). Original articles in the guidebook will be available in the future as California Division of Mines and Geology Special Report 106.

Open File Report

Base of fresh ground water (approximately 3,000 micromhos) in the Sacramento Valley and Sacramento-San Joaquin Delta, California. By C. F. Berkstresser, Jr. 1973. U.S. Geological Survey Water Resources Investigations Open File Report WR 1 40-73. Scale approximately 1" equals 8 miles.

Area covered is from Redding south to about the latitude of San Francisco. Contours are shown on a planimetric base. Available for study at California offices of the U.S. Geological Survey in San Francisco and Menlo Park and in the library of the California Division of Mines and Geology, Ferry Building, San Francisco.

Thesis

Glaciation of the Red Mountain Area, Klamath Mountains, California. By Gaylon Keith Lee. 1973. 91 p., maps. M.S. Thesis, Arizona State University, Tempe, Arizona. Available for study at the University, and, through the courtesy of the author and Professor Troy L. Pewe, at the California Division of Mines and Geology Library, San Francisco.

The author recognizes four glaciations in the Salmon and Marble Mountains in east-central Klamath Mountains. The earliest, the Shakleford till, he tentatively correlates with Mono Basin and Tahoe tills; the next oldest, Canyon Creek, with Tenaya and Tioga tills; the Campbell till with Hilgard; the Marble Mountain with Neoglacial sequences - Recess Peak, Matthes, and two unnamed tills. ⚒

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Students of the earth sciences may write for CALIFORNIA GEOLOGY—the author need not be a professional earth scientist. Information contained in the article must be accurate as well as interesting. In addition to information on "basic" geology, the editors of CALIFORNIA GEOLOGY solicit articles concerning mining and earth history, California scenic resources, gems and minerals, environmental and engineering geology, prospecting and mining, mineral resources and statistics, and paleontology. All articles will undergo a review process similar to that of our technical publications and will probably be edited.

Lead articles for CALIFORNIA GEOLOGY should be between 10 and 20 pages long, double-spaced, and typewritten. Shorter articles and news items are also solicited. Tables, graphs, drawings, and photographs that will enhance an article are encouraged. Photographs should be 8 x 10-inch black and white glossy prints. All photographs and illustrations should have captions that clearly explain the subject matter, and include the location, the name of the photographer or illustrator, and the date.

The California Division of Mines and Geology does not pay for material submitted for publication, but will provide a number of complimentary copies of the issue in which the article is published.

Questions regarding the publication of manuscripts in CALIFORNIA GEOLOGY should be directed to: CALIFORNIA GEOLOGY, 1416 Ninth Street, Room 1341, Sacramento, CA 95814, (916) 445-0514.

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