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STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF MINES
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Bound in orange cloth, the entire 147-page book, together with five plates folded in a pocket in the back (a geologic map lithographed in color, an economic map on the topographic base, a map showing the oil fields of the Newhall area, a map of the Placerita oil field, and a group of structure sections), is priced at $3.75. The order blank on page 16 may be used for ordering.

SANTA CRUZ MAP READY

The Santa Cruz sheet, the fourth in the new Geologic Map of California series, is now ready for distribution. It is one of an estimated 28 colored lithographed sheets which will depict the geology of California on a scale of 1:250,000 (approximately 1"=4 miles).

The area covered by this sheet is bounded by 36 and 37 degrees North latitude, and by 120° and 122° 12' West longitude. It includes all of San Benito County, and portions of Monterey, Fresno, Kings, Santa Cruz, Santa Clara, Merced, and Madera Counties. The area extends from the Pacific coast to the central portion of the San Joaquin Valley and includes portions of the Santa Lucia, Gabilan, and Diablo mountain ranges, and portions, or all, of Salinas, Santa Clara, Panoche, Pleasant and San Joaquin valley.

Thirty-six different map symbols have been used to depict the wide variety of rock units that range in age from pre-Cretaceous (Sur series) to Recent (dune sand and alluvium).

A number of interesting and significant geologic features are graphically portrayed by the map. These include the San Andreas fault zone, the syncline of the Vallecitos area, the anticline of the north dome of Kettleman Hills, the serpentine of the New Idria area, and the volcanic rocks of the Pinnacles National Monument area.

The topographic map, used as a base map for the compilation, was prepared by the Army Map Service, Washington, D.C. The township grid was provided by the U.S. Geological Survey and the offshore contours were adapted from work by Shepard and Emery which appeared in Special Paper No. 31 of the Geological Society of America. Each of these is an important contribution which has added to the usableness and usefulness of the completed map.

An explanatory data sheet accompanies the map sheet. It describes the sources from which the map was compiled, it explains the grouping of the stratigraphic units which comprise the various time-stratigraphic state map units, it contains an index of topographic quadrangles, and it also contains a striking photograph of the coastal area north of Pt. Sur.

The Santa Cruz sheet is available folded in a 9 x 12 inch manila envelope, or unfolded in a tube. The map sheet, and its accompanying explanatory data sheet, is priced at $1.50 (plus 6¢ tax for California residents). Copies of it and the previously published Death Valley, Alturas and San Luis Obispo sheets may be ordered from Division offices in San Francisco, Los Angeles, Sacramento, or Redding.

ORDER FORM

Please send me:

____copies, BULLETIN 172, Geology and mineral deposits of San Fernando quadrangle, at $3.75 each.

____copies, SPECIAL REPORT 11, Guide to the geology of Pfeiffer-Big Sur State Park, at $0.25 each.

____copies, SPECIAL REPORT 56, Limestone and dolomite, northern Gabilan Range, at $0.50 each.

____copies, SAN LUIS OBISPO SHEET, Geologic map of California (Olaf P. Jenkins edition), at $1.50 each.

____copies, SANTA CRUZ SHEET, Geologic map of California (Olaf P. Jenkins edition), at $1.50 each.

____copies, Information on the AUTOMATIC PURCHASE PLAN for sheets of Geologic map of California.

NAME_____ADDRESS_____

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Address orders to the California Division of Mines, Ferry Building, San Francisco 11, California. Checks and money orders should be made to the Division. No postage is required; please do not send stamps in payment. California residents please add 4% sales tax. ~mab~

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MINERAL INFORMATION SERVICE

STATE OF CALIFORNIA DIVISION OF MINES

VOLUME 13 NUMBER 1
JANUARY 1960

Geologic Sketch of the Southern Coast Ranges

by GORDON B. OAKESHOTT

The Division of Mines has recently published the San Luis Obispo and Santa Cruz sheets of the new, colored, 1:250,000-scale State Geologic Map. As this issue of Mineral Information Service goes to press, the Santa Maria sheet is expected shortly; the San Francisco sheet is nearing completion, and San Jose is in the planning stage. These five sheets encompass the Southern Coast Ranges, which extend from the Golden Gate-San Pablo Bay-Suisun Bay depression on the north to the Santa Ynez River in Santa Barbara County on the south, and from the Pacific Ocean on the west to the San Joaquin Valley on the east. The Southern Coast Ranges make up a northwestward-trending geographic and geologic province of broadly similar characteristics but one which shows great complexity in the details of its geologic history and geographic development. Climate is of the Mediterranean type, with warm, dry summers and mild winters; rainfall is moderately low in most of the area but ranges from as little as 5 inches in the eastern foothills on the margin of the San Joaquin Valley to as much as 100 inches, in some years, at Big Basin, north of Santa Cruz.

Looking south at Morro Bay. Morro Rock in the bay at the extreme right, is one of a linear series of dark volcanic necks which can be seen trending eastward across the photo. Photo by John S. Shelton.

MINERAL INFORMATION SERVICE

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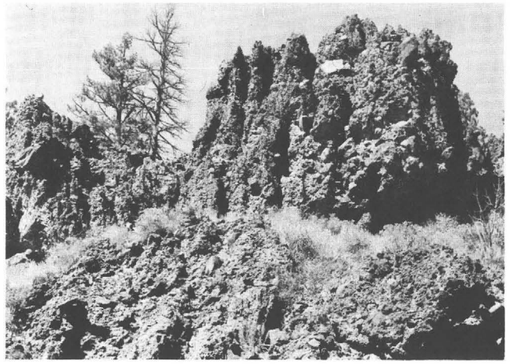
MINERAL INFORMATION SERVICE is designed to inform the public on the geology and mineral resources of California and on the usefulness of minerals and rocks, and to serve as a news release on mineral discoveries, mining operations, markets, statistics, and new publications. It is issued monthly by the California Division of Mines. Subscription price, January through December, is $1.00.

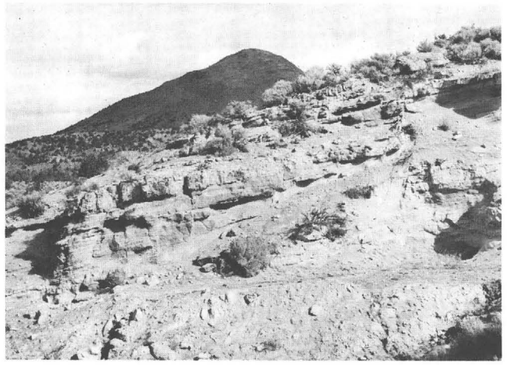
Other publications of the Division of Mines include the Annual Report of the State Mineralogist, the Bulletin and Special Report series, county reports, and maps. A list of the Division's available publications will be sent upon request. Communications to the Division of Mines, including orders for publications, should be addressed to the headquarters office.

Topography

Northwest-trending geologic structures and erosional processes during late Tertiary and Quaternary time have developed a series of alternating mountain ranges and valleys, also trending northwest. The very rugged and irregular coastline has a slightly more northerly trend and so generally intersects structures of the Southern Coast Ranges at a low angle, with consequent spectacular exposures of rock formations, faults, and folds along almost the entire coast. The Santa Cruz Mountains extend along the San Francisco Peninsula to the Pajaro River, which empties into Monterey Bay. East of the Peninsula, the depression occupied by San Francisco Bay narrows southeastward into the Santa Clara Valley and Hollister, or San Benito, Valley. East of the Bay are the Berkeley Hills. Mt. Diablo, elevation 3,849 feet, stands at the northeastern end of the Diablo Range in the Eastbay. Mt. Hamilton, elevation 4,372, east of San Jose, is another prominent peak in this high and rugged range. An eastern spur of the range has its southern limits in the area of the prolific oil fields of Coalinga and Kettleman Hills; the western portion merges southward into the Temblor and San Emigdio ranges. West of the central and southern

View south along crest of Reef Ridge toward San Joaquin Valley. Resistant lower Miocene sandstone forms dark ridge in foreground (A), while light ridge in middleground (B) is composed of the overlying Monterey shale. Photo by John S. Shelton.





Tuff breccia outcrop on Little Last Chance Creek, NW¼ Chilcoot quadrangle (left); sandstone member of Miocene lake beds, southeast corner of Chilcoot quadrangle (right). Pictured are two of the geologic units recently mapped by the Division's geologists as part of the reconnaissance mapping for the Chico Sheet of the State Geologic Map. The area under study comprises 900 square miles in portions of Lassen, Plumas, and Sierra Counties covered by four 15-minute quadrangles: Chilcoot, Loyalton, Sierraville, and Portola.

Volcanic, granitic, metavolcanic, and some Tertiary sedimentary rock form the predominant outcroppings. The Tertiary sedimentary rocks were intensely prospected for uranium in 1954—55. At least three deposits of possible commercial grade uranium were discovered and two mines were operated for a short time.

NEW BOOKS

The earth shook, the sky burned, by William Bronson. Published by Doubleday and Company, Garden City, New York. By this time most residents of the San Francisco Bay area, as well as many persons all over the country, have at least read reviews of this fine new book. Mr. Bronson has created a very lively documentary of the San Francisco earthquake of April 18, 1906. The more than 400 photographs are far more than ornament; they are the mainstay of the book. A nicely presented book that should interest anyone. Available at bookstores.

Rocks to riches, by Charles H. Dunning with Edward H. Peplow Jr. Published by Southwest Publishing Company, inc., Phoenix, Arizona. Subtitled "The story of American mining...past, present and future...as reflected in the colorful history of mining in Arizona, the nation's greatest bonanza", the book traces the story of mining in Arizona, written by a former director of the Arizona Department of Mineral resources (Mr. Dunning) and a writer-historian (Mr. Peplow). One of their conclusions of interest to the entire mineral industry is this: there is today a greater proved reserve of usable copper ore in Arizona than at any time during its history, despite the millions of dollars worth of ore already removed. Available at bookstores.

General crystallography, a brief compendium, by W.F. de Jong with the collaboration of J. Bouman. Published by W.H. Freeman and Company, San Francisco. Originally published in Dutch (Mr. de Jong is Lecturer at the Technical University of Delft), the new English volume is a translation, enlarged and revised. It is a brief summary (actually the text runs to 280 pages) of the modern view of crystallography. Its four major divisions are geometric crystallography (including crystallographic calculations), structural crystallography (as determined by x-ray, electron, or neutron ray), chemical crystallography (the molecular arrangement) and physical crystallography (including phoenomena such as pyroelectricity and piezoelectricity, and such properties as hardness, expansion, and tensile strength). Available at bookstores.

SAN FERNANDO BULLETIN RELEASED

A new bulletin, number 172 in the Division's Bulletin series, is now available. Entitled, "Geology and Mineral deposits of San Fernando quadrangle, Los Angeles County, California," the book has been awaited for some time by those who were familiar with the geologic map (plate 1 of the bulletin), issued previously.

This bulletin is one of the Division's series of quadrangle reports which are based on geologic mapping—scale one inch equals one mile—of areas which are significant for their mineral resources or potential. The author, Gordon B. Oakeshott, carried on the long-time field and laboratory studies of this part of the San Gabriel Mountains in addition to his duties as Deputy Chief, Division of Mines.

San Fernando quadrangle, because of its complex geologic history and diversity of rock formations, has produced a large number of mineral commodities. Cumulative mineral production from the quadrangle, to the end of 1953, is estimated at $51,000,000. Petroleum, principally from Placerita oil field, accounts for 84 percent of this; rock products, 9 percent; borates from Lang (Sterling) mine, 6 percent; and gold and minor amounts of titanium ore, about 1 percent. The region has an important potential for mineral production, particularly as it lies within a few miles of the great Los Angeles metropolitan area.

New Mines program . . .

One of the most promising phases of the Division's new research program, the cooperative program with the U.S. Bureau of Mines, has been initiated. The agreement, which became effective on November 2, 1959, provides for collaboration of the two agencies in programs of investigation and research. These studies will initiate the program: a) the production of tungsten and molybdenum metal by direct electrolysis of scheelite concentrate; b) the development of useful co-products from the anorthosite rock of the San Gabriel Mountains; c) slope stability studies in open pits. The work will be conducted by the Bureau of Mines using their facilities, equipment, materials, and personnel. The State will consult and advise the Bureau concerning the work.

Both parties are contributing to the cost of the work; the State contributing the sum of $35,000 to be matched equally with Federal funds.

The major portion of the funds will be applied toward the project on the production of tungsten and molybdenum metal. This has been a continuing project of the U.S. Bureau of Mines at Reno, Nevada where their laboratories have developed a new and simple method for producing commercial grade tungsten and molybdenum powders suitable for use in alloys. The method, known as fused-salt-bath electrolysis, consists of mixing scheelite concentrate with alkali phosphates or borates and subjecting the bath to electrolysis; molybdenum is first deposited on a cathode under a low-voltage charge, tungsten under higher voltage on a second cathode. This project is of particular interest to owners of California tungsten deposits in which scheelite is the major ore mineral.

AIME to hold 1960

Metals & Minerals meeting

More than 500 delegates and wives are expected to attend the 13th annual 1960 Pacific Northwest Metals and Minerals Conference of the American Institute of Mining, Metallurgical and Petroleum Engineers, to be held in Portland, Oregon, next April 28, 29, 30. There also will be sessions with American Society of Metals.

Conference site will be Portland's beautiful new Sheraton Hotel, which has an outdoor swimming pool; and is located next to the Lloyd Center, the nation's largest urban shopping area. These are a few of the attractions outside the conference proper.

Hollis M. Dole, director, Oregon Department of Geology and Mineral Industries, is general chairman. John R. Anderson, product engineer, Carborundum Company, Vancouver, Washington, is co-chairman.

The Conference will include a complete technical program embracing such fields as gold, physical metallurgy, geology, industrial minerals, iron and steel, mining, petroleum geology and refractories. Field trips and a showing of the Peschel Collection and Joy Machinery's collection of mining art at the Portland Art Museum will round out the program.

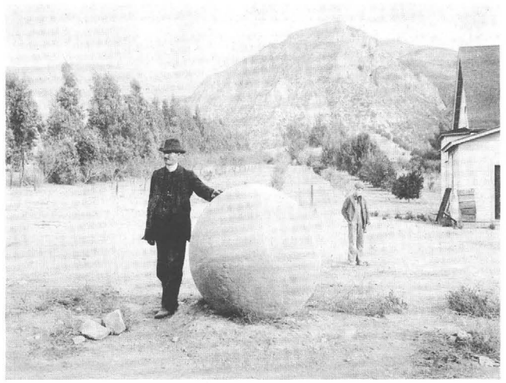
Details of the program will be announced later. Chairman Hollis Dole promises an interesting and exciting program, and urges interested persons to make definite plans now. Conferences are held annually at Spokane, Seattle and Portland on a rotating basis.

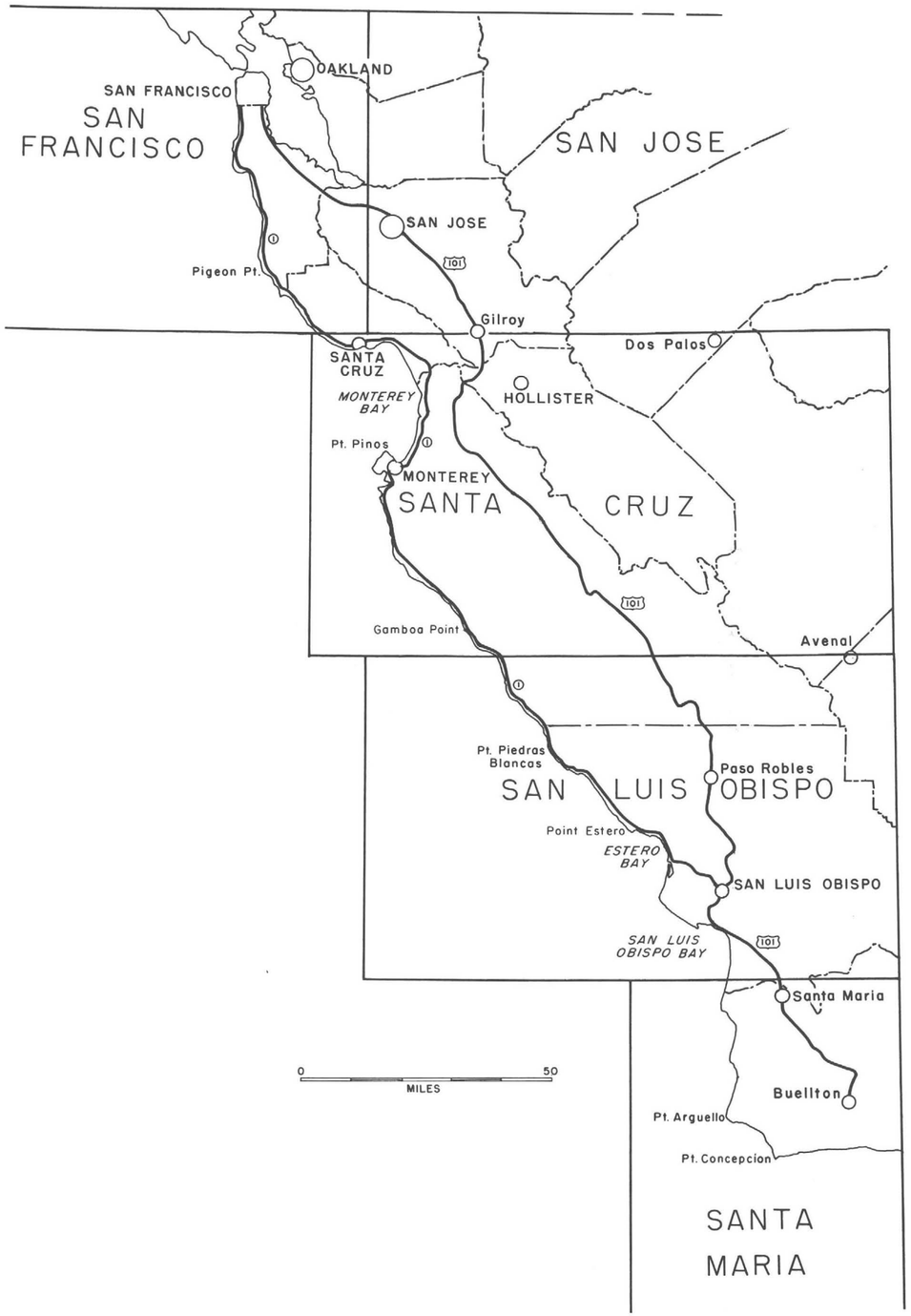
A PAGE FROM HISTORY

Two half-century-old photographs (below) of concretions from Miocene sandstone near Piru, Ventura County. At that time, the sandstone was identified as "Lower Neocene" in age. These photographs were made as part of the Division (then Bureau of Mines) study of petroleum in California; they were published in 1900 in Bulletin 19, written by W. L. Watts, a mining engineer whose photographs of geologic features have seldom been surpassed. The bulletin has, of course, been long out of print, though there are copies available for study in libraries.

At the time—the turn of the century—there were, in Ventura County, four oil fields on the south side of the Santa Clara River valley, and four and a part on the north. The total production of petroleum products the previous year, 1899, in the county—second among the California counties, led only by Los Angeles—had been 496,200 barrels, at a price of $1.00 per barrel.

Today there are more than thirty oil and gas fields in Ventura County; the 1958 total production of petroleum products was valued at nearly one hundred and eighty million dollars.





GEOLOGIC NAMES AND AGES USED IN THIS PAPER

Geologic units or formations	*Geologic period or epoch*	*Age in millions of years*	*Symbol on state map sheets*
Alluvium, beach sands, dune sands, terrace deposits, and lake beds	Pleistocene and Recent	0.5 to present	Qal, Qm, Qs, Qr, Ql, etc.
Santa Clara, San Benito, Livermore, and Paso Robles	Upper Pliocene and Pleistocene	0.5- 4 (?)	Qp
Marine middle and lower Pliocene formations	Middle and lower Pliocene	4(?) - 9	Pml
Volcanic rocks	Miocene	9 - 28	Mv
Upper Miocene marine formations, including "Santa Margarita"	Upper Miocene		Mu
Middle Miocene marine formations, including "Monterey"	Miocene		Mm
Marine lower Miocene formations	Lower Miocene		Ml
Oligocene formations		28 - 38	
Marine			Ø
Non-marine			Øc
Marine Eocene formations	Eocene	38 - 58	E
Paleocene formations	Paleocene	58 - 75	Ep
Cretaceous formations exclusive of Franciscan	Cretaceous	75 - 130	K
Upper (marine)			Ku
Lower (marine)			Kl
Granitic rocks	Early Upper Cretaceous	75 - 90	gr
Franciscan-Knoxville group	Upper Jurassic to Upper Cretaceous	90 - 140	KJf
Serpentine			ub
Volcanic rocks			KJfv
Sur series	Pre-Cretaceous	Over 140	m
Crystalline limestone in Sur series			ls

Diablo Range is the Gabilan Range. The long, narrow depression of the Salinas Valley is between the Gabilan Range on the east and the Santa Lucia Range on the west. In the southern part of the San Luis Obispo sheet the long valley-depressions of the Southern Coast Ranges narrow to leave an almost continuous succession of mountains from the Santa Lucia Range on the coast across La Panza Range and Carrizo Plain to the Temblor Range on the margin of the San Joaquin Valley. The most southerly of the Coast Ranges is the San Rafael Mountains, the southeastern end of which joins the mountains of the Transverse Ranges.

GEOLOGIC FORMATIONS AND HISTORY

Sur series and granitic rocks

The oldest rocks in the Southern Coast Ranges are the metamorphic rocks of the Sur series. They are schists, gneisses, quartzite, and crystalline limestone which are complexly folded and faulted in many places. Reference to the map sheets shows that they are distributed widely across the northern Santa Lucia Range and in small, scattered outcrops in the northern end of the Gabilan Range. Their age is unknown but many geologists consider them Late Paleozoic; they are certainly pre-Cretaceous. These rocks of uncertain age are all that geologists have on which to base the history of the Southern Coast Ranges during the vast extent of geologic time prior to some 140 million years ago! However, the rocks show that in that part of geologic time which they represent, seas existed over the area; and that sand, mud, limey sediments and some volcanic rocks were deposited. Rocks of the Sur series are best seen at Fremont Peak State Park, along the coast highway 31 miles south of Carmel, and in the less accessible heart of the range west of Hunter Liggett Military Reservation.

The Sur series has been intruded by great bodies of granitic rocks, best exposed in the Santa Cruz Mountains, Santa Lucia Range, La Panza Range, and Gabilan Range. It is interesting to note that neither the Sur series nor the granite is exposed east of the San Andreas fault zone. The ages of some samples of the granitic rocks have been determined by radioactivity methods; these ages suggest that most of the granite solidified from its magma about early Upper Cretaceous time, around 90,000,000 years ago. Exposures of the granitic rocks may be easily seen at many places, such as Montara on Highway 1, Pt. Lobos State Park near Carmel, and on the secondary road six miles east of King City.

Upper Jurassic and Cretaceous formations

One of the most widely distributed and typical assemblages of rocks exposed in the Southern Coast Ranges is the Franciscan-Knoxville group and the serpentine intruded into these rocks. The Franciscan rocks consist of dark, gray, arkosic sandstone (graywacke), black shale, chert, schists high in glaucophane and actinolite, and a variety of volcanic rocks formed as flows under water, and as sills and plugs. "Knoxville" is a name commonly used for thick, black shale strata of Upper Jurassic age. The whole Franciscan-Knoxville sequence is at least 25,000 feet thick and was all deposited in a great sinking trough or geosyncline, which occupied the site of the Coast Ranges. Fossils are rare but enough have been found to show that the Franciscan-Knoxville group includes rocks ranging from Upper Jurassic to early Upper Cretaceous in age. On the San Francisco peninsula, fos-

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Payne, Max B., 1951, Type Moreno and overlying Eocene strata on the west side of the San Joaquin Valley, Fresno and Merced counties, California: California Div. Mines Special Rept. 9, 29 pp.

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Mineral marketing . . .

The following quotations are taken from Engineering and Mining Journal Metal and Mineral Markets, published weekly by McGraw Hill Publishing Company.

METALS—November 26, 1959

COPPER, electrolytic, 33.905¢ per pound, domestic refinery, weekly average.

LEAD, refined, 12.8¢ per pound, [St. Louis]; 13.0¢ per pound, [New York].

PLATINUM, $77-$80 per troy ounce.

ZINC, prime Western, 12.5¢ per pound, [East St. Louis].

METALLIC ORES—November 26, 1959

ANTIMONY ore, per short ton unit Sb:

50-55%	$2.25 to	$2.40
60%	$2.50 to	$2.60
65% lump	$3.10 to	$3.20

CHROME ore, per long ton, dry basis, subject to penalties if guarantees are not met, F.O.B. cars, Atlantic ports: Turkish ore 48% Cr_2O_3, 3 to 1 chromium to iron ratio, $36 to $37, nominal.

MANGANESE ore, quotations on Indian ore, basis 46% to 48% Mn, export duty included, nominal at 87¢ to 90¢ per long ton unit, c.i.f. U.S. ports, import duty extra.

TUNGSTEN ore, U.S. scheelite, f.o.b., mine, $22 to $24 per short ton unit, 65% WO_3.

CALIFORNIA MARKET QUOTATIONS

The following quotations are from San Francisco area processors and dealers, and were those in effect on November 30, 1959.

QUICKSILVER, per flask of 76 pounds prime virgin, price paid to miner $200 [San Francisco] in small lots; [New York], $216.

INDUSTRIAL MINERALS

(Crude unless otherwise stated). Prices depend upon chemical analysis, color, impurities, and physical properties. Market is generally limited.

BARITE, 90% to 98% $BaSO_4$, crude, $16 per short ton. [San Francisco area].

BENTONITE [Wyoming type] carload lots, pulverized 200 mesh, $34.00 per short ton, [San Francisco area].

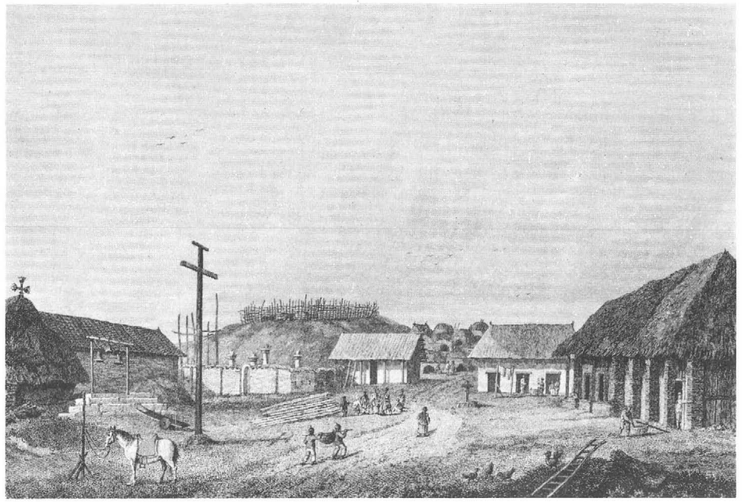
FIRE CLAY, crude, $7.00 per short ton depending on quality, [San Francisco].

GRAPHITE, Mexican, amorphous, f.o.b. shipping point, $15 to $19 per metric ton (2204 pounds), (Engineering and Mining Journal).

LIMESTONE, white, 97% $CaCO_3$, $7.50 per short ton [San Francisco].

PERLITE, Crude ground for expanding, per short ton, plant Saint Helena, $8.00. Expanded for plaster or concrete in 3 cu. ft. bags, 75¢ f.o.b. plant Saint Helena.

TALC, crude, $26.00 per short ton, [San Francisco area]. Soapstone, crude, $8.00 per short ton, [San Francisco area].



Carmel Mission as it appeared in the 1790s. From a sketch taken on the spot by J. Sykes.

and spectacularly rugged peninsulas along the California coast. Here, marine conglomerate beds and sandstone of Paleocene age are exposed where they lie on eroded Cretaceous granitic rocks.

For several miles south of Point Lobos, Highway 1 is alternately perched on terraces and cut into the very steep slopes of this rugged, mountainous coast. Along the slopes are exposures of Cretaceous granitic rock, which carries many inclusions of the older Sur gneiss and schist. Four miles beyond Palo Colorado, about 12 miles south of Carmel, white coarse crystalline Gabilan limestone (part of the Sur series) crops out. The northwest-striking Palo Colorado fault is one of a series of major faults, including the Sur thrust, which slice across the coastline, at an angle of about 45°, between Palo Colorado and Point Sur. The Sur thrust enters the ocean just north of Point Sur which is composed of Franciscan volcanic rocks. The highway then continues southeast into the deep valley of the Big Sur River which has been carved by erosion of the brecciated rocks in this major fault zone. Along the Big Sur River the Sur thrust essentially forms the contact between Franciscan rocks on the west and Sur series rocks on the east. Pfeiffer Big Sur State Park is in the Sur thrust fault zone 31 miles south of Carmel. Two branches of the fault are well-exposed in the Park. Sur series rocks, from the east, have been thrust up and over the Franciscan formation on the west, with a sliver of light-colored upper Miocene sandstone and breccia caught between. Geology of the Park is described in detail in Division of Mines Special Report 11.

Big Sur to San Luis Obispo

Granitic rocks and remnants of the Sur series are exposed in steep road cuts for the next few miles south of Big Sur State Park. At Slates Hot Springs, Upper Cretaceous dark shale and conglomerate have been preserved in a complex southward extension of the Sur fault zone between the Sur series on the east and Franciscan rocks on the west. For about 40 miles south of Slates Hot Springs, the highway winds in and out of abrupt canyons and along precipitous slopes through exposures of the heterogeneous rocks of the Franciscan formation and the occasional masses of serpentine which intrude it. The beach at Willow Creek, at Cape San Martin, is a noted locality for nephrite jade. This occurrence in serpentine is described in Division of Mines Special Report 10-A.

Shortly after crossing from Monterey County into San Luis Obispo County, from San Carpojo Creek near Ragged Point, the highway follows a low marine terrace of late Pleistocene age. A thin veneer of sediments on the terrace overlies the complex of Franciscan, Cretaceous, and Miocene rocks to a point some 8 or 10 miles south of San Simeon Beach State Park. Near San Simeon Point, a large parking area, with rest and refreshment facilities, is the take-off station for the bus trip up the mountain slope to Hearst Castle, now a State Park facility. This trip gives a spectacular view of the terraces, beaches and coast. Upper Cretaceous rocks are exposed along the coast from San Simeon Beach State Park to Cayucos Point on Estero Bay, but the highway moves inland a short distance and passes through poorly-exposed Franciscan rocks to Morro Rock State Park. Morro Rock is a sea stack, tied to land by a sand bar, which is the most northwesterly of a series of eroded volcanic necks that extends southeast several miles beyond Highway 101. The 13-mile stretch of Highway 1 from Morro Bay to 101 at San Luis Obispo passes through poor exposures of Franciscan rocks but a fine view of the succession of andesitic plugs or necks which lie south of the highway is afforded.

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sils suggest a mid-Cretaceous age for rocks of the Franciscan group. There is little doubt that shallow seas covered the site of the Southern Coast Ranges during most of this time, roughly between 100 and 140 million years ago. However, some lenses of conglomerate within the Franciscan contain pebbles which were obviously derived from older Franciscan rocks. Locally, as in the Stanley Mountain area, 14 miles east-northeast of Nipomo, fossiliferous Lower Cretaceous sedimentary rocks lie unconformably on Franciscan-Knoxville. Thus, mild crustal disturbances and local uplift must have taken place during Franciscan time, but the Jurassic period closed with a widespread uplift known as the Diablan orogeny (mountain-building epoch). Rocks of the Franciscan group and the distinctive greenish serpentine are so widely distributed in the Southern Coast Ranges that they may be seen along almost any road which crosses the ranges. They are exposed, for example, at the crest of Mt. Diablo, the top of Mt. Hamilton, on Pacheco Pass east of Gilroy, at Pfeiffer Big Sur State Park, and at San Luis Obispo on Highway 101.

Cretaceous sedimentary formations, exclusive of the Franciscan formation, are a marine sequence of arkosic sandstone, conglomerate, shale, and sandy shale that exceeds 30,000 feet in aggregate thickness in many places. The Diablan orogeny did not destroy the geosyncline that had existed in Upper Jurassic time, for shallow seas continued to spread widely over the area of the Southern Coast Ranges in Lower Cretaceous time. Another mild orogenic epoch occurred in mid-Cretaceous time, between the deposition of Lower and Upper Cretaceous strata. Again, in the midst of Upper Cretaceous deposition, local mountain-building, known as the Santa Lucian orogeny, took place in the Santa Lucia and Gabilan ranges. In spite of these periodic crustal disturbances, shallow seas must have covered most of the Southern Coast Ranges during Upper Jurassic and Cretaceous time, representing, in all, about 70 million years.

One of the most difficult and puzzling problems of Coast Range geology is that the relationships of the granitic intrusions to the rock formations of the Franciscan-Knoxville group and "Lower Cretaceous" are not accurately known. Granite has never been found in intrusive contact with Franciscan rocks; contacts are always faulted. Granitic rocks are normally developed by intrusion of molten material into an orogenic belt. In line with recent dating of these rocks, it may well be that the granitic rocks of the Southern Coast Ranges were intruded during the "mid-Cretaceous" and the Santa Lucian orogenic epochs. However, large lateral movements along the San Andreas fault have been suggested as a possible explanation of the proximity of the granite to unmetamorphosed sediments of approximately the same age.

Paleocene to lower Miocene time

The Cretaceous period seems to have closed with local uplift and erosion and probably considerable areas of the Southern Coast Ranges were left above the level of Paleocene seas. Shallow marine sandstone, conglomerate, and shale of Paleocene age, much like the Upper Cretaceous, are found only in small, widely scattered areas in the Southern Coast Ranges. Paleocene rocks are exposed lying on granitic rock at Pt. Lobos, on Upper Cretaceous rocks on the San Francisco peninsula, in fault blocks and lying on Upper Cretaceous and the Sur series in the central southern part of the Santa Lucia Range, and on Upper Cretaceous rocks in the southern Diablo Range. Paleocene sedimentary rocks are usually only a few hundred feet thick.

Looking south at the Santa Ynez Mountains, one of the Transverse Ranges. The low hills in the foreground are the southern end of the Coast Ranges province. Courtesy Spence Air Photos.

The history of the Southern Coast Ranges during Eocene to lower Miocene time is one of crustal unrest although no mountain ranges were formed at this time. The area was one of scattered low lands, narrow shallow seas and mild climates. This interval might be considered the time of the beginning development of the modern Southern Coast Ranges for, not only were low lands and islands widespread, but some of the great Coast Range fault zones show first evidence of displacement. Eocene marine sedimentary rocks are found in thick sections in the Santa Cruz Mountains, as scattered faulted remnants in the heart of the Santa Lucia Range, and are widely distributed on Upper Cretaceous and Paleocene rocks of the Diablo Range, particularly at the western margin of the San Joaquin Valley. Upper Eocene seas were more extensive than those of the lower or middle parts of the Eocene, but extensive erosion leaves their detailed distribution uncertain. The Oligocene epoch was a time of very limited and restricted seas, climates became more arid and sedimentary rocks of this epoch are, in some places, continental red beds. Marine Oligocene beds are known on the east flanks of the Diablo Range, in the San Ramon trough west of Mt. Diablo, and in the Santa Cruz Mountains.

Lower Miocene time opened with shallow seas spreading into straits, bays, lagoons, around islands and along open coasts. The rocks, therefore, include sandstone, conglomerate, shale, and limestone and are found widely scattered through the Southern Coast Ranges. Outcrops of marine lower Miocene rocks are found, for example, along the western margin of the San Joaquin Valley in the Diablo Range, are exposed in a major syncline trending west-northwest across San Benito County, and in the San Andreas fault zone. Lower Miocene seas spread over the southern Salinas Valley, across the southern Santa Lucia Range, and widely into the San Joaquin Valley. Most of the western and northern part of the Santa Lucia Range, the western Santa Cruz Mountains, the northern end of the Salinas Valley, the Gabilan Range, and the northern Diablo Range were probably land above sea level.

Miocene formations and history

In the Southern Coast Ranges seas advanced much more widely in middle and upper Miocene time as shown by the distribution of these marine rocks on the State Geologic map sheets. Rocks of these ages are chiefly shale, chert and cherty shale, marly limestones, diatomite, and sandstone. They include the well known "Monterey formation" whose type locality is at Monterey. Seas of middle and early upper Miocene time spread widely across the ancestral San Andreas fault zone; it was a time of relative crustal quiet and widespread seas. During middle Miocene time volcanic activity was widespread and a great variety and thickness of volcanic rocks accumulated with the shallow marine sediments.

Crustal unrest, forecasting the formation of the present ranges, became increasingly important in late Miocene time. Seas became more restricted and a change in the sedimentary rocks took place from predominant shale to sandstone. The beautifully white arkosic "Santa Margarita" sandstone, derived from granite, was deposited in upper Miocene to earliest Pliocene time.

Close of the Tertiary period and Coast Ranges orogeny

In early Pliocene time, about 9,000,000 years ago, the complex pattern of lands and shallow seas of upper Miocene time continued, but as time went on seas became more restricted and lands wider and higher. On the State map sheets, marine sedimentary rocks of the middle and lower Pliocene, largely sandstone, siltstone, diatomaceous siltstone, and conglomerate, are most widely distributed in a belt along the San Andreas fault zone, both east and west of it, across the southern Gabilan Range east of the Salinas Valley and southeast across the southern Diablo Range into the San Joaquin Valley in the vicinity of Kettleman Hills. This distribution roughly outlines a seaway which extended from the Santa Cruz coast to the San Joaquin Valley. The northern end of the Diablo Range was probably then the highest and most mountainous part of the area of the Southern Coast Ranges.

In late Pliocene time, strong compressive forces folded, faulted, and elevated all older rock formations in the greatest orogenic epoch known in the history of the region. The seas withdrew, basins narrowed, and the present Southern Coast Ranges were formed. The newly-elevated hills and mountains were subjected to very rapid erosion and a flood of gravel and coarse sand spread widely and thickly over the lowlands. Elevation and erosion continued into the Pleistocene and, indeed, is still active. The very coarse sediments which accumulated in Plio-Pleistocene time are known by various formation names, such as Santa Clara, San Benito, Livermore, and Paso Robles. Sediments of later Quaternary time consist principally of alluvium, beach sands, dune sands, terrace deposits, lake beds, and some near-coast marine deposits.

GEOLOGIC STRUCTURE

Casual examination of the State Geologic Map sheets which cross the Southern Coast Ranges shows a bewildering complex of folds and faults of widely different characteristics, types, and magnitudes, as well as blocks which seem to have been elevated or depressed more or less as a unit. Coast Ranges structure appears complex but its complexity is more in detail than in general features. Certain features of fundamental importance are: 1) The structural grain is northwest, as shown by alignment of major fault zones, fold axes, and geologic formational units. This grain was developed in response to great northeast-southwest compressional forces, whose real origin is unknown. 2) The present coastline has a more northerly trend than the major structures and ranges of the Southern Coast Ranges; this means that such features are intersected obliquely at the coastline. 3) A succession of epochs of crustal deformation culminated in the latest and greatest orogeny initiated in late Pliocene time. The combined result of all of these orogenies is reflected in the structures seen today; recognition and evaluation of the relative importance and effects of each is a major geologic problem. The geologist must, in imagination, "peel off" later geologic units and "iron out" structures to exhume and restore older features of the Ranges, epoch by epoch.

Paso Robles formation. Occasionally, erosion has exposed the older formations through "windows" of the Paso Robles, as for example, east of Camp Roberts and San Miguel.

South of Templeton, through Atascadero and Santa Margarita, Miocene rocks lie in a narrow synclinal fold, or trough, between the Nacimiento and Rinconada faults. White sandstone of the Santa Margarita formation lies on buff shale and chert of the Monterey formation. Entering Atascadero from the north, large road cuts may be seen in steeply east-dipping Monterey shale, with overlying white Santa Margarita sandstone immediately east of the road. Exposures of white Santa Margarita sandstone at the type locality, between the oil tanks and cemetery at the town of Santa Margarita (now by-passed by the new freeway), are noted for their large fossil oysters (Ostrea titan). East of Santa Margarita is La Panza high, an exposure of granitic rocks in the heart of La Panza Range which was being eroded in upper Miocene time to form the coarse Santa Margarita sand.

Santa Lucia Range and San Rafael Mountains

The approximately 20 miles of Highway 101 from Santa Margarita to San Luis Obispo Bay exposes a complexly folded and faulted geologic section directly across the Santa Lucia Range. The central core of the Range consists of Franciscan and Cretaceous rocks which are flanked on the north and south by marine sedimentary and volcanic rocks of middle and upper Miocene age. Rocks of all these ages are exposed over Cuesta Pass. At the south end of Cuesta grade, a mile north of San Luis Obispo, the northern projection of the West Huasna fault has brought serpentine against Franciscan sandstone. At the south edge of town, several sharp, steep, conical peaks are volcanic necks which represent the eroded remnants of Miocene andesitic volcanos which were built along a northwest-striking zone of weakness, probably a fault. Most northwesterly of these is Morro Rock at Morro Bay State Park, on Coast Highway 1. At San Luis Obispo, Highway 1 joins 101. Five miles south of this junction, the highway crosses south-dipping middle Miocene volcanic rocks and Monterey cherty shale, overlain by alternating white sandstone and brown siliceous shale members of the upper Miocene Santa Margarita formation. A mile farther south, a synclinal axis is crossed and then this section is reversed on the south limb, with middle Miocene volcanics exposed on the coast. A belt of these volcanic rocks is rather closely followed by the highway for more than 20 miles S. 60° E. from Pismo Beach; a prominent outcrop of the rhyolite is cut by Highway 101 just northwest of the town. Southeast of Arroyo Grande, highway cuts expose gravels of the Plio-Pleistocene Paso Robles formation which are here made up almost entirely of white shale pebbles derived from the nearby Monterey formation. The terrace north and south of Nipomo is a Pleistocene wave-cut terrace overlain by a very thin veneer of terrace deposits.

Santa Maria is located on the broad, gravelly floodplain and channel deposits of the Santa Maria River. At the south edge of town the important Santa Maria Valley oil field is crossed. It produces heavy oil (12°-17° API gravity), from fractured Miocene chert and sandstone lying on Franciscan "basement". The highway then turns southeast for about 4 miles across late Quaternary reddish dune sands, here called the Orcutt formation, and continues for another 20 miles across rolling hills of folded Plio-Pleistocene gravel beds of the land-laid Paso Robles formation to Zaca Creek. The highway then turns generally due south along the creek and across a well-exposed section of tightly-folded Monterey shale and chert for about 6 miles to the town of Buellton. This is the southern end of the Coast Ranges province. Just south of Buellton the Santa Ynez River and the east-west structures of the Santa Ynez Mountains, in the Transverse Ranges Province, are encountered.

A GEOLOGIC TRIP ALONG HIGHWAY 1

~SANTA CRUZ TO SAN LUIS OBISPO~

Highway 1 enters Santa Cruz from the northwest after following the coast southward along San Francisco Peninsula. A couple of miles west of Santa Cruz the natural bridge on the beach at Natural Bridges State Park has been formed by wave erosion in the Monterey shale. The route through Capitola, Watsonville, Castroville, and Fort Ord is largely across a recently elevated part of the coast through late Pleistocene marine terrace deposits, late Pleistocene dune sands of the Aromas formation and the latest beach and dune sands. The beach sands near Aptos are locally high in magnetite and ilmenite. Sea cliffs at the beaches at Capitola, Seacliff and Del Mar expose almost flat, fossiliferous, marine sandstone, siltstone, and sand of upper Pliocene age. At Moss Landing is the magnesia plant of Kaiser Aluminum and Chemical Corporation which uses sea water and dolomite from the Natividad quarry, 12 miles away. The big nearby electric power plant of Pacific Gas and Electric Company is supplied with natural gas by pipeline. This section of Highway 1 crosses the 6-mile-wide recent floodplain of the Salinas River. Between Neponset and Seaside the buff-colored dunes west of the highway are an important source of construction and specialty sands.

Monterey to Big Sur

In the town of Monterey, tilted beds of the marine middle and upper Miocene Monterey formation may be seen lying on Cretaceous granitic rocks. A fine-grained sandstone usually lies at the base of the Monterey. Instead of following Highway 1 directly to Carmel, a most interesting short side trip may be taken along the coast of the Monterey Peninsula. Bearing to the right at Monterey, the road follows past the historical custom house, Fishermen's Wharf, along Cannery Row, the low, rugged, granite coast of Pacific Grove, around Cypress Point and back to Highway 1 at Carmel Mission. On this coast, southwest of Pacific Grove, near Asilomar, Del Monte properties Company and Owens-Illinois Glass Company produce glass and specialty sands from large, white dunes of late Quaternary age. One entrance to the world-famous 17-mile drive is in Pacific Grove near Asilomar.

Near Carmel Mission, shallow road cuts along Highway 1 expose basal sand of the Monterey formation lying on granite. The entrance to Point Lobos Reserve State Park, on the right about 3 miles south of Carmel River, leads to one of the most beautiful

Looking east across the northern Gabilan Range from Fremont Peak. The three peaks in the foreground are limestone and dolomite; brush-covered hills are granite and schist, and the skyline ridge is underlain by Paso Robles gravel.

Salinas Valley

For approximately the next 100 miles, Highway 101 follows southeast along the structural depression of the Salinas Valley between the Sierra de Salinas (eastern part of the Santa Lucia Range) on the west and the Gabilan Range on the east. In the lower part of the Salinas Valley bedrock is down-warped several hundred feet below sea level. The Pleistocene Salinas River may well have cut its canyon far to the west heading into the submarine Monterey Canyon, so clearly shown by blue contours on the Santa Cruz sheet of the State map. For many miles along the west side of Salinas Valley, at the base of the Santa Lucia Range, great elevated alluvial fans are a prominent feature.

Five miles east of Chualar is the Jens feldspar quarry, now accessible by trail only. Large potash-feldspar, quartz, and mica crystals occur here in a pegmatite body cutting granite. From Gonzales a good secondary highway extends eastward across the granitic rocks of the Gabilan to the San Andreas rift valley. The road that leads to the entrance to Pinnacles National Monument follows the fault zone for a few miles. The Pinnacles are spectacularly eroded peaks and canyons in middle Miocene volcanic rocks. The double-pointed Chalone Peak, standing at the crest of the Gabilan Range on the southwest side of the Pinnacles, can be seen for several miles from Highway 101 in the vicinity of Soledad. Greenfield (9 miles south of Soledad) is the take-off point for a most interesting trip northwestward across the Santa Lucia Range via Arroyo Seco and Paloma Creek into the headwaters of the Carmel River, thence via the river valley to Carmel Mission at Coast Highway 1. This is the only through road across the northern Santa Lucia Range; it is a half-day trip, including time for viewing the geology.

At King City, Highway 101 crosses the Salinas River. Just west of the river, tilted gravel beds of the Plio-Pleistocene Paso Robles formation are well exposed. At this point a wide modern highway branches off from 101 in a due south direction through Jolon and Lockwood, and swings back to join Highway 101 two miles north of Bradley. The Jolon highway gives a fine view of much-folded and faulted shale, chert, and diatomaceous shale beds of the Miocene Monterey formation. The beautiful Mission of San Antonio de Padua is within 3 miles of Jolon. A rather narrow, steep, winding road extends west of Jolon across Cretaceous formations, the Nacimiento fault zone, and the Sur series to Franciscan rocks on Coast Highway 1 just south of Lucia.

A modern highway extends northeast of King City across the Gabilan Range to Bitterwater Valley in the San Andreas fault zone. This is interesting for it exposes nearly flat-lying marine uppermost Miocene-lower Pliocene sandstone and siltstone beds lying on an irregular surface of granitic rocks. The gently folded, or flat, Pliocene beds suggest that the Gabilan was elevated as a more or less rigid block of granite, faulted on the east side, during the late Pliocene-mid-Pleistocene orogeny. It is interesting that immediately west of King City the granite has been downwarped so that it lies beneath several thousand feet of folded and faulted sedimentary rocks.

Pumps in the San Ardo oil field may be seen producing heavy oil (11°-12° A.P.I. gravity) just south of the town of San Ardo (20 miles south of King City), in the river bottom and on terraces. The wells are about 2000 feet deep and produce from upper Miocene Santa Margarita sands. This is one of the world's great heavy-oil fields. In the next 12 miles south of San Ardo (passing on to the San Luis Obispo sheet of the State geologic map), highway cuts on the left bank of the Salinas River expose principally rocks of the Monterey and Santa Margarita formations. For the next 30 miles, from Bradley to Templeton and throughout hundreds of square miles east of the highway to the San Andreas rift zone, the land surface is underlain by a blanket of very gently-dipping, land-laid gravels and sands of the Plio-Pleistocene

The oldest rocks—the Sur series—are in fault contact or are unconformably overlain by all other formations. These rocks, of unknown age, were first deformed and metamorphosed prior to deposition of the Franciscan formation, but the time and extent of the orogeny, or orogenies, are unknown.

Upper Jurassic to late Cretaceous geosyncline

The formation of any great mountain range begins with deposition of sediments and volcanic materials in a long, relatively narrow, subsiding trough, or geosyncline. The usual pattern is accumulation of sediments to a thickness of at least 30,000 feet, when compressive forces directed at right angles to the geosynclinal axis begin to fold and elevate the sedimentary prism to build a mountain system. During and following the folding and elevation, masses of molten magma are intruded to cool as granitic rocks; faulting occurs as the elastic limit of the rocks is exceeded at some times and places, and volcanism may continue at intervals. Building of the Coast Ranges of California followed this general pattern.

Structural history of the Coast Ranges properly starts with the beginning of deposition of marine sediments of the Franciscan-Knoxville groups in Upper Jurassic time about 140,000,000 years ago, in a geosyncline whose axis lay far west of the rising Sierra Nevada, along the site of the Coast Ranges. Much of the sediments probably came from the rising ancestral Sierra Nevada on the east, but some geologists consider a western land mass of unknown extent to have been a major source of sediment. Geosynclinal deposition continued, with some interruptions, until late Paleocene time about 60,000,000 years ago, when the depositional trough was well on its way to destruction by active mountain-building. In late Jurassic time the minor Diablan orogeny affected the area of the Santa Lucia and Diablo ranges but did not seriously break up the geosyncline. It may have been at this time that basic intrusions of peridotite, gabbro, and serpentine took place into semi-consolidated Franciscan sediments. It is not known whether granitic magma was intruded into the Coast Ranges at this time as it certainly was in the western Sierra Nevada. Great thicknesses of volcanic rocks were deposited with the Franciscan sediments. Some faults such as the Sur thrust, Nacimiento, and ancestral San Andreas may have been initiated at this time but proof of this is difficult to obtain because of the overshadowing effects of later orogenies. Rocks of Franciscan type continued to be deposited in the northern parts of the Southern Coast Ranges until Upper Cretaceous time.

Cretaceous orogenies

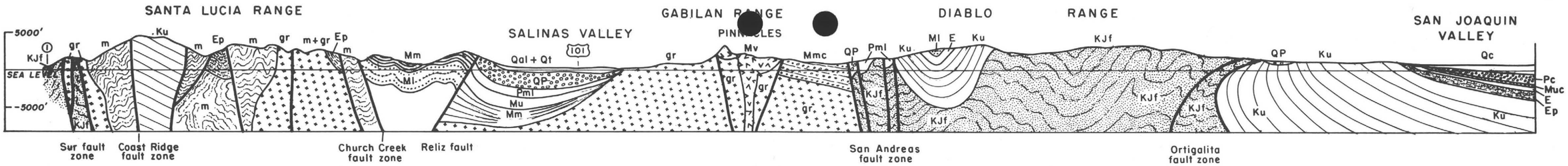
A mid-Cretaceous orogeny and the Upper Cretaceous Santa Lucian orogeny brought about broad arching and local faulting. Arching and uplift were greatest in the northern Santa Lucia and Gabilan Ranges. It is likely that the granitic rocks, so widely exposed in the Santa Cruz Mountains, the northern Santa Lucia Range, the Gabilan Range, and La Panza Range were intruded mainly during the Santa Lucian orogeny; perhaps intrusion began a little earlier, in the mid-Cretaceous. Upper Jurassic and Cretaceous sediments were being eroded from these areas—to expose the granitic rocks—immediately following the Santa Lucian mountain-building and during the Paleocene. The major geosynclinal axis in Upper Cretaceous time shifted eastward to the eastern margin of the Gabilan Range.

Eocene and Oligocene epochs

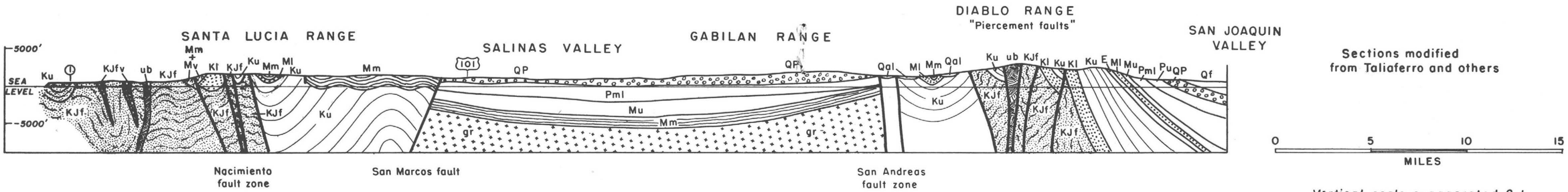
In Eocene-Oligocene time severe folding and faulting completed the break-up of the great geosyncline and outlined the major structural elements of the Southern Coast Ranges. It was probably during this time that many of the major northwest-trending normal faults developed; the extent of lateral movements on these faults is unknown. The ancestral San Andreas fault was strongly developed along the east sides of the Gabilan Range and Montara and Ben Lomond mountains on the San Francisco Peninsula; these mountain blocks were elevated west of the fault zone. Broad upwarps and downwarps also developed at this time, including for example, the Santa Cruz-San Benito trough, a narrow Eocene trough in the Santa Lucia Range, and the upwarp of the ancestral Coalinga anticline. The eastern foothills strip of the Diablo Range on the western margin of the San Joaquin Valley continued as a trough in Eocene-Oligocene time.

A great many of the faults and folds of these earlier epochs of diastrophism were covered by shallow Miocene seas, and to a lesser extent, by early Pliocene seas. Thus, these were epochs of relative crustal quiet.

The late Pliocene to mid-Pleistocene orogeny was the most severe that took place in the Southern Coast Ranges. Gentle broad compressive movements of Miocene time were succeeded by intense normal, lateral, and thrust faulting, and the development of tight folds. So intense was compression of the Diablo Range that a series of "piercements", or diapir folds, developed along the anticlinal crest of that range. This left masses of Franciscan rocks and serpentine, with fault contacts on all sides, thrust upward through younger flanking rocks; Mt. Diablo is a prime example. All the great fault zones, including the Sur thrust, Nacimiento, Tularcitos, Huasna, San Marcos, Huer Huero, San Andreas, Hayward, Calaveras, and others, were activated, or ancestral faults were reactivated, at this time. One of the most striking features of the fault pattern is that individual faults generally cut obliquely across the valleys and ranges; they only follow the valley-range boundaries for short distances. A prime example is the San Andreas which obliquely crosses the Santa Cruz Mountains on the San Francisco peninsula, cuts the northeastern end of the Gabilan, forms the eastern boundary of this Range for some distance, and then slices across the Temblor Range. The valleys and ranges of the Southern Coast Ranges are certainly of structural origin but appear to be the joint result of compressional forces which produced downwarps and upwarps, accompanied and followed by faulting. Minor uplift, depression, and movements along certain major faults have continued to the present; others, like the Sur thrust, have probably been inactive since mid-Pleistocene time.



GEOLOGIC STRUCTURE SECTION NORTHEAST ACROSS SANTA CRUZ SHEET FROM GAMBOA PT. TO SAN JOAQUIN VALLEY NEAR DOS PALOS



Sections modified from Taliaferro and others

Vertical scale exaggerated 2:1

GEOLOGIC STRUCTURE SECTION NORTHEAST ACROSS SAN LUIS OBISPO SHEET FROM PT. ESTERO TO SAN JOAQUIN VALLEY NEAR AVENAL

A GEOLOGIC TRIP ALONG HIGHWAY 101

≈GILROY TO BUELLTON≈

Crossing the Santa Cruz Mountains

Gilroy lies just north of the northern boundary of the Santa Cruz map sheet in the southern part of the structural depression of San Francisco Bay and Santa Clara Valley between the foothills of the southeastern end of the Santa Cruz Mountains on the west and the Diablo Range on the east. About 6 miles south of Gilroy, U.S. Highway 101 begins to cross the low Santa Cruz Mountains at Sargent. High on the left (east of Sargent) is the Sargent landslide which took place about 20 years ago. Strongly-tilted siltstone and sandstone beds in the road cut are those of the marine lower Pliocene Purisima formation. Four miles south of Sargent the great San Andreas Rift zone is crossed. Here it is marked by a rift valley and the fault can be easily seen on the highway because it marks the contact between Purisima sandstone and granite. An interesting side trip is to follow a small secondary road for 4 miles northwest, directly along the rift zone, by Anzar Lake, to Chittenden Pass. On the Chittenden Pass road is a striking exposure of the San Andreas fault-contact between the Miocene Monterey shale on the northeast and granite on the southwest. At this point, on the southeast side of the Pass, is the huge quarry of the Granite Rock Company in which the granitic rock has been broken by movements in the fault zone.

Continuing from the fault zone, Highway 101 turns west for about 4 miles across bold outcrops of the tilted coarse sandstone beds of the marine Oligocene Pinecate member of the San Lorenzo formation. These are best seen from the southern segment of the divided highway, where a picnic spot has been set up in the rocks. The road very shortly passes out of the Oligocene outcrops and into the blanket of loosely cemented dark-reddish dune and floodplain sands of the Pleistocene Aromas formation. A mile or so beyond the Aromas contact is an old quarry to the right of the road in which the Aromas sand is lying directly on granitic rock. The highway then continues due south to Salinas over low hills made up of the eroded Aromas sand and still younger terrace deposits. For several miles along this segment of the highway the prominent white scar of the Natividad dolomite quarry of Kaiser Aluminum and Chemical Company can be seen a few miles to the east. East of the quarries, the steep, high peak at the north end of the Gabilan Range is Fremont Peak (also called Gabilan Peak). Fremont Peak State Park is easily reached by a side trip through San Juan Bautista. The Peak is about 11 miles from the mission at San Juan Bautista and is one of the best places to see exposures of the crystalline limestone, dolomite, quartzite and schist of the Sur series, which here strikes due west across the Gabilan Range. Barite was mined at one time on Fremont Peak. Division of Mines Special Report 56 describes the geology of this area. Low down on its north slope, near San Juan Bautista, are the quarries and plant of the Ideal Cement Company which utilizes several high-calcium limestone deposits in the Sur series.

Sargent landslide in folded siltstone and sandstone beds of the lower Pliocene Purisima formation. Highway 101 is in the foreground. Photo by Clyde Sunderland.